Pergamon

Int. J. Heat Mass Transfer. Vol. 39, No. 5, pp. 885–963, 1996
Elsevier Science Ltd
Printed in Great Britain

0017-9310(95)00132-8

Heat transfer—a review of 1993 literature

E. R. G. ECKERT, R. J. GOLDSTEIN, W. E. IBELE, S. V. PATANKAR,
T. W. SIMON, P. J. STRYKOWSKI, K. K. TAMMA, T. H. KUEHN,
A. BAR-COHEN, J. V. R. HEBERLEIN, D. L. HOFELDT, K. A. STELSON
and J. H. DAVIDSON

Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN 55455, U.S.A.

INTRODUCTION

This review surveys and characterizes papers comprising various fields of heat transfer that were published in the literature during 1993. It is intended to encompass the English language literature, including English translations of foreign language papers, and also includes many foreign language papers for which English abstracts are available. The literature search was inclusive, however, the great number of publications made selections in some of the review sections necessary.

Several conferences during 1993 were devoted to heat transfer or included heat transfer topics in their sessions. They will be briefly discussed in chronological order in this section.

The *6th International Symposium on Transport Phenomena in Thermal Engineering* was organized by the Pacific Center of Thermal Fluids engineering in Seoul, Korea on 9–13 May. The program included heat exchangers, electronic equipment cooling and thermal control of equipment among its topics. Papers are included in a bound volume. The *38th ASME International Gas Turbine and Aeroengine Congress and Exposition* (ASME Turbo Expo 93) 24–27 May at Cincinnati, Ohio, U.S.A. contained in its program sessions on heat transfer, unsteady effects, external, internal and film cooling. Papers are available at the ASME order department. The *AIAA 28th Thermophysics Conference*, held in Orlando, Florida, U.S.A. presented among others papers on conduction, convection, radiation, phase change and thermal protection of spacecraft.

Two conferences organized by the Institute for Numerical Methods, University of Swansea, U.K. are of interest to workers in heat transfer: *Numerical Methods for Thermal Problems*, held 11–16 July and *Numerical Methods in Laminar and Turbulent Flow*, 18–23 July. Some papers are published in the Journal of the Institute. The *Fourth International Conferences on Circulating Fluid Beds* in Somerset, Pennsylvania, U.S.A., 1–5 August contained a session on heat and mass transfer. Papers are published in the conference proceedings. The conference is sponsored by the American Institute of Chemical Engineers. The *29th National Heat Transfer Conference* in Atlanta, Georgia, U.S.A. on 8–11 August was organized by the American Institute of Chemical Engineers. Its program encompassed all phases of heat transfer. Only a few topics will be listed here: spray and solid surface heat transfer interactions, process heat transfer, two- and multiphase flow, fouling, compact heat exchangers, engineering education, thin films, gas turbine, nuclear heat transfer, fire and combustion, and heat transfer in the oceans. The ASME Calvin Lecture on "Nuclear Power—Its Future Role in an Uncertain World" was given by John G. Collier. W. M. Kays received the 1992 Max Jakob Memorial Award and presented a lecture entitled "Turbulent Prandtl Number—Where are We?" S. Levy was the recipient of the Donald Q. Kern Award and lectured on "Multicomponent, Multiphase Heat Transfer". Proceedings of the conference are available from the ASME order department or through the AIChE.

The International Center for Heat and Mass Transfer organized symposia on *Heat and Mass Transfer in Energy Systems and Environmental Effects* in Cancun, Mexico on 22–25 August and on *New Developments in Heat Exchangers* at Lisbon, Portugal on 6–9 September. The majority of papers are published in bound volumes. The *7th Congress and Exposition, Gas Turbines in Cogeneration and Utility, Industrial and Independent Power Generation* (ASME Cogen Turbo Power 93) held at Bournemouth, U.K. on 21–23 September listed in its program no papers solely devoted to heat transfer, but transport processes were involved in various presentations. The *3rd World Conference on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics*, organized by an *ad-hoc* assembly, was held at Honolulu, Hawaii, U.S.A., 31 October–5 November.

The *114th Winter Annual Meeting of the American Society of Mechanical Engineers* at New Orleans, Louisiana, U.S.A. on 28 November–3 December included, as customary, a significant program in heat transfer organized in general, panel, poster sessions and symposia. Topics of the sessions ranged from heat and mass transfer in biosystems under microconditions, at microgravity, in fires, manufacturing and composite materials, to experimental and computational aspects of basic transport processes. Panel sessions discussed internationalization of heat transfer issues and innovative ways to conduct heat transfer conferences. The Robert Henry Thurston Lecture was presented by Chang-Lin Tien on the topic "Microscale Thermal Phenomena in Contemporary Technology". The recipient of the 1993 Heat Transfer Memorial Awards were V. S. Arpaci and W. J. Minkowycz. Conference volumes and technical papers may be ordered from the ASME Order Department.

The *XII Brazilian Congress of Mechanical Engineering* was organized by the Universidade de Brasilia at Brasilia on 7–10 December. Areas of interest included thermosciences and fluid mechanics.

A list of books related to heat transfer is presented on the following pages. To facilitate the use of the review, a listing of the subject items is made below in the order in which they appear in the text. The letter which appears adjacent to each subject heading is also added to the references cited in each category.

Conduction, A
Boundary layer and external flows, B
Channel flows, C
Flow with separated regions, D
Heat transfer in porous media, DP
Experimental techniques and instrumentation, E
Natural convection—Internal flows, F
Natural convection—External flows, FF
Convection from rotating surfaces, G
Combined heat and mass transfer, H
Change of phase—Boiling, J
Change of phase—Condensation, JJ
Change of phase—Freezing and melting, JM
Radiative heat transfer, K
Numerical methods, N
Transport properties, P
Heat transfer applications—Heat pipes and heat exchangers, Q
Heat transfer applications—General, S
Solar energy, T
Plasma heat transfer and MHD, U

Books

J. J. Berlin, *Hypersonic Aerothermodynamics.* American Institute of Aeronautics and Astronautics, Washington DC, U.S.A.

R. A. Bialecki, *Solving Heat Radiation Problems using the Boundary Element Method.* Computational Mechanics Publications, Ashurst Lodge, Ashurst, Southampton, U.K.

R. M. Cotta, *Integral Transforms in Computational Heat and Fluid Flow.* CRC Press, Inc., Boca Raton, FL, U.S.A.

E. L. Koschmieder, *Benard Cells and Taylor Vortices.* Cambridge University Press, New York, NY, U.S.A.

G. M. Mikhailov and V. Z. Parton, *Super and Hypersonic Aerodynamics and Heat Transfer.* CRC Press Inc., Boca Raton, FL, U.S.A.

C. Taylor (Editor), *Numerical Methods in Laminar and Turbulent Flow.* Pineridge Press Ltd, Mumbles, Swansea, U.K.

CONDUCTION

This category on literature relevant to conduction heat transfer encompasses a variety of issues dealing with various aspects. Of particular importance are the specific subcategories dealing with heat transfer involving contact conduction and contact resistance; layered and/or composite and anisotropic media; heat transfer involving thermal waves and shocks, laser/pulse heating and propagation; thermal distributions in tubes, rods and fins; mathematical models, analysis, and numerical simulation studies; coupled problems involving thermo-mechanical issues; inverse heat conduction models and related studies; miscellaneous and/or special applications; micro-electronic heat transfer issues; thermal conductivity issues; and conduction–convection and flow effects.

Heat transfer due to contact conduction–contact resistance

Issues dealing with conduction heat transfer between contacting bodies, gap conduction, shape factors influencing the flow of heat and contact resistance are important for a variety of problems encountered in engineering practice. Account of conduction shape factors for isothermal situations appears in [1A]. Thermal contact resistance between flat surfaces affected by lubricating films is described in [2A]. Effects due to casting–mold interface, comparison of contact models under the assumption of elastic and elasto-plastic constitutive behavior, and other related studies dealing with thermal conductance including gap conductance and thermal models which improve upon the heat transfer aspects for fibrous insulations, are identified in [3A–8A].

Layered and composite or anisotropic media

With the widespread activity and attention being focused today on composite materials and structures for engineering applications, few papers dealing with thermal heat transfer issues in such problems appeared in literature. These include multilayer insulations [9A], influence due to double conductivity media [10A] and thermal diffusion in cyclic laminated composites [11A]. The issues dealing with heat transfer due to the presence of cracks are identified in [12A, 13A]. Measurement techniques for surface temperatures, and pulse heating and/or periodic heat transfer aspects in composite or in homogeneous media are identified in [16A–22A], including composites for high temperature applications [22A].

Thermal waves and shocks; laser/pulse heating and propagation

Of interest the past year in this subcategory have been problems dealing with thermal waves (including the aspects of the so-called hyperbolic heat transfer mechanism) and shocks; heat transfer and propagation due to sudden pulse and/or laser heating of materials and thermal propagation. A numerical analysis of the hyperbolic heat conduction problem is described in [23A]. A theory dealing with multilayers heated by laser absorption, temperature predictions and correlations and models for thermal conduction due to laser heating including influence of temperature dependence of material properties and assessments of relaxation times in thermal wave propagation problems are identified in [24A–39A].

Thermal heat transfer in panels, rods and solids

Periodic steady state conduction heat transfer in cooling panels is identified in [40A]. The effects due to longitudinal heat conduction on thermal heat transfer in a rod type flow and in sliding solids influenced by internal heating sources appears in [41A, 42A].

Mathematical models, analysis and numerical simulations

As in past years, this subcategory continues to address a variety of issues in the general area related to conduction heat transfer problems. The issues continue to identify new mathematical models, developments in analysis and/or numerical algorithms, and simulations for a variety of situations in thermal conduction problems. Since it is beyond the scope of this review to outline the specific issues addressed in this subcategory, the reader is encouraged to see the various papers appearing in [43A–95A]. The issues include closed-form solution methods, optimization strategies, development of numerical techniques and algorithms and applications to a variety of engineering problems involving conduction heat transfer.

Thermo-mechanical applications

Temperature influence in materials and structures or structural components is a problem commonly encountered in a variety of applications. As such, this multi-disciplinary field involving thermo-mechanical disciplines continues to draw widespread research activity. The topics in this subcategory include thermo-elastic contact and interactions [96A, 97A], high speed frictional heating [98A], effects due to thermo-elastic coupling [99A] and a variety of issues dealing with coupled thermal and stress–strain models, influence of thermal stresses in cracks, pin joints, coatings and propagation of thermal waves [100A–114A].

Inverse models and heat transfer studies

Various aspects dealing with inverse heat transfer conduction models and analysis techniques including analytical, experimental and numerical studies appear in [115A–122A]. A simple method for inverse heat conduction with an optimization feature is addressed in [123A].

Miscellaneous conduction studies

Miscellaneous conduction heat transfer studies encompassing a variety of experimental and design studies including analytic models appears in [124A–141A].

Special applications

Some specialized applications are identified in this subcategory. These include experimental investigation of thermal behavior [142A], solution methods for transient heat transfer in slabs, mathematical models and modeling issues for alloys, particles, steel ingots and solidification, and influence of aerodynamic heating environments [143A–157A].

Microelectronic heat transfer

An approximate method for thermal contact conduction correlation appears in [158A]. Heat conduction in components influenced by mixed flow gas corrosion and stress relaxation, simulation of transient thermal behavior and resulting stresses and strains and optimization for various microelectronic heat transfer applications appears in [159A–165A].

Thermal conductivity issues

The issues dealing with effective thermal conductivity in isotropic media and/or composites including analytic/numerical studies in simple and complex geometries appears in [166A–172A].

Conduction–convection and flow

The influence of convection and related flow effects in conduction heat transfer included investigation of heat exchanges in heterogeneous flows [173A], conjugate forced convection–conduction analysis [174A], transient heat transfer due to conduction and internal sources in a slab [175A] and conjugate problems dealing with conduction and free convection [176A].

BOUNDARY LAYERS AND EXTERNAL FLOWS

The research on boundary layers and external flows during 1993 has been categorized as follows: flows influenced externally, flows with special geometric effects, compressible and high-speed flows, analysis and modeling techniques, unsteady flow effects, films and interfacial effects, flows with special fluid types, measurements and flows with reactions.

External effects

External effects include elevated free-stream disturbance, stagnation flows, mass transfer through the surface, and electrical and magnetic interaction [1B–5B].

Geometric effects

Several papers on this topic related to cylinder and tube bundles in cross-flow or other forms of impinging flows. Others dealt with swirl, embedded vortices, protuberances, fins, surface roughness effects and a simulation of a solar collector. One subcategory included moving surfaces, including road beds and stretching sheets [6B–32B].

Compressibility and high-speed flow effects

One group of papers in this category discussed aerodynamic heating, as experienced by re-entry vehicles, including its effect on the stability of the boundary layer, for various vehicle geometries. Several others dealt specifically with the effects of shocks on boundary layer heating [33B–44B].

Analysis and modeling

Numerous papers in this category dealt with the modeling of turbulence and transition. Turbulence-related papers focused mostly on modeling flows with a strong anisotropic nature. More specific, turbulence-related analyses dealt with curvature effects and flow around spheres and leading surfaces. Laminar flow analyses included heatline visualization and conjugate effects. A design technique was presented for baffle tray column design [45B–57B].

Unsteady effects

Flows with unsteady effects dealt with large-scale fluctuations, including those leading to transition and oblique waves. Driven unsteadiness effects included forced flow oscillations, sudden injection and immersion, and other variations in thermal heating boundary conditions [58B–66B].

Films and interfaces

Papers in this category included heat and mass transport from films on vertical pipes and walls of wedge and cone shapes, films with surfactants, and films experiencing thermocapillary effects. One paper was presented on the spreading of lava flows [67B–74B].

Fluid types

Flows in this category include non-Darcian or non-Newtonian flows, flows with surfactant effects, suspension flows, rarefied flows and ionized flows [75B–80B].

Conjugate heat transfer

Papers with a strong component of conjugate heat transfer included analyses of flat plates under various conditions, flows with lateral temperature fluctuations, responses of embedded bodies, and fins with generation. Application-specific papers dealt with window cooling, chemical vapor deposition, casting and strip milling, and heat transfer in laser cladding [81B–92B].

Measurements

Two papers with an emphasis on measurements focused on simultaneous temperature and velocity measurements or temperature field measurements with laser interferometry [93B, 94B].

With combustion and reaction

Papers related to combustion and reactions dealt with strained diffusion flames, the non-equilibrium boundary layer at a corundum wall in a combustion product environment, catalytic reactions and fouling [95B–98B].

CHANNEL FLOWS

Heat transfer research in duct flows (wall-bounded flows) was subdivided into the following categories: straight-walled circular and rectangular ducts; irregular geometries; finned passages; thermally developing and oscillatory flow; and miscellaneous duct flow.

Straight-walled circular and rectangular ducts

Forced convective heat transfer in ducts of circular and rectangular cross section is ubiquitous in engineering systems and continues to receive considerable attention in the archival literature [1C–25C]. Several interesting studies examined a variety of new applications including the flow of magnetic fluids, radiative–evaporative flow of low-velocity vapor, and the application of suction and blowing in a laminar square duct flow. The simple geometry imposed by straight-walled ducts provided a convenient "proving ground" for a variety of turbulence models and comparisons between direct numerical simulations (DNS) and experiment [1C–25C].

Irregular geometries

Convective heat transfer was examined in a large variety of geometries including: multiple intersecting ducts; serpentine channels with and without right-angled turns; ducts with periodically varying cross section, in one case where the cross sectional area was held fixed; wavy-walled ducts; curved ducts of square, circular, and annulus cross section; "distorted" duct flow; duct flows containing backward facing steps; flow in a square duct having a centered circular insert; straight elliptic duct flow; and elliptic duct flow rotating about a parallel axis [26C–52C].

Finned passages

Heat transfer augmentation often demands creative schemes which exploit extended surfaces which improve surface contact area while serving the dual role of promoting turbulence. The competing tendency of these devices/systems to increase total pressure loss must also be addressed as well as the manufacturability of the proposed devices. The ensemble of possible geometric configurations seems limitless, which perhaps explains why the literature in this area never seems to diminish. A number of studies considered the effect of roughness elements on the flow in circular and rectangular ducts, including wedge-shaped and delta-shaped inserts, full and V-shaped ribs, repeated blocks, as well as configurations designed to simulate the placement of electric components. Longitudinal ribs or fins were employed in circular, square, and annular ducts; one study examined microfins. Spirally configured systems were used with indentations at large pitch, in helically dimpled tubes, and in knurled tubes [53C–88C].

Thermally developing and oscillatory flows

A broad collection of thermal–fluid systems were examined in the literature where the primary focus was on the thermally developing regions; fully-developed hydrodynamic conditions were typically assumed. Step changes in wall heat flux or heat generation rate were considered in laminar and turbulent duct flows for circular, rectangular, and annular cross sections. Axial conduction was considered in a number of studies highlighting the importance of the wall-to-fluid diffusivity ratio. Heat and mass transfer were examined in ducts experiencing curvature as well as in straight-walled ducts experiencing streamwise acceleration. Transient conditions were also considered by the method of Laplace transforms. Time-dependent forced convection in ducts was investigated in periodically reversing flow such as that to be expected in a Stirling engine. Periodically compressed and expanded gas flow was studied as well as pulsating pipe flow [89C–112C].

Miscellaneous duct flow

There were several duct flow studies which did not fit well within the subcategories provided above. Non-Newtonian flow of Bingham plastic in the thermally and hydrodynamically developing region of a circular duct was examined numerically. Turbulent heat transfer of visco-elastic fluid in a helical pipe and the flow of a power-law fluid between parallel plates were also studied. Liquid hydrogen flow within the leading edge of the NASP was modeled numerically. Other miscellaneous studies included: the flow of supercritical hydrogen; thermocapillary and buoyancy-affected flow; heat transport in groundwater; heat transfer in a parallel-loop thermosyphon; and real gas effects on airfoil aerodynamics [113C–132C].

FLOW WITH SEPARATED REGIONS

Regions of flow separation, recirculation and reattachment can be expected whenever a nominally parallel flow encounters a rapid change in geometry. Common configurations explored in the literature in 1993 include the backward facing step, flow past obstructions including cylinders and plates, and cavities of varied geometry. The naphthalene sublimation technique was used to examine the effect of angle of attack on the heat transfer characteristics at the junction of a cylinder and its base plate. A number of studies considered the hydrodynamic and thermal fields in the neighborhood of single and multiple-cylinder arrangements. Unique investigations of elliptic cylinders, isolated gas turbine blades, and tube-type heat exchangers with woven threads were also considered. The fluid–thermal interactions past spheres were studied for droplets in electric fields, for vaporizing droplets, past spheres where a secondary flow was established due to acoustic streaming, and past spherical particles in unsteady flow. Separated flows in isolated heated jets, jets in cross flow, and multiple-jet configurations were studied experimentally. There was also a collection of papers where fundamental thermal transport mechanisms due to vortex motion were investigated [1D–36D].

HEAT TRANSFER IN POROUS MEDIA

Porous media means a mixture of fluid and solid phases that have interconnected pores or intergranular spaces through which fluid can move. Such systems are often advantageous because they have a large fluid–solid interfacial area which can enhance physical and chemical processes. As can be seen from the sub-headings in this section, many of the categories are parallel and duplicate the areas covered in other sections of the review. The unifying feature of papers in this section is the essential role of porous media.

Conduction and radiation

Several studies concern the prediction of properties of conduction dominated porous media from distribution and properties of their constituents [1DP, 5DP, 8DP]. In other situations, convection is negligible, but radiation and conduction are important [2DP–4DP, 6DP, 7DP, 9DP].

Forced convection (fixed bed)

Many applications consider a fixed solid material where fluid is forced through it by an externally imposed pressure difference [10DP, 12DP, 14DP, 16DP, 18DP–21DP, 23DP, 25DP, 26DP]. The statistical nature of the bed properties [11DP, 15DP] has been considered by some researchers. Several studies consider fluid flow past a porous surface [22DP, 28DP] and others consider heat transfer to bodies embedded in a porous medium [13DP, 17DP, 24DP, 27DP].

Natural or mixed convection (fixed bed)

There were many studies of natural convection in porous media in a variety of configurations and regimes [29DP, 33DP, 34DP, 40DP–42DP, 51DP, 58DP, 63DP, 67DP, 68DP, 69DP, 70DP, 73DP, 74DP]. Some studies considered mixed convection, i.e. combined natural and forced convection, [30DP, 31DP, 43DP, 44DP, 57DP, 61DP] while other studies considered non-Darcian effects [38DP, 39DP, 49DP], non-Newtonian effects [55DP, 56DP] and anisotropic media effects [35DP, 48DP]. Some papers concerned vapor–liquid counterflow [64DP, 65DP, 71DP, 72DP] and application to natural convection in fractured reservoirs [53DP, 60DP]. Many papers concerned the development of flow instabilities [32DP, 36DP, 37DP, 45DP–47DP, 50DP, 52DP, 54DP, 59DP, 62DP] and one paper concerned the feedback stabilization of such instabilities [66DP].

Fluidized beds

Fluidized beds are of great current technological interest, and a large number of articles for the current year are reported. The largest number of papers addressed the problem of predicting heat transfer coefficients between the particles, the fluid and the walls of the fluidized bed [75DP–77DP, 80DP, 81DP, 83DP, 85DP, 86DP, 87DP, 90DP, 91DP, 93DP–96DP, 98DP, 99DP, 103DP–105DP]. One paper describes capacitive imaging of a fluidized bed [88DP], another concerned vibratory fluidization [89DP], and another concerned a magnetofluidized bed [100DP]. Two papers considered three-phase fluidized beds [82DP, 92DP] while several papers concerned the specific problems of drying [97DP, 102DP], boiling [78DP], incineration of waste [79DP, 101DP] and limiting pollutants in industrial applications [84DP].

Heat transfer combined with mass transfer, chemical reactions or phase change

Numerous studies were done of situations with combined heat and mass transfer in porous media [106DP, 108DP, 111DP, 112DP, 115DP, 119DP, 120DP, 122DP–124DP, 127DP, 129DP, 135DP, 136DP] of which drying is an important application [116DP, 121DP, 133DP]. In fixed bed chemical reactors, both heat transfer and the reaction must be modelled [131DP, 132DP, 134DP]. Dissolution of a porous media by a reacting fluid [109DP, 110DP], devolatilization of coal [117DP], combustion within a porous media [113DP, 114DP] smoldering of polyurethane foam [130DP], cooking of food [137DP] and ablation of heat shields [107DP] are applications where reactions are coupled with heat transfer. Solid–liquid phase change in a porous media was investigated by several researchers [118DP, 125DP, 126DP, 128DP].

EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION

Many experimental results are cited in other categories of this review. The purpose of this section is to identify papers that focus on new or improved experimental measurement techniques or devices that are useful in experimental studies of heat transfer. The publications referenced here deal explicitly with some aspect of heat transfer measurement or include a general review of techniques that are applicable to heat transfer measurements.

Heat transfer measurements

Novel heat flux sensors include thin film devices, microcalorimeters and computer controlled sensors [2E, 6E–8E, 18E]. The dynamic response of local heat flux sensors has been evaluated [5E, 20E] and heat transfer coefficient determination from temperature oscillations has been made [15E]. Interferometric optical fiber sensors continue to be developed [9E–11E]. Infrared thermography has been used to measure local heat transfer coefficient distributions [1E, 17E]. Other methods include psychrometry, liquid crystals and photographic means [3E, 4E, 12E–14E, 16E, 19E].

Temperature measurements

Studies of thermocouples for temperature measurement emphasize the response and the fabrication of thin film devices [21E, 24E, 34E, 35E, 47E, 54E, 58E, 59E, 62E]. Infrared pyrometry was applied to measurement of surfaces, droplets, semitransparent media, and air flow temperature in contact with a screen [28E, 32E, 33E, 37, 38E, 42E, 52E, 55E]. Studies of resistance thermometers included an improved cold wire thermometer [30E], rhodium–iron and germanium thermometers [26E, 36E, 50E] and thin film thermometers [27E, 64E]. Two papers considered the use of holographic interferometry [29E, 45E]. Laser induced fluorescence and thermoluminescence methods were used in a variety of applications [40E, 41E, 44E, 46E, 57E, 63E]. Laser Raman and Rayleigh scattering techniques were applied to high temperature studies on combustors and ablating surfaces [39E, 43E, 53E]. Several authors used gas absorption methods to determine the temperature distributions in gases [23E, 25E, 48E, 51E, 56E]. Miscellaneous temperature measurement techniques include an inductive noise thermometer [61E], liquid crystals [60E], comparison of methods for integrated circuits [49E], the use of an inverse heat conduction method [22E] and the use of a temperature profile for control purposes [31E].

Velocity, concentration and flow visualization measurements—single phase

Considerable work continues in characterizing hot wire anemometers particularly their frequency response in turbulent flows and combining them with other instrumentation [65E, 68E, 70E, 73E–75E, 82E]. Several authors discussed the calibration and use of multiple sensor hot wire probes [76E, 78E, 81E, 84E, 88E]. Effects of structural vibrations [87E] and an automatic positioning device [83E] were also evaluated. Recent applications of particle image velocimetry have been described [80E, 85E]. A holographic focusing Schlieren system was used for high-speed three-dimensional flow visualization [72E]. Novel mass flow measuring devices have been developed that use the transient temperature change of a thermocouple [66E], radiometric measurements of combustion products [67E] and propagation of heat waves [79E]. Wall turbulence has been measured with electrochemical probes [71E] and atmospheric turbulence with anemometers, kites and the strain on wind turbine blades [69E]. Papers that describe surface concentration or sorption measurements include the use of a frequency response method [86E] and near-infrared measurements of surface moisture concentration [77E].

Multiphase flow measurements

Papers that discuss measurement techniques in two-phase flows include void fraction measurement, local interfacial area and local velocity measurement in liquid–vapor flow [90E, 92E, 93E]. Other work covers particle size and velocity measurements [89E] and interface position measurement in solidification processes [91E].

Properties

Several authors reported on various methods to measure thermal conductivity of solids [94E, 96E, 100E, 103E, 104E, 109E–111E, 114E]. Both steady and transient methods have been used to determine thermal diffusivity in solids and porous materials [97E, 101E, 113E, 115E]. Specific heat data were presented for a thermocouple material [102E]. Various methods were used to measure thermal radiative properties of solid and liquid surfaces [98E, 99E, 105E, 116E, 118E]. Miscellaneous measurement methods include the use of thermoacoustics, the Peltier effect and calorimetry [95E, 106E–108E, 112E, 117E].

Miscellaneous methods

Measurement methods that do not fit any of the categories above are included here. Several papers discussed solar radiation measurements [121E–123E, 125E, 128E, 131E, 132E]. Others include the use of radiometry [120E, 130E], plasma diagnostics [126E, 127E], dew point measurements [124E], heat exchanger fouling [129E] and reduction of error bias [119E].

NATURAL CONVECTION—INTERNAL FLOWS

Natural convection continues to be of great interest in a number of scientific and engineering disciplines. The present section covers natural convection studies in enclosed layers of fluids. These occur in natural phenomena, and industrial and conservation applications. Thus, such flows are studied by geologists to get a better understanding of movements in the Earth's mantle, by astrophysicists to understand the transport of energy from fusion deep within a star, to the surface where it is radiated away, by meteorologists to understand flows in the atmosphere, and by applied mathematicians working to understand complex self-contained flows defined by non-linear equations with different boundary conditions. This includes developing an understanding of the mechanisms of turbulent flow and the transitions that occur over a range of parameters. Such flows are also important in crystal growth, in insulation including multi-pane windows and attic systems, and a variety of engineering designs.

Horizontal layers heated from below

Rayleigh–Bénard flow is named after two researchers who first investigated phenomena in a fluid layer that is heated from below. Such a system, assuming a normal fluid whose density decreases with increasing temperature, in a body force field such as gravity tends to becomes unstable as the more dense fluid is above and the less dense fluid is below. The instability problem leading to the onset of flow, and the characteristics of the flow as one changes parameters, in particular the Rayleigh number, give rise to a range of two- and three-dimensional flows which with increasing Rayleigh number can become erratic, perhaps chaotic, and at sufficiently high values of the Rayleigh number, turbulent. The variety of studies covered in this area is very large [1F–22F].

Studies include bifurcation in the flow conditions going from oscillatory convection and then to chaos; the influence of geometry, in particular aspect ratio on the possibility of soft and hard turbulence, in both numerical and experimental studies; the influence of various boundary conditions such as rigid and stress free horizontal surfaces as well as the Prandtl number effect on convection. Other studies consider the thermal plumes that transport fluid and enthalpy between the boundary layers on the upper and lower surfaces, transient flows with sudden changes in the surface boundary conditions, and the effects of gravity modulation. The influence of additional surfaces and walls has been considered including roughness elements on the bottom surfaces, heat-conducting permeable partitions, and honeycombs. Other factors that affect the flow and heat transfer in Rayleigh–Bénard problems include even a slight cross flow which can change the basic flow pattern considerably. Heated from below systems with internal energy sources which might include the earth's mantle and certainly Joule heating of fluids are also of interest.

Double-diffusive systems

The density of a fluid can depend on more than one independent property that can vary (e.g. concentration and temperature), with gradients determined using diffusion equations as well as convection. Such flows are double-diffusive flows. The most common ones are those in which the density and thus the body force is dependent on a temperature difference and a difference in chemical concentration of species. These flows occur in solar ponds, the ocean, chemical reactors, and some manufacturing operations. Studies considered in the present review include examination of buoyant thermals in mixing, solar ponds, time-periodic instability in horizontal layers, analysis of rolls and cells established in an enclosure, and the unsteady double-diffusive convection with differential heating across a layer including flow structure and fluctuations, and a consideration of multilayered roll cells in the potentially transient flow in a differentially heated enclosure [23F–29F].

Thermocapillary flows

In thermocapillary flow [30F–42F] it is not, or not only, body forces that drive the flow, but rather variations in the surface free energy or capillary forces. In addition gravitational body forces may also affect the flow. Studies consider a single layer with an open (free) and deformable upper surface. Most of these are analytical or numerical. They include the effect of aspect ratio, three-dimensional thermocapillary convection and the presence of oscillations in a liquid at large Marangoni numbers. The influence of a horizontal pressure gradient as well as residual contamination and the collision of waves in Marangoni–Bénard convection have been analyzed. Thermocapillary flows occur not only with a free surface but with a surface between two immiscible fluids as well. Layered systems have been examined including the flow patterns for different variations of interfacial tension between layers. Marangoni or surface tension thermocapillary driven convection has also been considered in chains of bubbles in liquids as well as with a spinning droplet.

Vertical ducts and differential heating

Buoyancy driven flows in vertical layers of fluid include those in tubes, ducts, and vertical annuli. Differential heating occurs in a layer within which the temperature gradient is primarily in the horizontal direction often when two vertical opposing walls are maintained at difference temperatures. Many works have appeared in the past year in these fields. Some [43F, 45F, 49F, 51F, 53F, 57F, 59F, 62F–64F, 69F, 71F–73F, 76F–78F, 81F] deal with vertical tubes and slots including influence of dry walls, falling films, density inversion, Prandtl number and aspect ratio as well as ribbed channels, local energy sources and transient conditions usually at the onset of the flow. Studies in rectangular differentially heated enclosures consider such factors as partitions, non-Boussinesq effects, periodic heating, transient heating, density inversion, discrete energy sources and a variety of other problems in square rectangular channels [44F, 46F, 52F, 54F–56F, 58F, 60F, 61F, 65F–68F, 70F, 74F, 75F, 79F, 80F]. Other studies [47F, 50F, 82F–84F] consider convection in shallow cavities, and in a horizontal duct connecting two fluid reservoirs.

Horizontal tubes and annuli

Buoyancy driven convection in fluids held in horizontal tubes including circular tubes and annuli both circular and spherical have been reported in several studies [85F–94F]. These consider the influence of non-uniform distribution of heat flux, vortical structures, and temperature fields. Other studies on flow and heat transfer in annuli include finite element analysis, flow in a rhombic annulus, internally finned annuli and even the influence of non-uniform magnetic fields in a fluid containing magnetic media. Flow in spherical annuli have been examined using symbolic algebra, finite element analysis and finite difference methods.

Porous media

Flow in porous media [97F–102F] is often analyzed using the Darcy model or some related derivative. This holds for natural convection as well as forced flow. Buoyancy driven convection in porous media includes flows in vertical ducts, rectangular enclosures, and concentric spheres. Other studies performed in the past year include non-Darcy effects as well as transient phenomena.

Thermosyphons

In a thermosyphon, fluid circulates in a closed loop due to differences of the density in the fluid in the up-flowing leg and down-flowing leg. The difference in density is usually due to temperature variations. Recent studies include an interesting article on transient heat and mass transfer in a loop as well as one on an evaporative thermosyphon [103F, 104F].

Mixed convection

Flows with body forces, can also be affected by impressed flow or pressure differences in combined natural and forced convection or mixed convection. Such flows are often complex and three-dimensional [105F–114F]. Studies include those with horizontal tubes, vertical ducts, the influence of aiding and opposing flow (when the buoyancy and impressed forces are the same or in opposite directions respectively). Others studies concern the influence of a low Prandtl number fluid on the flow, and unsteady flows in rotating systems.

Miscellaneous

Studies in this section include a pot pourri of works [115F–135F] that examine inclined layers square cavities, slots, open cavities, and finned ones. Still others considered trapezoidal cavities parabolic enclosures, and triangular enclosures. Effects have been examined postulating different magnetic fields and different fluids with a range of geometries. Studies on the influence of radiation and rotation as well as melting and Prandtl numbers approaching zero are included.

Applications

Many of the applications for buoyancy driven flow are already included in the earlier sections. In the present section [136F–141F], items include flows in buildings, window cavities, the influence of multi-louvered surfaces, in solar-air heaters, flow in storage tanks and natural convection in coils to be used in superconducting generators.

NATURAL CONVECTION—EXTERNAL FLOWS

Vertical flat plate

The vertical plate continues to receive considerable attention. A linearization method has been developed that can handle arbitrary surface temperature variations [10FF]. Studies have been made that consider variable fluid properties and variations in the ambient fluid [1FF, 3FF, 12FF, 14FF]. Staggered vertical plates, plates that form a corner and projections from the surface have been investigated [8FF, 11FF, 13FF]. Combined heat and mass transfer effects have been considered for corroded surfaces, electrodes, and porous surfaces [2FF, 4FF, 7FF, 15FF]. Flow stability [5FF, 6FF, 9FF] and new wall functions for use in simulating turbulent flows [16FF] have been investigated.

Horizontal and inclined plates

Effects of blowing or suction on natural convection above horizontal plates [19FF], L-shaped corners with horizontal isothermal plates [17FF] and convection below horizontal plates [18FF] have been studied. Marangoni convection at air–liquid interfaces has also been investigated [20, 21FF].

Channels

Studies of convection in vertical channels have included variable property effects [23FF], effects of adiabatic extensions [26FF] and flow in a saturated porous medium [24FF]. Channels enclosed in a rectangular enclosure [25FF] and a single heated plate in a channel [22FF] have been considered.

Cylinders

Vertical cylinder studies include leading edge effects [33FF], conjugate heat transfer with liquid nitrogen [29FF], and an array of vertical tubes [30FF]. Bench mark numerical solutions were presented for a horizontal cylinder [31FF]. Theoretical investigations of an elliptic horizontal cylinder [27FF], unsteady flow from a horizontal cylinder or sphere in a stratified fluid [32FF] and heat transfer to liquid helium [28FF] were presented.

Bodies of revolution, cones and spheres

Pressure gradient and magnetic effects were studied near the stagnation point of axisymmetric bodies [35FF, 37FF]. Results for heat transfer from an isothermal cube [34FF] and from a vertical isothermal cone [36FF] were provided.

Buoyant plumes

Buoyant plume studies include a point source [38FF], round, turbulent buoyant jets [40FF, 41FF, 43FF], and buoyant wall plumes [39FF, 42FF].

Mixed convection

Publications on mixed convection include investigations of flat plates [44FF, 51FF, 57FF, 59FF, 61FF, 63FF, 64FF, 65FF] and flow over steps [45FF, 47FF] and channels [50FF, 53FF, 60FF, 62FF]. Other topics include cavities [49FF, 52FF], rotating bodies [48FF, 54FF], a horizontal cylinder [46FF] and flow in porous media [55FF, 56FF, 58FF].

CONVECTION FROM ROTATING SURFACES

Rotating disks

A review article covered flow and heat transfer from rotating surfaces such as disks and drums commonly found in turbomachinery [1G]. New studies on rotating disks include disks with thin liquid films [2G, 4G], flow between two rotating disks [3G, 6G] and a rotating disk-cylinder configuration [5G].

Rotating channels

Several papers appeared that considered heat transfer from cylinders and channels rotating about their axis [7G, 8G, 12G, 14G, 15G]. Mixed convection effects in rotating tubes and channels were studied [10G, 13G]. Other investigations include centrifugal effects of heat transfer to liquid nitrogen [9G] and the effect of rotating melt on the solidification of binary alloys [11G].

Fluid layers

Heat transfer within rotating cavities has been considered for disk cavities, cylinders and drums. Papers have been published for forced convection alone [18G, 20G, 21G], mixed convection [17G, 19G, 22G] and Maranoni convection in a partially filled container [16G].

Annuli

Rotating annuli papers include a study of mixed convection in a vertical annulus with the inner cylinder rotating [23G], natural convection in a horizontal annulus with the entire annulus rotating [24G] and double-diffusive convection in a rotating annulus [25G].

Cylinders, spheres and bodies of revolution

An analysis of mixed convection from a rotating body of revolution was made [30G]. Other studies considered heat transfer from rotating cylinders [26G, 28G, 31G] and rotating spheres [27G, 29G].

COMBINED HEAT AND MASS TRANSFER

This section on combined heat and mass transfer covers a number of somewhat divergent fields that include transpiration, ablation of surfaces, film cooling, jet impingement both submerged and free, spray and mist cooling, drying systems and a miscellaneous group.

Transpiration–ablation

Transpiration flow occurs with a porous surface through which a coolant passes, often to protect the surface from a hot gas stream flowing over it. With ablation a solid surface partially sublimes or loses material in other forms to absorb heat from an overflowing hot gas stream. Studies have been conducted on blunt cones in a non-uniform supersonic flow with gas injection from the surface, and on transpiration cooling as applies to missiles, aircraft, and electromagnetic guns. A numerical study considers both arbitrary injection and suction through a plate surface and their effect on heat transfer [1H–3H].

Film cooling

Film cooling [4H–7H] in which injection of a fluid at discrete locations into a boundary layer is used to prevent overheating of a wall has many applications. Most recently efforts have been directed toward cooling of gas turbine combusters, blades and vanes. In addition, investigators have considered the cooling of rocket nozzles and other systems. The coolant can enter through an array of holes, two-dimensional slots, and in the case of a very dense array of holes, sometimes called full surface film-cooling, the flow approaches transpiration. Studies in the past year include the influence of mainstream turbulence and film-hole geometry on film cooling effectiveness in the leading edge of a blade. Other studies considered film cooling downstream of a rearward facing step and the scale of mixing of a jet with a cross flow as occurs in film cooling. Liquid film cooling, in which a liquid coolant takes advantage of latent heat to cool the boundary layer, has also been examined.

Submerged and free jet cooling

Impinging jets are widely used in cooling applications because of the thin boundary layers in the impingement region and the resulting high localized heat transfer. An array of jets permits cooling of a large surface where the flow distribution can be controlled if non-uniform heating is present. Submerged jets generally are gas jets (most often air) entering into a similar medium (often air) though the temperature of the jet and the ambient can be quite different. In contrast a free jet might be a liquid jet entering an ambient gas; then, the jet density is much higher than that of the ambient fluid.

Submerged jet studies [8H–20H] examined include a series of flow field experiments to help evaluate a turbulence model, a comparison of the flow field with different models, measuring heat transfer from a single round jet to a flat surface, cooling of surfaces with fin type extensions, and use of an oblique impinging jet to cool a confined wall. Other studies include numerical and experimental investigations of slot jets in a rectangular cavity and of jets used in drying paper and textiles, submerged slot jets of liquid water and the influence of intermittence on heat transfer in the impingement region. Modeling of non-confined circular jets has been examined considering chemical vapor deposition. The influence of cross flow on impingement heat transfer and heat transfer from a special buoyancy induced jet have also been examined.

Measurements with liquid jets impinging on a surface [21H–30H], include a two-phase jet and the influence of boiling on the surface, application of laser–Doppler velocimetry to study the flow structure in the radial layer of impinging free surface liquid jets and the conjugate heat transfer from a heated disk to a thin liquid film from an impinging free jet. Analysis of the stagnation point heat transfer with liquid jets includes the influence of surface tension. Measurements include heat transfer from simulated microelectronics' chips and a surface with extremely high heat flux. Other liquid jet studies included multiple jets and the development of correlating equations for heat transfer in single circular jets.

Spray cooling

Spray or mist cooling [31H–38H] is similar to cooling by liquid jets. However, rather than a continuous flow of fluid, individual particles, droplets, or an array of thin streams impinge on the surface. Studies include the dynamic behavior and heat transfer of a single liquid droplet, cooling with flow of an aerosol and a numerical analysis of the flow pattern in impinging liquid sprays. Simplified analytical models and critical heat flux limits have also been examined. Specific applications include the use of spray cooling with a liquid refrigerant and cooling with diesel fuel sprays.

Drying

Drying is an important process in many industries, e.g. food, grain, and paper, as well as the production of films and certain plastics [39H–47H]. High frequency electromagnetic fields in the cooling of films and a review of advances in transport phenomena with convective drying using superheated steam and moist air have been examined. Drying has also been studied in desiccant coolers and for moisture problems in roof tops and buildings. Studies of fixed bed dryers, and various jet dryers have been examined as have applications to paper drying. Development of ceramic material for evaporation and cooling of water in arid regions has been reviewed.

Miscellaneous

Studies cover a wide variety of processes having combined heat and mass transfer [48H–53H]. These include numerical simulations for transport processes in rotary dehumidifiers, combined heat and mass transfer in turbulent falling liquid films and problems in optimizing dryers. Modeling wood structures during fire and such divergent issues as supersonic dust bearing flows and electrohydrodynamic Rayleigh–Taylor instability with heat and mass transfer have also been examined.

CHANGE OF PHASE—BOILING

Thermal transport phenomena, associated with liquid-to-vapor phase change, continue to attract significant attention in the heat transfer community. The 1993 archival English language literature reflects considerable activity in evaporation from droplets and films (43 papers), pool boiling (44 papers), and flow boiling (43 papers). More modest publication rates were encountered in the subcategory of bubble characteristics and boiling incipience (24 papers), as well as in two-phase thermohydraulic phenomena (nine papers). In addition to the 163 papers dealing with evaporative and ebullient heat transfer, surveyed in this section, the interested reader will find reference to these phenomena in some of the papers included in Change of Phase—Condensation (JJ), Heat Transfer Applications—Heat Pipes and Heat Exchangers (Q) and Heat Transfer Applications—General (S).

Droplet and film evaporation

The evaporation of small drops serves as a convenient starting point for studies of spray combustion, liquid fuel rockets, internal combustion engines, gas turbines, planetary atmospheres, spray drying, spray cooling, powder metal formation and quenching of hot solid surfaces. During this review period, archival studies in this area addressed the effect of radiation absorption [29J], high-pressure [12J, 19J, 21J], and a condensing species [40J], as well as an inert gas [44J], on droplet evaporation. The flow field generated by evaporation from a spherical surface [38J], coupled conduction in a droplet and the contacting surface [4J, 13J], evaporation of drops in contact with immiscible liquids [41J], and the subtleties of multicomponent droplet evaporation [1J, 24J, 28J, 36J] were also studied. The influence of an electric field on evaporation from a non-conducting drop was explored in [34J], while [2J, 3J] examined the electromagnetic vaporization of molten-metal drops. Intense evaporation and explosion of liquid drops was the subject of [7J, 26J, 27J]; the interactions between evaporating drops were considered in [9J, 23J]; the evaporation of a jet, a dense spray and an aerosol were studied in [25J, 30J, 31J], respectively; and the kinetics of flowing aerosols in [15J, 35J].

The successful design of refrigeration, distillation and desalination equipment, as well as food and material processing systems, often requires an understanding of thin liquid film evaporation. [42J, 43J] discuss the influence of thin film evaporation on mixed convection in a vertical channel. [37J] explores the development of the Knudsen layer near a liquid evaporating into a vacuum and [8J, 10J] study the behavior of an evaporating film in the region near the meniscus. The evaporation of a liquid into a gas–vapor mixture, as encountered in molten metals [6J] and condensed gas in the atmosphere [11J], and the simultaneous evaporation of several components [22J], also received attention. Several studies addressed industrial and commercial uses of evaporation, including evaporatively cooled air-conditioner condensers [16J], metallurgical application [18J] evaporative air coolers [14J], falling film evaporators [17J], the thin-layer drying of grain and kenaf [32J, 33J], respectively, and "thermal protection" by evaporation [5J]. Furthermore, the archival literature contains studies of evaporation from open bodies of water, in the presence of composition–temperature gradients [20J] or monolayer suppressants [39J].

Bubble characteristics and boiling incipience

The nucleation of vapor bubbles and the incipience of boiling are critical phenomena in ebullient heat transfer. The liquid superheat associated with flashing and bubble nucleation is discussed in [48J] for rapid decompression, in [60J] for flow in nozzles, in [51J] for a superheated liquid bombarded by neutrons, in [53J] for a liquid placed in an arbitrary container and in [61J] for boiler ash hoppers. Boiling incipience from rapidly heated film heaters is examined in [52J]. The influence of surrounding bubbles on nucleation is the subject of [47J] and boiling incipience hysteresis is explored in [59J].

Knowledge of bubble characteristics is essential to modeling of boiling and two-phase flow phenomena. A unified model for the prediction of bubble departure diameters in pool and flow boiling is offered in [67J, 68J], respectively. Bubble diameters and rise velocities in highly-viscous liquids were studied in [57J], while terminal velocity for a two-phase bubble was the subject of [65J]. Other fundamental studies included: energy transfer in resonant bubble oscillations [49J], signal propagation in a swarm of bubbles [50J], and the effects of bubble motion on the redistribution of bubble interfacial energy [63J]. Reference [54J] describes the behavior of bubble swarms entrained by plunging jets, [45J, 46J] heat transfer from bubble layers, and [64J] the use of a laser to measure bubble coalescence. Bubble characteristics in air-lift columns and fluidized beds were examined in [55J, 56J, 58J, 62J, 66J].

Pool boiling

Thermal transport by pool boiling continues to attract considerable attention, with emphasis on unconventional fluids and geometries, as well as boiling in the presence of microgravity and electrical fields. The boiling of cryogenic liquids was reported in [73J], addressing pressure effects on helium; in [86J], helium boiling on a surface of a high temperature superconductor and in [90J], nitrogen on a micro-configured surface. Ebullient heat transfer to magnetic liquids, typically toluene-solvent with magnetite, was the subject of several studies, including boiling from a steel cylinder [71J, 105J] and from a horizontal surface [103J, 104J, 106J]. Boiling of an octane enhancer, MTBE, is reported in [102J] and that of sodium polyacrylate, during the quenching of a steel plate, in [78J]. The mechanism of boiling in a horizontal tube bundle was investigated in [82J] and the translation of results from wires to cylinders in [80J]. The results of boiling from a thin film, with vibration [100J] and during quenching [79J], also appear in the literature, along with results for boiling in narrow spaces [84J] and in porous layers [99J, 110J]. Nucleate pool boiling under microgravity conditions was examined in [69J, 96J, 101J]. Enhancement of pool boiling by the use of various fin structures was reported in [91J, 98J, 108J, 113J] and under the influence of electric fields in [76J, 94J, 95J]. Measurement techniques for boiling research were explored in [70J, 89J, 107J] and the use of boiling to indirectly cool a high power microprocessor in [81J].

Many of the published studies of ebullient heat transfer focussed on specific pool boiling regimes. The influence of nucleation site density and nucleation rate on nucleate pool boiling was the subject of [72J, 85J, 111J, 112J]. While the mechanisms responsible for critical heat flux in single species liquids were examined in [97J, 109J], data and correlations for binary mixture critical heat flux were discussed in [74J, 87J]. Mechanistic models and correlations for film pool boiling were presented in [75J, 88J, 92J] and a database of results for film boiling with gas injection in [77J]. The influence of heating surface on transition boiling [83J] and transition pool boiling with helium [93J] are also discussed in the literature.

Flow boiling

Flow boiling phenomena are strongly influenced by the enthalpy of the coolant, the orientation of the channel, and the geometry of the heated surface. Fundamental studies of flow boiling parameters addressed bubble departure diameters [134J], temperature and velocity fields in the bubbly layer [148J] and nucleation site density [157J]. Forced convective boiling of refrigerants attracted considerable attention with studies reported on a correlation for pure refrigerants in smooth tubes [154J], for binary mixtures in smooth tubes [117J, 142J, 155J] and for binary mixtures with an array of heaters in [141J]. The effects of axially non-uniform heat flux in tubes [130J] and a comparison of transient and steady-state behavior [132J] are also reported. An emphasis on channel and heater geometry effects can be found in [115J] dealing with channel gaps in light water reactors, in [146J] dealing with microchannels, in [156J] dealing with small-diameter horizontal tubes, in [138J] examining flow boiling from simulated electronic components, in [128J], where cooling of reactor debris is explored, in [145J] addressing cooling during steel strip formation and in [114J] dealing with liquid jets inside a cryoprobe. A direct comparison of flow boiling heat transfer in upflow and downflow in an annular channel was the subject of [150J]. Recent uses and proposed modifications to the RELAP5 thermohydraulic reactor model are discussed in [127J, 140J, 147J] and other numerical analyses of flow boiling in [135J, 139J]. High flux cooling, using a particulate–liquid mixture, undergoing phase change, was studied in [126J].

A large number of flow boiling studies in the 1993 archival literature deal with critical heat flux (CHF). Detailed explorations of the thermofluid mechanisms responsible for flow boiling CHF for short heated walls were presented in [122J, 123J], for symmetrically heated vertical channels in [152J], and for nuclear reactor channels in [137J]. Reference [151J] explored the prediction of CHF based on adaptive learning networks. Instabilities associated with electrically heated test sections were discussed in [131J]. References [129J, 143J, 144J, and 149J] examined the characteristics of CHF under low-pressure, low velocity conditions; [153J] reported CHF measurements for new refrigerants and [136J] transient CHF in simulated light water reactors. Several published studies dealt with geometric effects on CHF, including channel diameter [116J, 118J], protruding heat sources (simulating electronic components) [124J, 125J] and tight lattice reactor cores [133J]. The dryout limit in horizontal tubes was examined in [119J]. Film flow boiling, which represents post CHF behavior, was the subject of [120J, 121J].

Two-phase thermohydraulic phenomena

The study of the thermal phenomena associated with flow boiling can not be divorced from the analysis and/or prediction of the relevant thermohydraulic parameters. The thermohydraulics of nuclear reactor channels are explored in [158J, 165J] and two-phase instabilities in [159J, 163J]. A new pressure drop correlation for subcooled flow boiling is offered in [162J], anomalies in channel pressure drop are discussed in [165J], and void fraction measurements are the subject of [161J, 166J]. Reference [160J] describes NMR imaging of multiphase flow in porous media.

CHANGE OF PHASE—CONDENSATION

Papers on condensation in 1993 dealt with surface geometry, system global geometry and boundary condition effects. Techniques for modeling and analysis were presented for film and free-surface condensation. Several studies investigated unsteady effects and, again this year, binary mixture condensation was popular.

Surface geometry and material effects

Several papers reviewed measurements taken with enhanced surfaces which used porous coatings; in one, suction was applied. One paper looked at the effects of a fouling layer on the surface and another investigated the appropriateness of applying dry-surface heat transfer correlations. Finally, one paper demonstrated the effect of surface material for steam condenser tubes while another showed the effects of material in chemical vapor deposition [1JJ–8JJ].

Global geometry and thermal boundary condition effects

Effects of geometry included condensation inside and outside pipes, on elliptical tubes, on slabs, and on vertical, top-sealed ducts. Also, the effects of temperature variation, corona discharge, condensation intensity, and velocities of the vapor or the liquid droplets were documented [9JJ–21JJ].

Analysis techniques

Papers on this topic discussed analysis or modeling of condensation on surfaces in various orientations, internal and external. Many presented correlations, one used a familiar software package. An analysis was presented for analyzing the moisture content in producer gases [22JJ–29JJ].

Free surface condensation

Free surface condensation papers included one on homogeneous condensation in transonic nozzles, one on condensation of sea water, and another on condensation of a refrigerant for gas hydrate cold storage [30JJ–33JJ].

Transient effects including nucleation

Papers in this category included one on condensation at the entrances of small vapor engines, one on heterogeneous nucleation of a mixture of benzene and cyclohexane on a cold substrate, and another on thermal accretion formation during cold gas injection [34JJ–36JJ].

Binary mixtures

Condensation with binary mixtures was discussed in numerous experimental and analytical papers, including several related to laminar films, one on a vertical flat plate, and one with a non-azeotropic refrigerant mixture. One paper applied the RELAP code to steam condensation and another evaluated the heat transfer coefficient in forced convection condensation. Finally, a paper investigated the used of surfactants to retard the growth of atmospheric mist drops [37JJ–43JJ].

CHANGE OF PHASE—FREEZING AND MELTING

This section reviews phase change problems dealing with freezing and melting for a variety of problems encountered in engineering, mathematical physics and related engineering sciences. In this category, a problem involving an optimization model for the Stefan problem (one paper); solidification in alloys and castings (four papers); issues encountered in and dealing with crystals (11 papers); freezing and melting involving frost, ice and snow (11 papers); influence of convection (six papers); continuous casting applications (five papers); methods, models and analysis and simulation techniques (50 papers); various related freezing and melting applications (16 papers); and miscellaneous applications involving change of phase as related to freezing and/with melting (16 papers) are briefly reviewed.

Stefan problem

An optimization model for the Stefan type problem involving a change of phase is identified in [1JM].

Solidification in alloys/castings

The solidification pattern of an aluminum alloy [2JM], casting influenced by adjustable heat power effects [3JM], the formation of negative and positive segregated bands during solidification [4JM], and collision-controlled growth of composites in casting nozzles [5JM] appear in this subcategory.

Solidification: crystals

Of emphasis in this subcategory have been problems involving solidification and microstructure evolution [6JM], floating-zone melting of cdTe [7JM], directional solidification issues [8JM–10JM], and crystal growth and microstructure developments [11–16JM] including a numerical simulation dealing with cdTe crystal growth [15JM].

Freezing and melting: frost, ice and snow

The freezing and melting issues dealing with change of phase as related to frost, ice and snow appear in this subcategory. The issues include contact melting during sliding of ice [17JM], jet discharge in an ice-covered reservoir [18JM], onset conditions for enhancement of ice accumulation [19JM], melting process of ice from a vertical wall [20JM], solid–liquid phase change in porous media [21JM, 22JM], and other related problems in the melting of snow, ice layers, and ice formation phenomenon and freezing [23JM–28JM].

Influence of convection and flow

The papers appearing in this subcategory deal with fully developed plume convection of ammonium chloride [29JM], thermal model of infrared reflow soldering process [30JM], convection influence in S_pMTS process [31JM], linear-stability theory due to thermo-capillary convection [32JM], magnetically damped convection [33JM] and characteristic features of convective heat release [34JM].

Continuous casting process

Papers dealing with continuous castings and related processes appear in [35JM–38JM] and [119JM].

Method/models and analysis and simulation techniques

As in past years, there is clearly evident much research activity dealing with development of mathematical models, techniques, and numerical developments for change of phase problems encompassing freezing and melting. The issues encompass inverse approaches, microscale heat and mass transfer, contact melting, shrinkage and void formation, moving boundaries, two- and three-dimensional applications, and applications involving a variety of numerical methods such as finite difference, finite element, boundary element, etc. [39JM–8JM].

Freezing and melting applications

The effect of energy conservation on heat transfer [87JM], the freezing of aqueous sodium chloride solution in packed beds [88JM], advances in research on water-freezing and ice-melting problems [89JM], melting heat transfer as related to heated tubes immersed in fluidized beds [90JM], in cavities [91JM] in porous media [94JM] and under related experimental and analytic studies are identified in [93JM–102JM].

Miscellaneous applications

Various applications involving a change of phase either due to freezing and/or melting for a variety of special applications are identified in this subcategory. These include calculations and investigations of freezing or melting as related to solidification in metals and alloys and liquids [103JM–118JM].

RADIATIVE HEAT TRANSFER

Papers in this category discuss problems associated with radiative heat transfer. Modeling efforts continue to dominate the field, both in terms of general techniques and specific applications. A few experiments were conducted to verify various aspects of the models. The subcategories below were chosen to further classify the papers according to their principle emphasis; however, significant overlap still occurs, and cross-references are given where appropriate.

Radiative transfer to/from/within complex geometries

These papers are linked by the importance of geometric factors to the solutions, and generally consider radiation in the absence of participating media, convection, or conduction. A number of techniques were used to model enclosures [1K, 10K, 17K, 21K, 150K] and view factors [2K, 4K, 5K, 19K, 20K]. Additional papers can be found in the sections involving participating media and combustion systems. Radiative heat transfer from bodies [7K, 8K, 12–16K, 22K], radiators [6K, 9K], the ground or vegetative canopies [11K, 18K] was also discussed. The treatment of nonlinearities arising in flux-limited diffusion approximations was the subject of [3K].

Radiative transfer in scattering media

This subcategory includes papers which consider the effects that scattering media have on radiative heat transfer. Many of the papers also include absorbing and emitting gases and some consider problems which arise in combustion systems, but the common focus is on scattering. A variety of methods for obtaining numerical solutions were discussed, some for general cases [25K, 30K, 33K, 36K, 38K, 51K, 56K, 59K, 60K, 68K, 75K] and others optimized for particular geometries [23K, 26K–28K, 40K, 49K, 52K, 57K, 58K, 61K, 63K, 65K, 67K, 69K, 74K]. A number of models and some data were presented for fluidized/packed beds or porous/fibrous media [29K, 31K, 32K, 34K, 35K, 39K, 41K, 45K, 55K, 66K]. Atmospheric applications were also investigated [24K, 43K, 53K, 54K, 64K]. Finally, a group of papers considered inverse scattering problems [42K, 46K, 50K, 62K, 70K] or characteristics of particle scattering [44K, 47K, 71K, 72K].

Radiative transfer in hot gases

Papers in this sub-category discuss the effects of molecular and atomic spectra (absorption and emission) on radiative transfer in gaseous participating media (see also the scattering and combustion subcategories). Numerical techniques were again predominate [77K, 78K, 83K–86K, 93K, 95K], with particular solutions and some data presented for re-entry [37K, 76K, 79K, 80K, 82K, 87K, 88K, 94K], plume [81K, 89K], and enclosure [90–92K] applications.

Flames, fires and combustion systems

Radiative transfer in combustion processes is often influenced by both molecular spectra and particle scattering. Papers in this section deal specifically with combustion products or systems, but readers should also check the previous two sub-categories. Various flame models were presented [96K, 99K, 100K, 103K, 111K, 113K] along with some experimental data for an arc-assisted flame [98K]. Models for realistic burner and boiler combustion geometries were also discussed [48K, 97K, 101K, 102K, 105K, 106K, 115K], with data presented for heat transfer augmentation by porous media inserts [110K]. Properties of combustion products [e.g. soot, fly ash, alumina, CO_2 and H_2O, were given in [104K, 107–109K, 112K, 114K].

Radiation with convection or conduction

Combination or coupling of radiative heat transfer with convection or conduction was considered by several authors. Flow of hot gases within enclosures is an obvious area where this occurs [116K, 118K, 129K, 130K, 132K]. A wide range of specific applications were also discussed, ranging from laser rod heating to glass manufacture to low gravity environments [117K, 119K, 122K, 124K, 127K, 128K, 131K]. Several papers presented theoretical discussions of the effects of different geometries, boundary conditions, or properties [120K, 121K, 125K].

Radiative transfer to/from surfaces

This category is actually a subset of the preceding one, but the papers have been grouped separately due to the common concern with intense applied radiation fields [73K, 126K, 133K–137K].

Experimental methods/radiative properties

Measurements of emissivity, reflectivity, and transmissivity were reported by several groups using various detection techniques [149K, 144K, 146K, 142K, 148K]. Absorptivity of liquid uranium, which depends on the complex refractive index, was measured over the visible and near infrared wavelength regions [140K]. Properties of aerogel windows [141K, 143K, 147K], and a $BaSO_4$ pigmented paint [145K] were also given. Finally, a feasibility study of the potential of using differential absorptive LIDAR (DIAL), techniques to measure rocket plume temperature profiles was also published [139K].

NUMERICAL METHODS

Research in numerical methods continues to grow in heat transfer and related fields. New techniques and algorithms are developed for solving the governing partial differential equations. The resulting methods are also being vigorously applied to a variety of physical problems. In this review, the papers that focus on the application of a numerical method to a specific problem are included in the category appropriate to that application. The papers that deal with the details of a numerical method are referenced in this section.

Heat conduction (direct problems)

The heat conduction problem can be considered as the fundamental problem in the solution of partial differential equations for scalar variables. It, therefore, provides a convenient testing ground for the development and evaluation of numerical methods. Also, heat conduction and other mathematically analogous phenomena are present in many applications. A number of papers deal with direct heat conduction problems. Both finite-difference and finite-element methods have been developed. Attention is given to the accuracy and efficiency of the methods [1N–7N].

Heat conduction (inverse problems)

Some papers deal with inverse heat conduction problems, in which the problem description is extracted from some information about the solution. Often, the work is done in conjunction with experimental measurements. Nonlinear heat conduction problems are now being handled in an inverse manner [8N–10N].

Phase change

Application of numerical techniques for phase change has been accomplished primarily through the enthalpy method. Of the available papers on the topic, one paper presents a comparison of different solution techniques for phase change [11N, 12N].

Convection and diffusion

The governing equations for fluid flow and heat transfer almost invariably contain convection and diffusion terms. A proper formulation of these terms is essential for satisfactory accuracy and reliability of the numerical method. The continuing challenge is to devise a method that would eliminate false diffusion and still maintain the solution within physically realistic bounds. Therefore, new and improved formulations of the convection–diffusion problem are being worked out. The papers included in this category either present new schemes or evaluate a number of different schemes [13N–33N].

Multigrid techniques

It is well known that the convergence of iterative methods slows down as the number of grid points is increased. Thus, when a large number of grid points are employed for obtaining adequate accuracy in a complex problem, the solution becomes unacceptably slow. In recent years, the multigrid technique is employed as a remedy for this problem and has shown significant promise. The papers dealing with multigrid techniques describe applications to heat conduction, convection and diffusion, and fluid flow. They also deal with curvilinear coordinates and nonlinearity [34N–39N].

Radiation

The equations that describe the local directional intensity of radiation in a participating medium are far more complex than the equations for heat conduction or fluid flow. Therefore, special numerical techniques are required for radiation. Variants of the discrete ordinates method, finite-volume techniques and Monte Carlo methods have been considered. The methods deal with irregular geometries and nongray effects [40N–44N].

Solution of flow equations

The calculation of convective heat transfer is inseparably connected with the calculation of fluid flow. Calculation methods for fluid flow are published extensively; here only the work that is relevant to heat transfer is reviewed. These papers deal with finite-volume and finite-element methods. Issues of interest include staggered or collocated formulations, body fitted coordinates, unstructured grids, multigrid techniques and domain decomposition [45N–63N].

Other studies

Various other studies have been presented in this section. These papers include reviews and position statements on the current state of numerical methods and their future prospects. Also, nonstandard applications of numerical techniques have been addressed [64N–73N].

TRANSPORT PROPERTIES

Thermal conductivity determinations dominate research in the transport properties area.

Thermal conductivity

Major interest focuses upon a myriad of special substances employed in a growing number of novel devices and processes. Thus data is reported for some common cryostat materials (0.05–2 K), Ag–Au and Ag–Cu alloy tapes used in oxide superconductors, R22–DMF mixtures used in vapor-absorption cooling systems, an epoxy resin, a and b zirconium, "karbotekstim-V" graphited fiber, ceramics based on $A^{II}B^{VI}$ compounds, and an analysis of the size and boundary effects of a gallium arsenide—(GaAs) based quantum well (Qw) structure [1P, 5P, 6P, 10P, 11P, 27P, 29P, 30P]. Other works treat aqueous solutions of salts, hydrocarbon mixtures, monolithic carbon aerogels, foams (uniform and layered), rock marbles, ash deposits from a specific Russian coal and float glass [3P, 13P, 15P, 21P, 22P, 24P, 33P, 35P].

A number of papers take a somewhat less specific approach to consider practical, accurate expressions for the conductivity of atom–diatom gas mixtures, the influence of rotational molecular motion on the isochoric conductivity of molecular crystals, the role of interfacial gaseous heat transfer in carbon fiber-reinforced glass, the use of carbon fibers in the place of conventional metals, the use of ceramic tape in electronic packaging, and the efficacy of alkoxysilanes as heat transfer fluids.

Some papers focus upon a distinguishing characteristic of the system or the process: nonstationary conductivity of multilayered bodies, the behavior of the heat transfer coefficient for ceramic under thermal shock, diffusivity of a film on substrate from pulsed, transient analysis, thermal conductance at low joint pressures, and thermal properties of slags containing iron oxides.

In the area of measurements there are reports of results using the heat pulse technique, dynamic light scattering to obtain the diffusivity of transparent fluids, the method of temperature waves to obtain high temperature diffusivity for insulation materials, and thermal diffusivity to gain the conductivity of gadolinium. Other investigations employ the cylindrical probe to measure soil conductivity, an a.c. technique to measure diffusivity of high temperature superconductors in the presence of magnetic fields, a combined three w/decay scheme to measure properties of electrically conducting solids and the phase lag of a traveling thermal wave to obtain properties for diamond sheets of a few hundred μm thickness.

Diffusion coefficients

Research here is limited to measuring the fluctuations of the refractive index when a laser beam is passed through a heated plane airstream and modeling the effect of chemical reactions on turbulent diffusivities [37P, 38P].

Viscosity

Using a simple rheological parameter, a method is described for estimating the viscosity of Newtonian and non-Newtonian inelastic solutions [43P]. In another paper, the bulk viscosity in relaxing media is examined [42P]. Other works consider transport coefficients of barium, zinc, and cadmium vapors, water–Xylitol mixture viscosity and the viscosity of polymers [39–41P, 44P].

Thermodynamic data

These range over areas of fundamental inquiry and technical application. In power and reversed thermodynamic cycle design and analysis several papers will be of interest: Comparative study of state equations for calculating R-12 properties, Property evaluation for R-22, Selecting ozone-safe fluids and generalized thermodynamic calculations for combined heat and power units [45P, 50P, 53P, 54P]. Other works study properties of a tungsten–copper pseudoalloy, methyl and isopropyl alcohols, combustion products of MHD powder fuels, low-boiling point metals and a thermosetting polymer during curing [49P, 51P, 52P, 56P, 58P]. The relationship between thermal expansion and other properties to atomic and crystal structure and possible discontinuity in heat capacity are examined [46P, 57P] and several papers consider biological and thermoelastic properties [47P, 48P, 55P].

HEAT TRANSFER APPLICATIONS—HEAT PIPES AND HEAT EXCHANGERS

As evidenced by the number of papers a high level of interest continues in the analysis, design, control and maintenance of heat exchangers over a broad spectrum of applications.

Heat pipes

The early start-up period from the frozen state is simulated and analyzed and a general approach taken to the classification and optimization of exchangers using heat pipes and therosyphons. Also examined is the thermal performance of a flat-plate collector array, thermosyphon solar water heaters, and the design of a solar chemical heat pipe. Specific consideration is given to antigravitational effects, axial rotation, transient response, and heating mode. Applications include space radiators, hypersonic vehicles, solar energy storage and semiconductor chips [1Q–18Q].

Heat exchangers

Flow around tube bundles is analytically considered over a range of Reynolds numbers and the results compared with those of others. Complimenting this work are a number of experimental studies: forced, combined natural convection with water, isothermal flow losses through an exchanger array, heat transfer (sensible and latent) in a baffled finned tube exchanger, performance of a bayonet tube using air under laminar flow and a coil-type liquid desiccant system.

Several papers analyze certain situations: the flow and heat transfer in the shell-side of a surface condenser, a scraped surface exchanger, crossflow exchangers, double-pipe exchanger, multistage exchangers, automatic control in parallel flow exchangers and the exergy efficiency for counter flow exchangers. For exchanger networks a global optimization algorithm is described and a procedure for estimating capital costs.

Areas of exchanger applications include: combustion in a continuous-flow reactor, natural circulation in reactor cores, thermal hydraulics in fusion reactors, exchanger practice in New Zealand, performance of advanced exchangers for ammonia refrigeration systems and the experience of mechanically bonded exchangers in railroad practice. Exchangers for the future are examined because of the combination of heat recovery with other processes [19Q–43Q].

Design

A number of papers provide insight on factors which influence design: tube layout for tube banks in transitional flow, chaotic advection in twisted curved channels and coils and uncertainty analysis and the Monte Carlo simulation technique. The design process is aided by computerized analysis for exchange network and the failure analysis of existing equipment.

A group of studies focuses on space heating and cooling: a thermodynamic analysis of heating options, modeling heat recovery, control of multizoned systems, comparative analysis of cooling systems, and the effect of size and control on peak residential loads. Optimum conditions are given for a micro system to cool laser mirrors.

The interaction between process integration and exchanger design is explored and the need to consider all aspects of exchanger design, heat transfer and operation if the exchanger process is to be optimized [44Q–56Q].

Enhancement

Reported work is extensive, involving both analysis and experiment. Among the former several works analyze longitudinal fins, of rectangular and trapezoidal profile, under varying boundary conditions. For an immersed finned exchanger coil, heat transfer correlations and the influence of baffles are reported. Internally grooved tubes and channels are analyzed for heat transfer efficiency, as are pin fins and plate fins for optimal spacing in laminar forced convection. Other analyses consider the thermal aspects of the spiral exchanger, the effect on heat transfer of a slit presence in a rib of a rib-mounted wall, and the performance of the fin–refractory system in a cyclone furnace.

Experimental papers consider various influences on the behavior of a single-row, annular finned tube exchanger, the heat-transfer effectiveness of shrouded rectangular-fin arrays, flat plain fins and round tube exchangers, and the efficacy of wing-type vortex generators for fin-and-tube exchangers and thin inclined plates for rectangular channels. Further works report measurements on cylindrical pin fin arrays (including the effect of missing pins, flow in thin-gapped diamond-shaped channels, wetted floating fins and the influence of baffles in a slurry bubble column [57Q–80Q]).

Fouling/deposits/surface effects

The possibility of reducing fouling through exchanger design promises a reduction of exchanger size (and weight) in a given application. To understand the fouling process the effects of sodium and potassium chlorides on silica deposition are studied experimentally; crystallization of calcium sulphate in a plate and frame exchanger was measured; and data on the fouling of double-walled tube banks reported. Fouling rates of river-water are compared for spirally indented and plain tubes and the problems and costs associated with exchanger fouling summarized for New Zealand industries. Two works on surface effects consider gas injection and thermal erosion [80Q–88Q].

Packed beds/storage

For packed beds the drying process is modeled and for cooling towers the influence of structured packing or fills is examined. Other works consider transport modeling of packed-tube reactors and the unsteady heat transfer influence on the water–zeolite absorption process [89Q–98Q].

Regenerators/rotary devices

The effect of solid heat conduction cross-flow regenerators is analyzed in several papers. For a single-blow exchanger temperatures are calculated for arbitrary initial solid and inlet gas temperatures. Numerical simulation of the combined heat and mass transfer is investigated using a new finite difference method, Laplace transform techniques, and schemes for the series solutions of the classical governing equations [99Q–106Q].

Shell and tube exchangers

The simulated transient behavior of these devices is considered by several investigators. Factors considered are: heat conduction in tubes and shells, longitudinal heat conduction in the exchanger core, multidimensional phase change, and variations in fluid heat capacities, inlet temperatures disturbances and maldistribution. Experimental investigations measure flow distribution on the shellside of a cylindrical exchanger, leakage in exchangers with segmented baffles, and boiling heat transfer for R-22 and R-717 on different surfaces [107Q–116Q].

Transient

The response of three types of fins (longitudinal, spine, and annular), each of three possible shapes (rectangular, triangular and parabolic) is analyzed numerically for four initial step changes. Other works consider the relation between the variation of surface temperature and that of the heat transfer coefficient, heat flow from a buried pipe, and the response of a counterflow heat exchanger with finite wall capacitance. Transient effects are also investigated for a rod bundle at heat transfer crisis and in a honeycomb reactor [117Q–122Q].

Miscellaneous

Papers included here involve applications which are rather specific; only a few of which can be cited. Several focus on heat-pump and reversed cycle devices using different fluids. Another group deals with the heat exchangers used with internal combustion engines and yet a third is concerned with material behavior [123Q–139Q].

HEAT TRANSFER APPLICATIONS—GENERAL

Aerospace

A numerical simulation [1S] uses the breakup of the liquid film into rivulets to calculate the temperature field in the water and wall. The transient velocity and temperature fields are studied on an aircraft brake housing [2S]. Input of heat to a thin wing at hypersonic velocity can be used [4S] to control its aerodynamic characteristics. A numerical study [7S] describes the effect of fuel and air flow in a ducted rocket combustor on thermal parameters. A physical model for liquid quench of a solid rocket motor is based on experimental results [9S]. External flow penetrates only two gap width into re-entry vehicle tile gaps [3S] when normal to flow, much deeper when parallel. Information is needed [5S] on the effect of temperature and radiation on the performance of multijunction multibandgap solar cells.

Bioengineering

Convective heat transfer coefficients were obtained [10S] at the fluid–particle interface to simulate aseptic processing. An analysis [12S] simulates heat transfer heat exchange between arteries and veins and the temperature fluctuations [11S] in living tissue.

Digital data processing, electronics

Pulsed laser radiation at the nanosecond scale [14S] produces transient heating of thin silicon layers. Transient reflectivity measurements and calculations [15S] are reported in laser annealing. Computations [23S] and experiments [20S] consider cooling of heat generating boards and discuss optimization [17S]. An equation describes the Nusselt number for forced convection cooling of printed-circuit boards [21S]. A numerical study [16S] determines the particle deposition rate by thermophoretic transport in the manufacture of wave guides. The reliability of electronics clips is sensitive to the junction temperature. A numerical simulation [22S] studies the coupled convective–conductive heat transfer process. The thermal characteristics of metallic point contacts suggest their use as microscale temperature sensors. Experiments [19S] studied the contact formed by pressing an Ag whisker against an Ag or Cu plate.

Energy

Experimental documentation and analysis [48S, 49S] show how hot streaks affect rotor airfoil temperatures. Great progress in the calculation of heat transfer in gas turbines is predicted [54S]. Numerical computation [36S, 45S] describes heat and mass transfer in combustors. The losses in turbomachines are studied [27S] in terms of entropy increase and coolant optimization in gas turbines is investigated.

The performance of utility boilers is numerically modeled [53S] and the development of dry cooling towers for *steam power plants* is discussed [50S]. The bottoming cycle for combined plants can be improved [38S]. Heat transfer by water in hot dry rock geothermal systems is studied [60S] experimentally. A model [55S] describes the thermohydraulic behavior of liquid saturated, self heated debris after an accident in a fast breeder nuclear reactor. Fluidized beds with immersed heat transfer tubes are proposed [51S] for multitubular reactors. Accelerated piston tests [57S] can establish structural integrity for natural gas engines. 75% of the exhaust emissions of gasoline vehicles occur in the first 2 min after a cold start. This process is modeled [47S] for a catalytic convertor. The influence of heat and mass transfer on metal hydride heat pump performance is analyzed [35S].

Heat transfer in cranked thermosyphons found unusual attention [37S, 39S–43S].

Heat transfer was studied for various situations like pneumatic transport of particles [44S], petroleum cooling in tanks [30S], for flat evacuated glazing [29S], for latent heat storage modules [25S], for optimal distribution of insulation [24S], for supercritical helium and He II in cables [31S], for vapor deposition reactors [34S], for wet suit material used in skin and SCUBA diving [58S], and in batteries for electric vehicles [28S].

A paper studied energy resources, conservation and greenhouse effect [46S].

Environment

A sound *design* philosophy is proposed [79S] that should reduce the energy consumption of *buildings*. Spectral decomposition is used [65S] to compare analytical models with experimental data. Design aspects are also treated [67S] including locations in foreign countries [61S, 68S]. Five-year measurements of the temperature and energy consumption [87S] were compared with computer simulation for a semi-underground room. Numerical analysis determines heat transfer in basements [76S], for edge insulation [62S], for slabs on the ground [69S], in residential space cooling [81S] on the effect of frost-heave on underground pipelines [84S], and on pipe insulation with radial baffles. Energy consumption of buildings can be reduced [72S] by heat storage in materials which absorb and release heat with temperature change imbedded in the walls.

Experiments [78S] studied the influence of *environment* on the surface heat flux from the soil of an alfalfa field. Shallow layers of water become unstable when solar irradiation heats the bottom. The character of the resulting flow is studied [70S] analytically. Heat and mass transfer from buried nuclear waste canisters is studied [80S] as well as the environmental impact of N_2O [63S].

Modeling techniques are discussed which describe the influence of sprinklers on *fires* [73S–75S], the turbulence induced in the airflow through a vertical tunnel by fire [86S], and the loss of protection of steel columns by partially missing insulation [85S]. A dense vegetative layer can be pyrolized when irradiated by visible radiation for 1 to 2 s [71S]. The pulsation frequency of a flame formed by a horizontal surface can be predicted [83S].

The heat loss of sleeping bags can be reduced by coating polypropylene fibers of the insulating layers with aluminum [66S]. Dispersion of solid particles in slurries such as paints or varnishes enhance heat transfer [82S].

Manufacturing

An increasing number of papers responded to the increasing use of *lasers* in manufacturing processes with the aim to understand its working in welding of metals [100S], in producing coatings by cladding with powdered metals [105S], in laser machining [89S, 106S], and in color printing [98S]. The influence of crystallographic and heat flux orientation is studied [96S].

Mold filling and heat transfer were investigated analytically [112S] and in laboratory experiments [115S] for *casting* of steel. Turbulent heat transfer was shown to play a critical role in continuous ingot casting [101S, 108S]. Convective heat transfer is shown to become important in die casting [90S] where the fill time is long. Heat and mass transfer in castings are calculated in a boundary fitted coordinate system [104S]. Parameters influencing porosity of cast goods are studied [97S]. Exudation causes surface segregation in aluminum DC casting [102S] and reduces surface quality. Microsegregation in binary alloys causes difficulties in solidification [110S].

Heat transfer is studied by computer modeling and analytically for pulsed current arc *welding* [91S], by friction welding [109S], and for a moving high intensity beam [113S]. The solid–fluid transition zone is studied for the solidification of binary alloys [92S].

Rock spallation induced by thermal stress caused by a supersonic flame is used for *drilling* through hard rock [114S]. Waterjets can cut in a similar way through metals, rock, and concrete [103S]. The thermal behavior of *hot-forging* is analyzed [107S] and checked by experiments. An analysis studies heat transfer in *injection molding* of plastics [93S] with the aim to predict shrinkage and warpage. Directed gas flows are used to control distortion in high-pressure *quenching*. Instability in quenching of superconducting wires can cause difficulties [111S]. A mathematical model of glass flow and heat transfer is presented [95S] for the platinum downspout of a glasstank furnace.

Processing

Energy and time can be saved [120S] in industrial *drying* where the air is replaced by superheated steam. The underlying principles of drying with microwave power are discussed [116S] as well as the phenomena in grain drying [121S] and in rotary drying [147S]. Drying for various applications is found in numerous papers including: natural crumb rubber [123S], pasta noodles [124S], droplets of gelatin solution [132S, 133S], sludge [135S], yoghurt [144S] and paper [148S].

Drying of *food* products was investigated analytically and experimentally. A hypothesis was developed [149S] linking the baking process of bread with the formation of an evaporation front. The thermal conductivity of unleavened flat bread was measured [130S] as were heat transfer coefficients for specimen of potato and carrot [119S]. Baking of biscuits was modeled [146S]. In hydro-air cooking air is passed over food products wetted by a thin film of water [143S]. Mathematical models are developed for *sterilizers* [118S, 150S]. Sterilization of canned food was studied [125S] theoretically and experimentally.

Multistage flash, multiple effect, and the effect of noncondensable gases on the distillation of sea water are reviewed and compared [128S, 142S]. Dehumidification of atmospheric air can be a source of fresh water in climates with high temperatures and humidity [138S]. Experiments clarify the coupling of crystallization of polymers with heat flow [127S]. In many processes, coal particles come into contact with molten phase. Heat transfer in this situation is studied [134S]. Experiments clarify the effect of magnetic fields on thermal processes in magnetorheologic suspensions [140S].

Models are developed for the processes in CVD *reactors* [1175, 1375], in polymerization reactors [139S], in photochemical reactors [122S], and in packed-bed absorbers and regenerators [129S]. A new heat transfer medium improves the performance of aluminum smelters [141S]. The hot dip-coating process is analyzed [151S] for cladding of metal strips, sheets and wires.

SOLAR ENERGY

Buildings and enclosed spaces

Strategies for utilizing passive solar energy to create controlled environments within residential and commercial building spaces are investigated. Window treatments including transparent silica aerogel insulation and chemically deposited glazing are examined. Analyses of heat transfer in walls address trombe walls, reflective insulation and evaporative cooling. Numerical simulation of specific passive buildings provide design guidelines [1T–17T].

Collectors

The majority of the papers concern design and performance of solar concentrators. Designs evaluated include line-axis curved mirror concentrators constructed with rolled steel tape, edge-ray secondary concentrators, 3D compound parabolic concentrators, configurations for flat receivers, sun-tracking for photovoltaics, design of solar dynamic modules for space station freedom, and oscillatory behavior of PI controlled distributed collector fields. Liquid metal reflux and multicavity receivers are investigated.

Studies of flat-plate collectors include experimental evaluation of polymer absorber materials, silica aerosol insulation, and a collector in which the heat transfer fluid is passed in a sheet along the back of the absorber plate. Applied modeling efforts address use of external reflectors for flat plate collectors, shaped glass evacuated tube collectors and heat loss from unglazed transpired collectors for building ventilation. Other modeling and analysis efforts yield better understanding of transient behavior, second law efficiency and multiple regression prediction from dynamic testing of collectors [18T–42T].

Radiation characteristics and related effects

Models are developed for generating synthetic radiation data. The majority of papers focus on characterization and effect of cloud cover. Sun temperature and position are also considered. Efforts continue to obtain site specific solar radiation data. Comparison of measured and predicted meteorological data is used as the basis for adjusting models [43T–72T].

Solar heating and cooling

Study of solar water heating in the United States continues to focus on single-family residential applications. Characterization of thermal stratification of water storage tanks is measured and methods of incorporating stratification in computer simulations are addressed. Validation of TRNSYS by comparison of measured and predicted performance is performed. A large scale solar water heating demonstration project in Denmark is presented.

Efforts in solar air heating concentrate on optimization of rock-bed storage and alternative collector designs (corrugated absorber plates, flow configuration). Analysis of hybrid air–water systems are considered for several climates.

Papers on solar air conditioning describe and evaluate performance of hybrid compression refrigeration cascaded with a solar ammonia–water vapor absorption system, adaptation of the ejector refrigeration cycle for solar air conditioning and unglazed solar assisted absorption cooling. Heat-pump systems are considered for refrigeration and domestic heating [73T–92T].

Stills/desalination

Analytical and numerical models of the solar distillation process are aimed at optimizing still design. Designs considerations include use of external solar collectors (both active and thermosiphon, with and without heat exchangers), effect of forced and natural convection air flow, effect of water depth and velocity, and inclination of the cover [93T–105T].

Storage

Efficiency of various storage alternatives including sensible heat storage in rocks and water, latent heat storage in phase-change transition and hygroscopic salts are examined. Many of the papers analyze efficiency on a Second Law basis. Applications in solar dynamic power generation for space, water heating, space heating, and food processing are considered [106T–118T].

Solar ponds

Studies aimed at improving thermal and cost effectiveness of solar ponds compare design alternatives primarily through simulation. Saturated ponds, ponds with enhanced ground storage, equilibrium solar ponds and the introduction of a stratified flowing layer near the bottom of the gradient layer are considered [119T–124T].

Power generation/industrial applications

Theoretical investigations of solar thermal conversion systems seek to maximize performance of a closed cycle Brayton gas turbine and an Otto air-standard cycle.

Efforts in photovoltaics continue to seek improvements in conversion efficiency. One proposed concept is a modified JNLD cell with a new superlattice structure.

Studies of industrial applications of solar energy include exploratory experiments of simultaneous production of iron from ore and of syngas from natural gas in a solar furnace, solar pumped lasers, solar driven photocatalytic destruction of organic contaminates in water, production of hydrogen and chlorine from hydrochloric acid solutions and photovoltaics for cathodic protection of steel pipelines [125T–138T].

Cookers and dryers

Use of solar cookers and dryers continues to expand in developing countries. Experimental and theoretical studies of box ovens, grills, and food dryers provide design guidelines for improvements in the ergonomics and heat transfer characteristics of these devices. A solar timber kiln is evaluated for use in Delhi [139T–155T].

PLASMA HEAT TRANSFER AND MAGNETOHYDRODYNAMICS

Plasma heat transfer modeling

Descriptions of non-equilibrium radiative transfer are dominating the plasma heat transfer modeling publications [1U–3U, 8U, 9U, 11U]. Benoy *et al.*

describe in two papers the radiation from non-equilibrium and recombining argon plasmas using a hybrid collisional radiative approach [2U, 3U]. A similar approach has been chosen in [8U] to describe the coupling of the radiative transfer with the flow field in non-equilibrium reacting flows. A more general approach is presented in [11U] where the radiative transfer for non-equilibrium multi-level media is described. Quantum defect theory has been employed to derive a new expression for the continuum spectra in plasmas [8U]. The interaction of high intensity laser radiation with a plasma is given in [1U]. The reduction in the plasma temperature of a free-burning arc due to increased radiation losses after introducing metal vapor is shown in [10U].

Ambipolar diffusion processes in multicomponent two-temperature plasmas are described in [15U]. The same authors present a description of the turbulent mixing of an argon plasma jet flowing into a cold air environment [5U]. A k–ε model is used to describe the turbulence, and a comparison of the simulation results with experimental data, although reasonable, did show some systematic discrepancies. The most likely anode attachment for an arc in a channel with superimposed flow is presented in [14U]. A similar configuration is investigated in [17U], and oscillations are found to propagate with the flow velocity of the gas in the cold boundary layer. A three-dimensional model has been developed for the description of cold gas injection into a plasma flow, and the slowing of the mixing process due to temperature (and viscosity) differences has been demonstrated [12U, 13U]. The effect of different kinds of gas injection at the cathode end of a transferred arc has been shown in [7U], and comparisons with experimental results are also presented. Decaying plasmas are treated in [16U], where the nucleation of droplets from a vapor in an expanding jet is described, and in [6U] where the decay of the electrical conductivity after current zero has been calculated for an argon plasma by means of an energy balance coupled with a rate equation system.

Plasma wall and plasma particle interactions

Several models for arc-electrode interactions have been published [18U, 19U, 21U, 22U, 24U, 26U, 27U, 30U, 31U]. In [19U], the plasma composition in the electrode boundary layer is calculated taking diffusion effects into account, but neglecting space charge effects. The same approach is used in [32U] for predicting the onset of electrode melting. The effect of melting and evaporation of electrode material has also been simulated and experimentally verified in [19U]. A similar approach for modeling the boundary layer is presented in [26U], and in [18U] for the special condition of a stagnation flow hitting the electrode. The results show the possibility of a diffuse and a constricted attachment. The cathode jet of a 1MW arc is modeled with a finite diference scheme and a gray band approach for the radiative transport [24U]. The cathode heat fluxes have been calculated for very high power arc heaters (6000–18000 A, 50–200 atm) in [21U, 22U] in order to obtain electrode design information. Analytical solutions for heat conduction in a semi-infinite solid have been used to predict temperature distributions and onset of melting in the electrode of a spark discharge [31U]. Cathode emission currents have been calculated for thermo-field emission, and the errors due to various approximations are pointed out in [30U].

Heat transfer calculations from an arc to an insulating plane wall are presented in [25U], and the effect of ablation from the wall of a cylindrical channel surrounding the arc are shown in [28U].

The important effect of charged species on the heat transfer from a rarefied plasma to a particle is shown in [23U]. Both particle charging and the Debye screening are found to be important. For a similar environment, the influence of particle charging on the thermophoretic force has been calculated [20U]. The heat transfer inside particles in a plasma jet is presented in [29U].

Plasma properties

Determination of properties for non-equilibrium plasmas has been treated in [34U] and [33U]. In [34U], an approach is presented for calculating the thermodynamic properties of hydrogen in thermal and chemical non-equilibrium expressing the deviation from equilibrium using chemical affinities. In [33U], the fluid mechanics and thermochemistry in a shock wave as encountered during re-entry are described by a traditional continuum approach and by a Monte Carlo method, and both are found to give similar results in the near continuum. A new equation of state for plasmas is presented in [35U] approximating calculated data for nitrogen and SF_6 plasma flows. The net emission coefficient for radiative transport from an arc containing various mixtures of arcing gases with metal vapors has been calculated in [36U].

A new formula for the electrical conductivity for moderately non-ideal plasmas ($n_e = 10^{18}$ to $10^{20}\,\mathrm{cm}^{-3}$) has been derived in [37U], and the result represents a significant improvement over the use of the Spitzer formula under these conditions. The electrical conductivity for a partially ionized hydrogen plasma has been calculated using quantum kinetic equations and considering elastic and inelastic collisions [38U].

Diagnostics

A review of measurement techniques for determining characteristics of arcjets for re-entry material testing is presented in [60U]. In three publications [50U, 51U, 61U], the results of several different diagnostic methods applied to an atmospheric pressure plasma jet are compared. The methods used include enthalpy probe and high spectral resolution laser scattering measurements for plasma temperature and velocity determination in supersonic and subsonic flows [50U, 51U], and a combination of enthalpy probe and gas analyzer for additional species concentration profile measurements [61U] in gas mixtures or when entrainment of gas from a different environment is important. The same system has been used combined with a laser Doppler velocimetry system and a two color pyrometer for plasma and particle characterization in a plasma spray jet [49U]. A stagnation heat flux probe combined with measurements of acoustic, optical and arc voltage fluctuations has been used to characterize the transition from laminar to turbulent in a plasma jet. The temperature distributions in free burning argon and nitrogen arcs derived from emission spectroscopic measurements using the Fowler–Milne method are reported in [52U], and the measurement of the cathode temperature in similar arcs is described in [53U].

Laser induced fluorescence of CH and C_2 radicals has been used to determine the temperature in low power arcjets applied to diamond deposition [59U]. The quench rates of some excited argon levels have been measured with a diode laser based saturated-fluorescence method in an inductively coupled plasma [41U].

Several papers report on Langmuir probe measurements for plasma characterization under differing conditions [43U, 45U, 47U, 55U, 56U, 58U]. The plasma flow velocity has been measured by correlating the fluctuating signals from two probes [56U], and the density of an rf plasma has been derived from a single probe measurement using a novel rf suppression circuit, and compared to a microwave interferometry measurement [58U]. A new approach to evaluating data from a planar Langmuir probe exposed to a plasma flow has taken the influence of convection on the sheath development into account [45U], and a similar probe has been used for plasma characterization with the assumption of a shifted Maxwellian electron energy distribution [55U]. A new numerical treatment of data from a cylindrical probe exposed to a flowing plasma is presented in [43U], and a different approach to the same problem is described in [47U] for atmospheric pressure plasmas.

Transient measurements are used for describing the radiation from a cathode spot (streak photography and time-resolved spectroscopy) in [62U], and the electron density in a laser produced plasma (interferometry) in [44U]. The plasma generated by the interaction of laser pulses with a solid surface are also investigated in [57U], where the shielding of the surface by the plasma is described, in [54U] where time-resolved emission spectroscopy has been used to characterize the plasma, and in [46U] where the mass ablation rates have been used for plasma characterization. The interaction of shock waves in high speed plasma flows with laser irradiation is described in [40U]. The velocity of a plasma jet from a spark plug has been measured using a time of flight analysis and an electron multiplier tube [42U]. The characterization of a plasma in a new type of plasma generator in which the arc heated plasma is flowing through a nozzle into a vacuum chamber but remains confined through the use of a magnetic field is described in [39U], including the population inversion of some excited states.

Specific plasma heat transfer applications

Models of arc welding processes are presented in [68U, 72U, 73U]. In [73U], a three-dimensional finite element analysis is used to describe the flow and temperature fields in the weld pool, whereas in [68U] the influence of space charge effects on welding and cutting performance is discussed in a simplified model, and a model describing gas-metal arc welding of aluminum is described in [72U]. A model for the spark used in electrical discharge machining uses conservation equations and a plasma equation of state to describe the machining process [69U]. A numerical simulation of the splat formation and freezing processes during plasma spraying is based on solving the full Navier–Stokes equations and a two-phase flow continuum model for the growing layer, and this modeling approach is able to predict the effects of substrate temperature and arriving droplet velocity [74U]. In deriving scaling laws for rail guns with plasma armatures, the electrical and thermal characteristics of the armature are described using a one-dimensional quasisteady model with power law fits for the thermodynamic and transport properties [78U].

Two studies have been concerned with the modeling of the diamond growth process from a thermal plasma using chemical kinetics calculation for the boundary layer [66U, 71U]. In [66U], a dc plasma jet has been modeled as the source of the dissociation products, while in [71U] the model of a rf induction plasma is combined with the description of the chemical kinetics in the boundary layer and on the surface. Both calculations show the dependence of the dominant growth species on the atomic hydrogen mole fraction. A parametric study of the factors influencing the diamond deposition process with a rf induction plasma torch is presented in [76U].

A plasma production process of acetylen from coal is described in [65U], and the results of an experiment and a chemical kinetics calculation for the destruction of chlorofluorocarbons in a dc thermal plasma reactor are presented in [77U]. Another plasma process for the destruction of hazardous wastes uses silent (or barrier) discharge generated plasmas for treatment of volatile organic compounds in gas streams, and the removal of trichloroethylene has been demonstrated experimentally and described by a model [70U]. The experimental and theoretical investigation of plasma deoxidation of copper melts has shown the importance of the relative mass transports of oxygen, hydrogen and water vapor and the kinetics of the reaction between hydrogen and oxygen [64U].

Two papers deal with the heat transfer in microelectronics processing reactors [63U, 67U]. In [67U], an energy balance for the wafer is obtained with accurate surface temperature measurements as input, and heating by the plasma and conduction loss to the substrate holder are found to be the important terms. In [63U], the etch chemistry is modeled including the heat balance of the wafer, and experimental verification is obtained through etch rate monitoring using multi-channel interferometry. Investigations on a hypersonic shock tunnel used for re-entry simulation are reported in [60U].

Magnetohydrodynamics

Several investigations have studied specific flow effects under MHD conditions. A numerical solution for the non-similar boundary layer equations of a free convection MHD flow over a wedge is described in [91U], and the effects of secondary flow structures in MHD channels on heat transfer and turbulence are presented in [81U]. The limited value of using a renormalization group method for describing the details of two-dimensional turbulent MHD flows is demonstrated in [87U], while a one-dimensional model assuming uniform properties and treating the seed material with particle balance equations is presented in [86U]. Two particular flow situations are described in [92U] where a similarity solution has been found for the hydrodynamic flow and heat transfer in a fluid covered by a thin film which is spreading axisymmetrically, and in [85U] for the case of a rotating spherical shell.

Performance calculations and specific concepts are presented by several authors. An analysis of the efficiency of two different types of MHD generators is presented [79U], and the effect of channel geometry on power generation performance is calculated with a quasi one-dimensional model [90U]. The effect of current leakage on the performance of coal-fired MHD generators is calculated with a two-dimensional equivalent circuit model for the electrodynamics, and a time-dependent one-dimensional approximation for the gas dynamics [84U]. A liquid metal MHD generator is modeled in [80U] describing the two-phase flow and including velocity slip, and a flow model for a high temperature (> 10 000K) MHD generator using hydrogen is presented assuming local thermal equilibrium, but including energy transport by radiation [89U]. A conceptual design has been developed for a nuclear powered MHD reactor for space applications [88U].

Pollution due to MHD generators using different fuels has been determined in a combustion analysis [80U], and the use of a MHD–steam combined system fired by oxygen and coal has been found attractive because compared to a conventionally fired combined system little performance degradation is encountered in case the CO_2 is recycled [83U].

One experimental investigations showed the effect of working gas temperature on the closed cycle MHD generator performance using argon and helium [82U].

CONDUCTION

Heat transfer due to contact conduction–contact resistance

1A. Xuefeng Tian and F. E. Kennedy, Jr, Contact surface temperature models for finite bodies in dry and boundary lubricated sliding, *J. Tribology* **115**(3), 411 (1993).

2A. S. Song, M. M. Yovanovich and F. O. Goodman, Thermal gap conductance of conforming surfaces in contact, *J. Heat Transfer* **115**(3), 533 (1993).

3A. A. Bejan and Al. M. Morega, Thermal contact resistance between two flat surfaces that squeeze a film of lubricant, *J. Heat Transfer* **115**(3), 763 (1993).

4A. I. Anteby and I. Shai, Modified conduction shape factors for isothermal bodies embedded in a semi-infinite medium, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 233 (1993).

5A. T. H. McWaid and E. Marschall, A comparison of elastic and plastic contact models for the prediction of thermal contact conductance, *Wärme Stoffübertrag.* **28**(8), 441 (1993).

6A. L. J. Salerno, P. Kittel and A. L. Spivak, Thermal conductance of augmented pressed metallic contacts at liquid helium temperatures, *Cryogenics* **33**(12), 1104 (1993).

7A. C. Stark and J. Fricke, Improved heat-transfer models for fibrous insulations, *Int. J. Heat Mass Transfer* **36**(3), 617 (1993).

8A. Mythily Krishnan and D. Ganpath Ram Sharma, Effect of alloy properties on the heat flow across the casting–mold interface, *Scripta Metall.* **28**(4), 447 (1993).

Layered and composite or anisotropic media

9A. C. J. Hooke, K. Mao, D. Walton, A. R. Breeds and S. N. Kukureka, Measurement and prediction of the surface temperature in polymer gears and its relationship to gear wear, *J. Tribology* **115**(1), 119 (1993).

10A. R. G. Jenkins, H. Jones, I. Belenli, M. Yang, M. J. Goringe and C. R. M. Grovenor, Orientation and thermal cycling effects on the critical currents of high Tc superconducting composites, *Cryogenics* **33**(1), 81 (1993).

11A. T. Q. Qiu and C. L. Tien, Heat transfer mechanisms during short-pulse laser heating of metals, *J. Heat Transfer Trans. ASME* **115**(4), 835 (1993).

12A. T. Q. Qiu and C. L. Tien, Size effects on non-equilibrium laser heating of metal films, *J. Heat Transfer Trans. ASME* **115**(4), 842 (1993).

13A. C. K. Chao and R. C. Chang, Steady-state heat conduction problem of the interface crack between dissimilar anisotropic media, *Int. J. Heat Mass Transfer* **36**(8), 2021 (1993).

14A. Ph. Leturcq, J. M. Dorkel, F. E. Ratolojanahary and S. Tounsi, A two-port network formalism for 3D heat conduction analysis in multilayered media, *Int. J. Heat Mass Transfer* **36**(9), 2317 (1993).

15A. J. L. Auriault and P. Royer, Double conductivity media : a comparison between phenomenological and homogenization approaches, *Int. J. Heat Mass Transfer* **36**(10), 2613 (1993).

16A. M. Bouzidi and P. Duhamel, Thermal diffusion in cyclic laminated composites : spectral properties and application to the homogenization, *Int. J. Heat Mass Transfer* **36**(11), 2715 (1993).

17A. C. K. Chao and L. Y. Kuo, Thermal problem of curvilinear cracks in bonded dissimilar materials with a point heat source, *Int. J. Heat Mass Transfer* **36**(17), 4085 (1993).

18A. A. Sengupta, M. S. Sodha, M. P. Verma and R. L. Sawhney, Periodic heat transfer through inhomogeneous media—II. Hollow cylinder, *Int. J. Energy Res.* **17**(4), 243 (1993).

19A. A. Sengupta, M. S. Sodha, M. P. Verma and R. L. Sawhney, Periodic heat transfer through inhomogeneous media—III. Hollow sphere, *Int. J. Energy Res.* **17**(4), 265 (1993).

20A. Toshiyuki Amano, Thermal performance of mul-

tilayer insulation, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(563), 42 (1993).
21A. V. A. Kudinov, A. A. Kudinov, B. V. Vorob'yev and A. Yu. Denisov, A method for reducing heat-transfer problems from multilayer to unilayer constructions, *Izvestiya AN SSSR Energetika Transport* (3), 135 (1993).
22A. A. A. Shubin, V. N. Prokushin, V. V. Klejmenov and G. M. Majorova, Low density carbon composite materials for high temperature thermal insulation, *Khimicheskie Volokna* (6), 48 (1993).

Thermal waves and shocks; laser/pulse heating and propagation
23A. L. Malinowski, A relaxation model for heat conduction and generation, *J. Phys. D* **26**(7), 1176 (1993).
24A. W. Schulz, D. Becker, J. Franke, R. Kemmerling and G. Herziger, Heat conduction losses in laser cutting of metals, *J. Phys. D* **26**(9), 1357 (1993).
25A. D. Y. Tzou and J. Li, Thermal waves emanating from a fast-moving heat source with a finite dimension, *J. Heat Transfer* **115**(3), 526 (1993).
26A. K. D. Cole and W. A. McGahan, Theory of multilayers heated by laser absorption, *J. Heat Transfer* **115**(3), 767 (1993).
27A. Yong-Feng Lu, Laser-induced temperature distribution in substrates with periodic multilayer structures, *J. Appl. Phys.* **74**(9), 5761 (1993).
28A. Y.-N. Liu and E. Kannatey-Asibu, Jr, Laser beam welding with simultaneous Gaussian laser preheating, *J. Heat Transfer Trans. ASME* **115**(1), 34 (1993).
29A. D. Y. Tzou, An engineering assessment to the relaxation time in thermal wave propagation, *Int. J. Heat Mass Transfer* **36**(7), 1845 (1993).
30A. H.-T. Chen and J.-Y. Lin, Numerical analysis for hyperbolic heat conduction, *Int. J. Heat Mass Transfer* **36**(11), 2891 (1993).
31A. J. Golebiowski and A. J. Jordan, Transmittances and frequency characteristics of wave and diffusion heat transfer in the flat slab, *Int. J. Heat Mass Transfer* **36**(12), 3099 (1993).
32A. P. Ehrhard, C. Hölle and C. Karcher, Temperature and penetration depth prediction for a three-dimensional field below a moving heat source, *Int. J. Heat Mass Transfer* **36**(16), 3997 (1993).
33A. L. J. Shaw-Klein, S. J. Burns and S. D. Jacobs, Model for laser damage dependence on thin-film morphology, *Appl. Opt.* **32**(21), 3925 (1993).
34A. G. P. Ledneva, Laser heating of cylindrical carbon particles, *High Temp.* **30**(6), 977 (1993).
35A. F. Osterstock, Contact damage submitted to thermal shock: a method to evaluate and simulate thermal shock resistance of brittle materials, *Mater. Sci. Engng A Struct. Mater. Prop. Microstruct. Process. A* **168**(1), 41 (1993).
36A. Tie Gao, T. Nishikawa, M. Hibi and M. Takatsu, Temperature dependence of so-called heat transfer coefficient under thermal shock, *J. Ceram. Soc. Jpn* **101**(1175), 788 (1993).
37A. Gao Tie, T. Nishikawa, N. Harada and M. Takatsu, Effect of temperature dependence of material properties on the critical quenching temperature difference under thermal shock test of ceramics, *J. Ceram. Soc. Jpn* **101**(1177), 1021 (1993).
38A. K. Etori, Temperature correlation in hyperbolic heat conduction with random heat-generation source, *Jpn J. Appl. Phys.* **32**(55), 2175 (1993).
39A. E. Oesterschulze, M. Stopka, M. Tochtrop-Mayr, K. Masseli and R. Kassing, Nondestructive evaluation of solids and deposited films by thermal-wave interferometry, *Appl. Surf. Sci.* **69**(14), 65 (1993).

Thermal heat transfer in panels, rods and solids
40A. K. A. Antonopoulos and F. Democritou, Periodic steady-state heat transfer in cooling panels, *Int. J. Heat Fluid Flow* **14**(1), 94 (1993).
41A. W. Y. D. Yuen, Temperature fields in sliding solids with internal heat sources, *Int. J. Heat Mass Transfer* **36**(15), 3711 (1993).
42A. V. A. Kurganov, Effect of longitudinal heat conduction on heat transfer in rod flow, *High Temp.* **30**(4), 605 (1993).

Mathematical models, analysis and numerical simulations
43A. N. Postacioglu, P. Kapadia and J. Dowden, A mathematical model of heat conduction in as prolate spherical coordinate system with applications to the theory of welding, *J. Phys. D* **26**(4), 563 (1993).
44A. G. Simon, U. Gratzke and J. Kroos, Analysis of heat conduction in deep penetration welding with a time-modulated laser beam, *J. Phys. D* **26**(5), 862 (1993).
45A. Tungyang Chen, Interfacial discontinuities in thermal conductions, *Int. J. Engng Sci.* **31**(3), 425 (1993).
46A. C. K. Hsieh, Unification of source-and-sink method and boundary element method for the solution of potential problems, *J. Heat Transfer* **115**(3), 775 (1993).
47A. Mohammad H. N. Naraghi and Shun-Chang Tsai, A boundary-dispatch Monte Carlo (Exodus) method for analysis of conductive heat transfer problems, *Numer. Heat Transfer Part B Fundam.* **24**(4), 475 (1993).
48A. Albert L. Nichols, III and Kenneth W. Westerberg, Modification of a thermal transport code to include chemistry with thermally controlled kinetics, *Numer. Heat Transfer Part B Fundam.* **24**(4), 489 (1993).
49A. S. M. Zubair and M. A. Chaudhry, Heat conduction in a semi-infinite solid subject to time-dependent surface heat fluxes: an analytical study, *Wärme Stoffübertrag.* **28**(6), 357 (1993).
50A. S. M. Zubair and M. A. Chaudhry, Heat conduction in a semi-infinite solid when subjected to spatially decaying instantaneous laser source, *Wärme Stoffübertrag.* **28**(7), 425 (1993).
51A. H. Sofrata and B. Salmeen, Optimization of insulation thickness using micros, *Energy Convers. Manage.* **34**(6), 471 (1993).
52A. K. A. Antonopoulos and F. Democritou, Correlations for the maximum transient non-periodic indoor heat flow through 15 typical walls, *Energy* **18**(7), 705 (1993).
53A. F. A. Mohamed, The energy-integral method: application to linear hyperbolic heat-conduction problems, *Appl. Sci. Res.* **50**(2), 107 (1993).
54A. J. V. Beck, A. M. Osman and G. Lu, Maximum temperatures in diamond heat spreaders using the surface element method, *J. Heat Transfer Trans. ASME* **115**(1), 51 (1993).
55A. G. S. Dulikravich, B. Kosovic and S. Lee, Magnetized fiber orientation control in solidifying composites: numerical simulation, *J. Heat Transfer Trans. ASME* **115**(1), 255 (1993).
56A. M. F. Zedan and A. M. Mujahid, Laplace transform solution for heat transfer in composite walls with periodic boundary conditions, *J. Heat Transfer Trans. ASME* **115**(1), 263 (1993).
57A. P. Ulysse and M. M. Khonsari, Thermal response of rolling components under mixed boundary conditions: an analytical approach, *J. Heat Transfer Trans. ASME* **115**(4), 857 (1993).
58A. Y. Maday and A. T. Patera, A general estimate for the thermal time-to-steady-state for a solid body suddenly immersed in a fluid stream, *Int. J. Heat Mass Transfer* **36**(4), 941 (1993).
59A. B. D. Shaw, Asymptotic analysis of the lumped-capacitance approximation, *Int. J. Heat Mass Transfer* **36**(4), 999 (1993).
60A. M. A. Chaudhry and S. M. Zubair, Analytic study of temperature solutions due to gamma-type moving

point-heat sources, *Int. J. Heat Mass Transfer* **36**(6), 1633 (1993).

61A. S. Hou, A. C. Cogley and A. Sharma, A discrete element method for composite media: one-dimensional heat conduction, *Int. J. Heat Mass Transfer* **36**(12), 3009 (1993).

62A. F. F. Polivoda, Heat conductivity analysis of anisotropic thermal insulation of heat lines and solar collectors, *Therm. Engng* **40**(6), 483 (1993).

63A. I. Dincer, An exact heat transfer analysis of spherical products subjected to forced-air cooling, *Int. J. Energy Res.* **17**(1), 9 (1993).

64A. R. B. Cresdee, W. J. Edwards, P. J. Thomas and G. F. Voss, Analysis of beam distortion during hot dip galvanizing, *Mater. Sci. Technol.* **9**(2), 161 (1993).

65A. L. G. Stepanskij and T. A. Simunina, A temperature calculation for metal surface during hot pressure of steel and titanium profiles, *Kuznechno-Shtampovochnoe Proizvodstvo* (3), 3 (1993).

66A. Y. Li, B. V. Holcombe, A. M. Schneider and F. Apcar, Mathematical modelling of the coolness to touch of hygroscopic fabrics, *J. Text. Inst.* **84**(2), 267 (1993).

67A. M. Furuyama, A. Hijikata, K. Mitani and K. Fukuta, Temperature and degree of cure in orthogonal triaxial carbon fiber reinforced three-dimensional composites during cure, *J. Text. Inst.* **46**(1), 95 (1993).

68A. A. Joly, J. P. Joly, E. Karmazsin and J. L. Veau, Heat transfer modeling in a polymer sample located in a microwave field—I. Steady state, *J. Therm. Anal.* **39**(10), 1285 (1993).

69A. Y. Satoh, Influence of temperature dependence of the dynamic absorber elements on the vibration reduction characteristics, *Nippon Kikai Gakkai Ronbunshu C Hen* **59**(566), 2968 (1993).

70A. M. Hendrick, C. Silva, F. Oliveira and P. Tobback, Generalized (semi)-empirical formulae for optimal sterilization temperatures of conduction-heated foods with infinite surface heat transfer coefficients, *J. Food Engng* **19**(2), 141 (1993).

71A. C. De Elvira, Use of alternating direction implicit methods to model diffusion phenomena in elliptic products, *J. Food Engng* **19**(2), 159 (1993).

72A. A. Montanaro, On heat flux in simple media, *J. Elast.* **30**(1), 81 (1993).

73A. H. Eda, E. Ohmura, S. Yamauchi and I. Inasaki, Computer visual simulation on structural changes of steel in grinding process and experimental verification, *Ann. CIRP.* **42**(1), 389 (1993).

74A. P. P. Camus, D. J. Larson and T. F. Kelly, Simulation of rapid thermal pulsing for field evaporation, *Appl. Surf. Sci.* **67**(14), 467 (1993).

75A. R. M. Cotta and M. D. Mikhailov, Integral transform method, *Appl. Math. Model.* **17**(3), 156 (1993).

76A. A. G. Madra, Modeling of stochastic heat transfer in a solid, *Appl. Math. Model.* **17**(12), 664 (1993).

77A. F. El Moussali and J. J. Vullierme, Transferts electriques et thermiques couples dans un materiau composite carbone-verre epoxy. Application a la realisation d'un degivreur de pale d'helicoptere transferts electriques et thermiques couples dans un materiau, *Rech. Aerosp.* (2), 57 (1993).

78A. Qi Zhang, Jialong Xu, Zuqing Sun and Zhongdong Yu, Computer simulation of strip casting heat transfer in twin-roll machine, *Kang T'ieh* **27**(12), 24 (1993).

79A. Yu. A. Surinov and V. V. Rubtsov, Nonstationary radiant–conductive heat transfer in the system of two coaxial cylinders of various length separated by diathermal medium, *Izvestiya VUZ Aviatsionnaya Tekhnika* (1), 58 (1993).

80A. P. Petrov, Numerical modelling of temperature distributions during electron beam welding, *Int. J. Joining Mater.* **4**(4), 110 (1993).

81A. E. Lorenzini, M. Spiga and M. Trentin, Temperature distribution in a divertor of a fusion reactor, *Heat Technol.* **10**(34), 33 (1993).

82A. R. M. Cotta, A. J. K. Leiroz and J. B. Aparecido, Steady-state diffusion problems with variable equation coefficients, *Heat Technol.* **10**(34), 104 (1993).

83A. Ahmed K. Noor and W. Scott Burton, Computational models for high-temperature multilayered composite plates and shells, *Appl. Mech. Rev.* **45**(10), 419 (1993).

84A. Y. Sugano and Y. Chuuman, Analytical solution of transient hygrothermoelastic problem due to coupled heat and moisture diffusion in a hollow circular cylinder, *Nippon Kikai Gakkai Ronbunshu A Hen* **59**(564), 1956 (1993).

85A. Narendra S. Goel, Satyendra P. Rana and D. V. Sreenath, Heat conduction in heterogeneous materials and irregular boundaries—II. A simple and fast algorithm for massively parallel computer, *Int. Commun. Heat Mass Transfer* **20**(6), 803 (1993).

86A. Shao Wang, C. Cusano and T. F. Conry, Dynamic model of the torque and heat generation rate in tapered roller bearings under excessive sliding conditions, *Tribol. Trans.* **36**(4), 513 (1993).

87A. Gregory A. Kriegsmann, Microwave heating of dispersive media, *SIAM J. Appl. Math.* **53**(3), 655 (1993).

88A. Hyek H. Choi and Thomas A. DeMassa, Closed-form model for electrostatic discharge thermal runaway in semiconductor devices, *Solid State Electron.* **36**(11), 1511 (1993).

89A. K. Harste, N. Bannenberg, B. Bergmann and K.-H. Spitzer, Optimization and monitoring of process control in the continuous casting of steel, *Stahl Eisen* **113**(7), 51 (1993).

90A. Guiping Lin and Xiugan Yuan, Dynamic simulation of a solar-powered solid absorption ice maker—I. Model of reaction fronts, *Taiyangneng Xuebao* **14**(2), 105 (1993).

91A. Guiping Lin and Xiugan Yuan, Dynamic simulation of a solar-powered solid absorption ice maker—II. The finite difference method *Taiyangneng Xuebao* **14**(2), 112 (1993).

92A. M. A. El-Osairy, I. A. El-Osairy, A. M. Metwally and M. A. Hassan, Two-dimensional dynamic analysis of metal hydride hydrogen energy storage conduction bed models, *Int. J. Hydrogen Energy* **18**(6), 517 (1993).

93A. P. Sangsurasak, D. A. Mitchell and M. Hossain, Transient two-dimensional heat conduction by orthogonal collocation technique, *Int. Commun. Heat Mass Transfer* **20**(4), 557 (1993).

94A. B. S. Vilbas, Analytical solution for the heat conduction mechanism appropriate to the laser heating process, *Int. Commun. Heat Mass Transfer* **20**(4), 545 (1993).

95A. Y. Chen, M. A. Delichatsios and V. Motevalli, Material pyrolysis properties—I. An integral model for one-dimensional transient pyrolysis of charring and non-charring materials, *Combust. Sci. Technol.* **88**(56), 309 (1993).

Thermo-mechanical applications

96A. A. A. Yevtushenko and O. M. Ukhanska, Plane contact problem of thermoelasticity with quasi-steady frictional heating, *Int. J. Engng Sci.* **31**(11), 1565 (1993).

97A. T. Y. Chen and Frederick D. Ju, High-speed frictional heating of an elastic medium with a near-surface horizontal line crack, *J. Tribology* **115**(1), 56 (1993).

98A. W. Li, M. A. Ebadian, T. L. White and R. G. Grubb, Heat transfer within a concrete slab applying the microwave decontamination process, *J. Heat Transfer Trans. ASME* **115**(1), 42 (1993).

99A. D. Y. Tzou, Reflection and refraction of thermal waves from a surface or an interface between dissimilar materials, *Int. J. Heat Mass Transfer* **36**(2), 401 (1993).

100A. Richard B. Hetnarski, Generalized thermoelasticity: closed-form solutions, *J. Therm. Stresses* **16**(4), 473 (1993).

101A. D. S. Chandrasekharaiah and H. Narasimha Murthy, Thermoelastic interactions in an unbounded body with a spherical cavity, *J. Therm. Stresses* **16**(1), 55 (1993).

102A. Ronggang Zhang and J. R. Barber, Transient thermoelastic contact and stability of two thin-walled cylinders, *J. Therm. Stresses* **16**(1), 31 (1993).

103A. Y. Kurosaki, I. Satoh and H. Kim, Effects of thermal molding conditions on the residual stress and residual birefringence in an injection-molded polymer strip, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(566), 3236 (1993).

104A. Chung-Kuo Chi, Hsueh Kung and Cheng Hsueh Pao, Effects of nonlinear thermoelastic coupling term upon plane problems, *J. Chin. Soc. Mech. Engng* **14**(2), 171 (1993).

105A. S. Itou and Q. Rengen, Thermal stresses around two parallel cracks in two bonded dissimilar elastic half-planes, *Arch. Appl. Mech.* **63**(6), 377 (1993).

106A. K. T. Andrews, P. Shi, M. Shillor and S. Wright, Thermoelastic contact with Barber's heat exchange condition, *Appl. Math. Optim.* **28**(1), 11 (1993).

107A. G. N. Tret'yachenko and V. G. Barilo, Thermal and stressed state of multilayer coatings, *Problemy Prochnosti* (1), 41 (1993).

108A. M. I. Letavin and N. I. Shestakov, Solution of thermo-elasticity equations in the cross-section of rotating cylinder by the method of singular perturbation, *Prikladnaya Matematika Mekhanika* **57**(2), 124 (1993).

109A. N. I. Shestakov, M. I. Letavin and V. P. Egorov, Thermoelastic stresses in continuous-casting machine rolls, *Pribory Sistemy Upravleniya* (1), 74 (1993).

110A. D. K. Das, B. R. Koci and J. J. Kelley, Development of a thermal mechanical drill for sampling ice and rock from great depths, *Tunnelling Underground Space Technol.* **7**(4), 372 (1993).

111A. A. I. Shutov, N. V. Lalykin and A. V. Ovchinnikov, Modification of toughening stresses curve in sheet glass, *Steklo Keramika* (1112), 22 (1993).

112A. Youhua Ju, Heating process of steel and face crack of blank, *Kang T'ieh* **27**(12), 60 (1993).

113A. G. Funk, J. R. Boehmer, F. N. Fett and R. Hentrich, Coupled thermal and stress–strain models for the continuous casting of steels, *Steel Res.* **64**(5), 246 (1993).

114A. R. Singh and T. S. Ramamurthy, Thermomechanical generalization of pin joints in finite plates, *Comput Struct.* **47**(1), 73 (1993).

Inverse models and heat transfer studies

115A. O. Bogatin, I. Chersky and N. Starostin, Simulation and identification of nonstationary heat transfer in a nonuniform friction contact, *J. Tribology* **115**(2), 299 (1993).

116A. H. J. Reinhardt, Analysis of sequential methods of solving the inverse heat conduction problem, *Numer. Heat Transfer Part B Fundam.* **24**(4), 455 (1993).

117A. C.-T. Liauh, R. G. Hills and R. B. Roemer, Comparison of the adjoint and influence coefficient methods for solving the inverse hyperthermia problem, *J. Biomech. Engng Trans. ASME* **115**(1), 63 (1993).

118A. A. J. Silva Neto and M. N. Özisik, Inverse problem of simultaneously estimating the timewise-varying strengths of two plane heat sources, *J. Appl. Phys.* **73**(5), 2132 (1993).

119A. C.-T. Liauh and R. B. Roemer, Multiple minima in inverse hyperthermia temperature estimation problems, *J. Biomech. Engng Trans. ASME* **115**(3), 239 (1993).

120A. S. T. Clegg and R. B. Roemer, Reconstruction of experimental hyperthermia temperature distributions: application of state and parameter estimation, *J. Biomech. Engng Trans. ASME* **115**(4), 380 (1993).

121A. A. Haji-Sheikh and F. P. Buckingham, Multidimensional inverse heat conduction using the Monte Carlo method, *J. Heat Transfer Trans. ASME* **115**(1), 26 (1993).

122A. J.-S. Le Brizaut, D. Delaunay, B. Garnier and Y. Jarny, Implementation of an inverse method for identification of reticulation kinetics from temperature measurements on a thick sample, *Int. J. Heat Mass Transfer* **36**(16), 4039 (1993).

Miscellaneous conduction studies

123A. J. Vogel, L. Sára and L. Krejcí, A simple inverse heat conduction method with optimization, *Int. J. Heat Mass Transfer* **36**(17), 4215 (1993).

124A. H. Hoff and P. Jung, Experimental observation of asymmetrical heat conduction, *Physica A* **199**(34), 502 (1993).

125A. W. M. Lee and Han S. Uhm, Effect of temperature gradient on concentration profile of hydrogen in a palladium lattice, *J. Appl. Phys.* **73**(3), 1011 (1993).

126A. H. R. Shober, Soft phonons in glasses, *Phys. A* **201**(13), 14 (1993).

127A. I. Pócsik, Do phonons exist in non-crystalline matter? *Phys. A* **201**(13), 34 (1993).

128A. R. A. Doyle and V. V. Gridin, Effect of superimposed electrical and thermal gradients in bismuth-based high temperature superconductors, *Cryogenics* **33**(5), 492 (1993).

129A. L. Duband, L. Hui and A. Lange, Thermal isolation of large loads at low temperature using Kevlar rope, *Cryogenics* **33**(6), 643 (1993).

130A. B. Chanda and T. K. Dey, Heat conduction in vanadium substituted $(\mathrm{Bi}_{0.8}\mathrm{Pb}_{0.2-y}\mathrm{V}_y)_2\mathrm{Sr}_2\mathrm{Ca}_2\mathrm{Cu}_3\mathrm{O}_x$ sintered pellets between 10 and 150 K, *Cryogenics* **33**(10), 980 (1993).

131A. A. Keiller and F. Feuillebois, Heat conduction through an inhomogeneous suspension, *Proc. R. Soc. A* **440**(1910), 717 (1993).

132A. A. V. Hassani, K. G. T. Hollands and G. D. Raithby, A close upper bound for the conduction shape factor of a uniform thickness, 2D layer, *Int. J. Heat Mass Transfer* **36**(12), 3155 (1993).

133A. V. Kumar and A. K. Gupta, Design and performance of a simple substrate heater for in-situ deposition of high-Tc superconducting thin films, *Meas. Sci. Technol.* **4**(7), 790 (1993).

134A. V. Groger and M. Zehetbauer, Onset mechanisms of discontinuous flow at low temperatures in one- and two-phase Cu–Be alloys, *Mater. Sci. Engng. A Struct. Mater. Prop. Microstruct. Process. A* **164**(12), 240 (1993).

135A. A. Kramer-Flecken, A. Rogister and M. Z. Tokar, Asymmetry of radial heat pulse propagation at TEXTOR, *Nucl. Fusion* **33**(6), 921 (1993).

136A. R. M. McMarlin and R. W. Gerrish, Can your 'non-combustible' insulation burn? *Hydrocarbon Process.* **71**(11), (1993).

137A. A. Greve, M. Dan and J. Penalver, Thermal behavior of millimeter wavelength radio telescopes, *IEEE Trans. Antennas Propag.* **40**(11), 1375 (1993).

138A. V. N. Zhivoderov and V. S. Sulimov, Experience with grout injection in laying concrete on the Sayano–

Shushinsk Dam, *Gidrotekhnicheskoe Stroitel'stvo* (1), 40 (1993).

139A. Von Sieghfried Haziak, K. Starke, G. Glaser and J. Caspar, District heat supply in the new Federal States—Development and ways for refurbishment, *Fernwaerme Int.* **21**(12) (1993).

140A. H. W. Gudenau, Tianjun Yang, T. Gemershausen, H. Rosenbaum and Keng Wu, Heat transfer in an iron bath of a two-stage smelting reduction process, *Steel Res.* **64**(89), 372 (1993).

141A. A. S. Kotov, A heat-conducting unit for insulation of power semiconductor devices from coolants, *Elektrotekhnika* (4), 30 (1993).

142A. S. B. Basri and D. T. Gethin, An experimental investigatio into the thermal behavior of a three lobe profile bore bearing, *J. Tribology* **115**(1), 152 (1993).

Special applications

143A. W. Dmochowski, K. Brockwell, S. DeCamillo and A. Mikula, A study of the thermal characteristics of the leading edge groove and conventional tilting pad journal bearings, *J. Tribology* **115**(2), 219 (1993).

144A. S. S. Hsiau and M. L. Hunt, Kinetic theory analysis of flow-induced particle diffusion and thermal conduction in granular material flows, *J. Heat Transfer* **115**(3), 541 (1993).

145A. K. E. Wurster and H. W. Stone, Aerodynamic heating environment definition/thermal protection system selection for the HL-20, *J. Spacecr. Rockets* **30**(5), 549 (1993).

146A. K. E. Goodson and M. I. Flik, Electron and phonon thermal conduction in epitaxial high-Tc superconducting films, *J. Heat Transfer Trans. ASME* **115**(1), 17 (1993).

147A. I. Dincer and E. Akaryildiz, Transient temperature distributions within spherical products with internal heat generation and transpiration: experimental and analytical results, *Int. J. Heat Mass Transfer* **36**(7), 1998 (1993).

148A. I. Dincer, A simple solution for transient heat transfer during heating of a slab product—I. Dincer, *Int. J. Energy Res.* **17**(5), 341 (1993).

149A. Yu. A. Zeigarnik, F. P. Ivanov, S. V. Lyubarskii, N. N. Silina, V. V. Skripnikov and V. V. Tikhomirov, Temperature distributions inside a mirror and thermal deformations of the reflecting surface, *High Temp.* **31**(2), 369 (1993).

150A. J. Hamel, Warming of a frozen paper roll, *J. Pulp Pap. Sci.* **19**(3), 101 (1993).

151A. P. H. Leo, T. W. Shield and O. P. Bruno, Transient heat transfer effects on the pseudoelastic behavior of shape-memory wires, *Acta Metall. Mater.* **41**(8), 2477 (1993).

152A. Bekele Olika and Bo Bjorkman, Prediction of steel temperature in ladle through time–temperature simulation, *Scand. J. Metall.* **22**(4), 213 (1993).

153A. A. Warczok and T. Arnfinn Utigard, Determination of the heat transfer coefficient between liquid fayalite slags and solid metal, *Scand. J. Metall.* **22**(2), 68 (1993).

154A. O. V. Gotina, E. I. Ryabova, E. M. Folomeeva and A. P. Smirnov, Mathematical model of steel ingot generation in VAR, *Stal* (5), 33 (1993).

155A. A. L. Berin, A. P. Pukhov, M. A. Tsejtlin and I. Sh. Tuktamyshev, Effect of blast furnace charging conditions on heat transfer and reduction pattern, *Stal* (5), 12 (1993).

156A. M. M. El-Kassaby and A. E. Ahmed, Modeling of a heat exchanger utilizing a phase-change material for short-term storage, *Renewable Energy* **3**(8), 857 (1993).

157A. S. Thiem, W. Loser and M. Jurisch, Solidification modelling of microstructure in twin-roller thin strip casting of stainless steel, *Steel Res.* **64**(6), 307 (1993).

Microelectronic heat transfer

158A. M. A. Jog, I. M. Cohen and P. S. Ayyaswamy, Analysis and simulation of thermal transients and resultant stresses and strains in TAB packaging, *J. Electron. Packag.* **115**(1), 34 (1993).

159A. V. W. Antonetti, T. D. Whittle and R. E. Simons, An approximate thermal contact conductance correlation, *J. Electron. Packag.* **115**(1), 131 (1993).

160A. Ling Yan, A. Haji-Sheikh and J. V. Beck, Thermal characteristics of two-layered bodies with embedded thin-film heat source, *J. Electron. Packag.* **115**(3), 276 (1993).

161A. S. H. Bhavnani, C.-P. Tsai, R. C. Jaeger and D. L. Eison, An integral heat sink for cooling microelectronic components, *J. Electron. Packag.* **115**(3), 284 (1993).

162A. S. K. Rastogi and D. Poulikakos, Modeling of heat transfer in the surface mounting of electronic components, *J. Electron. Packag.* **115**(4), 373 (1993).

163A. S. Bhagath and M. G. Pecht, Modeling the effects of mixed flowing gas (MFG) corrosion and stress relaxation on contact interface resistance, *J. Electron. Packag.* **115**(4), 404 (1993).

164A. A. Mertol, Optimization of extruded type external heat sink for multichip module, *J. Electron. Packag.* **115**(4), 440 (1993).

165A. A. Majumdar, Microscale heat conduction in dielectric thin films, *J. Heat Transfer Trans. ASME* **115**(1), 7 (1993).

Thermal conductivity issues

166A. J. Fukai, H. Orita, T. Nejime, K. Saruwatari and O. Miyatake, Effective thermal conductivity of isotropic formed green carbon during carbonization process, *Heat Transfer Jpn Res.* **22**(5), 435 (1993).

167A. D. Veyret, S. Cioulachtjian, L. Tadrist and J. Pantaloni, Effective thermal conductivity of a composite material: a numerical approach, *J. Heat Transfer Trans. ASME* **115**(4), 866 (1993).

168A. D. Y. Tzou and J. Li, The overall thermal conductivity in a straining body with microcrack evolution, *Int. J. Heat Mass Transfer* **36**(16), 3887 (1993).

169A. Bao Ke-Da, Lu Hui and G. Grimvall, Transverse conductivity in non-ideal fiber composite geometries, *Int. J. Heat Mass Transfer* **36**(16), 4033 (1993).

170A. T. Gambaryan, E. Ya. Litovsky and M. Shapiro, Influence of segregation–diffusion processes on the effective thermal conductivity of porous ceramics, *Int. J. Heat Mass Transfer* **36**(17), 4123 (1993).

171A. D. P. H. Hasselman, K. Y. Donaldson and J. R. Thomas, Jr, Effective thermal conductivity of uniaxial composite with cylindrically orthotropic carbon fibers and interfacial thermal barrier, *J. Compos. Mater.* **27**(6), 637 (1993).

172A. P. G. Klemens, Theory of thermal conduction in low density materials, *J. Non Cryst. Solids* **145**(13), 191 (1993).

173A. N. Onur and M. Sivrioglu, Transient heat conduction with uniform heat generation in a slab subjected to convection and radiation cooling, *Wärme Stoffübertrag.* **28**(6), 345 (1993).

Conduction–convection and flow

174A. W.-S. Yu and H.-T. Lin, Conjugate problems of conduction and free convection on vertical and horizontal flat plates, *Int. J. Heat Mass Transfer* **36**(5), 1303 (1993).

175A. H. Kazeminejad, M. A. Yaghoubi and F. Bahri, Conjugate forced convection–conduction analysis of the performance of a cooling and dehumidifying vertical rectangular fin, *Int. J. Heat Mass Transfer* **36**(14), 3625 (1993).

176A. O. M. Alifanov and I. V. Repin, Investigation of heat exchange in heterogeneous flows by the method of inverse problems of heat conduction, *Teplofizika Vysokikh Temperatur* **31**(1), 78 (1993).

BOUNDARY LAYERS AND EXTERNAL FLOWS

External effects

1B. H. J. H. Brouwers, The effect of blowing or suction on laminar free convective heat transfer on flat horizontal plates, *Wärme Stoffübertrag.* **28**(6), 341 (1993).

2B. G. S. Dulikravich, V. Ahuja and Seungsoo Lee, Simulation of electrohydrodynamic enhancement of a laminar flow heat transfer, *J. Enhanced Heat Transfer* **1**(1), 115 (1993).

3B. R. S. R. Gorla, Combined forced and free convection in an axisymmetric stagnation flow on a vertical nonisothermal cylinder, *Wärme Stoffübertrag.* **28**(3), 153 (1993).

4B. M. Hori, J. Yata and T. Minamiyama, Effects of a free stream turbulence on a turbulent boundary layer on a flat plate with zero pressure gradient—II. Contribution of turbulent length scales, *Heat Transfer Jpn Res.* **22**(1), 1 (1993).

5B. J. C. Misra, S. C. Samanta and A. K. Chakrabarti, Magnetic–mechanical interaction in a aeolotropic cylindrical shell at an elevated temperature, *Computers Struct.* **46**(5), 851 (1993).

Geometric effects

6B. N. Afzal, Heat transfer from a stretching surface, *Int. J. Heat Mass Transfer* **36**(4), 1128 (1993).

7B. N. Afzal, A. Badaruddin and A. A. Elgarvi, Momentum and heat transport on a continuous flat surface moving in a parallel stream, *Int. J. Heat Mass Transfer* **36**(13), 3399 (1993).

8B. S. E. Aly, Study of a zero-pressure gradient boundary layer blown at low injection ratios, *Energy Convers. Manage.* **34**(7), 587 (1993).

9B. A. Aziz and H. Nguyen, Two-dimensional performance of convecting-radiating fins of different profile shapes, *Wärme Stoffübertrag.* **28**(8), 481 (1993).

10B. S. M. Bazydola and M. E. Taslim, An experimental investigation of a staggered array of heatsinks in the hydrodynamic and thermal entrance regions of a duct, *J. Electron. Packag.* **115**(1), 106 (1993).

11B. Th. Bes and W. Roetzel, Fluid temperature distribution in cross-flow tube bundles, *Wärme Stoffübertrag.* **28**(8), 457 (1993).

12B. U. Brockmeier, Th. Guentermann and M. Fiebig, Performance evaluation of a vortex generator heat transfer surface and comparison with different high performance surfaces, *Int. J. Heat Mass Transfer* **36**(10), 2575 (1993).

13B. W. Chakroun and R. P. Taylor, The effects of moderately strong acceleration on heat transfer in the turbulent rough-wall boundary layer, *J. Heat Transfer* **115**(3), 782 (1993).

14B. L. W. Fite, W. D. Bruce and W. S. Janna, Mass transfer from a sublimating r-dichlorobenzene or naphthalene cylinder to a crossflow of air, *Appl. Energy* **46**(2), 161 (1993).

15B. S. V. Garimella and D. J. Schlitz, Reducing inter-chip temperature differences in computers using vortex generators in forced convection, *J. Electron. Packag.* **115**(4), 410 (1993).

16B. A. Hamdouni and J. P. Bonnet, Effect of external manipulators on the heat transfer on a flat plate turbulent boundary layer, *Appl. Sci. Res.* **50**(34), 369 (1993).

17B. M. H. Hosni, H. W. Coleman, J. W. Garner and R. P. Taylor, Roughness element shape effects on heat transfer and skin friction in rough-wall turbulent boundary layers, *Int. J. Heat Mass Transfer* **36**(1), 147 (1993).

18B. A. Hossain and R. K. Brahma, Experimental investigations of fluid flow and heat transfer characteristics of a slot jet impinging on a square cylinder, *Wärme Stoffübertrag.* **28**(7), 381 (1993).

19B. A. Hossain and R. K. Brahma, Experimental investigations of fluid flow and heat transfer characteristics of a slot jet impinging on a rectangular cylinder, *Wärme Stoffübertrag.* **28**(7), 433 (1993).

20B. P. C. Huang and K. Vafai, Flow and heat transfer control over an external surface using a porous block array arrangement, *Int. J. Heat Mass Transfer* **36**(16), 4019 (1993).

21B. A. M. Jacobi, A scale analysis approach to the correlation of continuous moving sheet (backward boundary layer) forced convective heat transfer, *J. Heat Transfer Trans. ASME* **115**(4), 1058 (1993).

22B. M. I. Kussoy and K. C. Horstman, Three-dimensional hypersonic shock wave–turbulent boundary-layer interactions, *AIAA J.* **31**(1), 8 (1993).

23B. H. J. Luring, Heat exchange between strata and roadway air, *Glueckauf Forschungsh.* **54**(2), 81 (1993).

24B. H. Memar, J. P. Holman and P. A. Dellenback, The effect of a swirled annular jet on convective heat transfer in confined coaxial jet mixing, *Int. J. Heat Mass Transfer* **36**(16), 3921 (1993).

25B. V. T. Morgan, External thermal resistance of aerial bundled cables, *IEE Proc. Part C* **140**(2), 65 (1993).

26B. N. Onur, Forced convection heat transfer from a flat-plate model collector on roof of a model house, *Wärme Stoffübertrag.* **28**(3), 141 (1993).

27B. Bingjing Su and M. S. El-Genk, Forced convection of water in rod-bundles, *Int. Commun. Heat Mass Transfer* **20**(2), 295 (1993).

28B. R. P. Taylor, J. K. Taylor, M. H. Hosni and H. W. Coleman, The turbulent thermal boundary layer with an abrupt change from a rough to a smooth wall, *Int. J. Heat Mass Transfer* **36**(1), 141 (1993).

29B. R. P. Taylor and W. M. Chakroun, Heat transfer in turbulent boundary layers with a short strip of roughness, *J. Thermophys. Heat Transfer* **7**(1), 183 (1993).

30B. K. Vajravelu and A. Hadjinicolaou, Heat transfer in a viscous fluid over a stretching sheet with viscous dissipation and internal heat generation, *Int. Commun. Heat Mass Transfer* **20**(3), 417 (1993).

31B. Xin Zhang and M. W. Collins, Flow and heat transfer in a turbulent boundary layer through skewed and pitched jets, *AIAA J.* **31**(9), 1590 (1993).

32B. V. I. Zinchenko, A. G. Kataev and A. S. Yakimov, Investigation of the temperature regimes of bodies immersed in flow with surface blowing, *J. Appl. Mech. Tech. Phys.* **33**(6), 821 (1993).

Compressibility and high-speed flow effects

33B. S. Balanchandar, D. A. Yuen and D. Reuteler, Viscous and adiabatic heating effects in three-dimensional compressible convection at infinite Prandtl number, *Phys. Fluids A* **5**(11), 2938 (1993).

34B. V. A. Bashkin and V. N. Shabanov, Supersonic gas flow over a semi-infinite plate with small harmonic spanwise disturbances, *Fluid Dyn.* **28**(1), 111 (1993).

35B. V. Ya. Borovoi and T. V. Kubyshina, Hypersonic tail-fin heat transfer, *Fluid Dyn.* **28**(2), 171 (1993).

36B. D. B. Hash and H. A. Hassan, Monte Carlo simulation of entry in the Martian atmosphere, *J. Thermophys. Heat Transfer* **7**(2), 228 (1993).

37B. E. Josyula and J. S. Shang, Computation of nonequilibrium hypersonic flowfields around hemisphere

cylinders, *J. Thermophys. Heat Transfer* **7**(4), 668 (1993).
38B. M. I. Kussoy, K. C. Horstman and C. C. Horstman, Hypersonic crossing shock-wave–turbulent-boundary-layer interactions, *AIAA J.* **31**(12), 2197 (1993).
39B. S. A. Lutz, Correlation of Type III turbulent shock interaction heating data on a hemisphere, *AIAA J.* **30**(12), 2973 (1993).
40B. N. Narayanswami, C. C. Horstman and D. D. Knight, Computation of crossing shock–turbulent boundary layer interaction at Mach 8.3, *AIAA J.* **31**(8), 1369 (1993).
41B. A. K. Pandey, Thermoviscoplastic response of engine-cowl leading edge subjected to an oscillating shock–shock interaction, *J. Spacecr. Rockets* **30**(6), 771 (1993).
42B. D. A. Thorockmorton, Leeside shock-layer transition and the Space Shuttle Orbiter, *J. Spacecr. Rockets* **30**(6), 774 (1993).
43B. M. S. Woronowicz and D. Baganoff, Drag and heat transfer correlations for rarefied hypersonic flow fast flat plates, *J. Thermophys. Heat Transfer* **7**(1), 63 (1993).
44B. E. V. Zoby, R. N. Gupta and K.-P. Lee, Hypervelocity stagnation-point heating rate discrepancies, *J. Spacecr. Rockets* **30**(6), 773 (1993).

Analysis and modeling

45B. K. Bremhorst and L. Krebs, Eddy diffusivity based comparisons of turbulent Prandtl number for boundary layer and free jet flows with reference to fluids of very low Prandtl number, *J. Heat Transfer* **115**(3), 549 (1993).
46B. P. A. Durbin, Application of a near-wall turbulence model to boundary layers and heat transfer, *Int. J. Heat Fluid Flow* **14**(4), 316 (1993).
47B. J. R. Fair, How to design baffle tray columns, *Hydrocarbon Process.* **72**(5), 75 (1993).
48B. B. Hassan, F. R. DeJarnette and E. V. Zoby, Effect of nose shape on three-dimensional streamlines and heating rates, *J. Spacecr. Rockets* **30**(1), 69 (1993).
49B. C. Kleinstreuer and H. Chiang, Convection heat transfer of closely-spaced spheres with surface blowing, *Wärme Stoffübertrag.* **28**(5), 285 (1993).
50B. T. Kondoh, Y. Nagano and T. Tsuji, Computational study of laminar heat transfer downstream of a backward-facing step, *Int. J. Heat Mass Transfer* **36**(3), 577 (1993).
51B. Y. Lee and K. C. Kim, An analysis on effect of transverse convex curvature on turbulent flow and heat transfer, *Wärme Stoffübertrag.* **28**(12), 89 (1993).
52B. J. A. Masad and M. R. Malik, Transition correlation in subsonic flow over a flat plate, *AIAA J.* **31**(10), 1953 (1993).
53B. Al. M. Morega and A. Bejan, Heatline visualization of forced convection laminar boundary layers, *Int. J. Heat Mass Transfer* **36**(16), 3957 (1993).
54B. M. Raudensky, Heat transfer coefficient estimation by inverse conduction algorithm, *Int. J. Numer. Methods Heat Fluid Flow* **3**(3), 257 (1993).
55B. K. Sada and Y. Ichikawa, Simulation of air flow over a heated flat plate using an anisotropic K–epsilon model, *J. Wind Engng Ind. Aerodyn.* **46,** 697 (1993).
56B. S. S. Sadhal, Transient heat transfer from a solid sphere translating at low Reynolds number: perturbation solution for low Peclet number, *Wärme Stoffübertrag.* **28**(6), 365 (1993).
57B. N. Suzuki, A. Matsumoto, Y. Nagano and M. Tagawa, Anisotropy of heat transfer and its modeling in homogenous turbulent flow, *Heat Transfer Jpn Res.* **22**(4), 325 (1993).

Unsteady effects

58B. S. A. Al-Sanea and A. A. Mujahid, A numerical study of the thermal performance of fins with time-dependent boundary conditions, including initial transient effects, *Wärme Stoffübertrag.* **28**(7), 417 (1993).
59B. N. Bagheri and B. R. White, Experimental measurements of large-scale temperature fluctuation structures in a heated incompressible turbulent boundary layer, *Int. J. Heat Mass Transfer* **36**(4), 907 (1993).
60B. Yu. I. Bublikov and V. M. Fomichev, Stability of oblique waves in a laminar boundary layer on a nonuniformly heated surface, *High Temp.* **31**(2), 301 (1993).
61B. J. P. Clark, P. J. Magari and T. V. Jones, On the distribution of the heat transfer coefficient in turbulent and "transitional" wedges, *Int. J. Heat Fluid Flow* **14**(3), 217 (1993).
62B. I. Dincer, Heat transfer rates during immersion cooling of spherical and cylindrical products, *Int. Commun. Heat Mass Transfer* **20**(3), 445 (1993).
63B. B. A. Jubran, M. A. Hamdan, B. Tashtoush and A. R. Mansour, An approximate analytical solution for the prediction of transient response of the trombe wall, *Int. Commun. Heat Mass Transfer* **20**(4), 567 (1993).
64B. F. Khodabakhsh, R. Konduri, S. Mumukutla and S. Idem, Transient thermal mixing following sudden transverse injection of a fluid, *J. Thermophys. Heat Transfer* **7**(4), 732 (1993).
65B. Won Jae Lee, Y. Kim and E. D. Case, Effect of quenching media on the heat transfer coefficient of polycrystalline alumina, *J. Mater. Sci.* **28**(8), 2079 (1993).
66B. J. S. Nigen and C. H. Amon, Forced convective cooling enhancement of electronic package configurations through self-sustained oscillatory flows, *J. Electron. Packag.* **115**(4), 356 (1993).

Films and interfaces

67B. M. S. Bohn and S. H. Davis, Thermocapillary breakdown of falling liquid films at high Reynolds numbers, *Int. J. Heat Mass Transfer* **36**(7), 1875 (1993).
68B. R. W. Griffiths and J. H. Fink, Effects of surface cooling on the spreading of lava flows and domes, *J. Fluid Mech.* **252,** 667 (1993).
69B. O. E. Jensen and J. B. Grotberg, The spreading of heat or soluble surfactant along a thin liquid film, *Phys. Fluids A* **5**(1), 58 (1993).
70B. I. Morioka, M. Kiyota and R. Nakao, Absorption of water vapor into a film of aqueous solution of LiBr falling along a vertical pipe, *JSME Int. J. Ser. B* **36**(2), 351 (1993).
71B. M. M. Rahman and A. Faghri, Transport in a thin liquid film on the outer surface of a wedge or cone embedded in a porous medium—III. Computation and comparison of results, *Int. Commun. Heat Mass Transfer* **20**(1), 29 (1993).
72B. M. A. Yaghoubi, H. Kazeminejad and A. Farshidiyanfar, Heat and mass transfer with dehumidification in laminar boundary layer flow along a cooled flat plate, *J. Heat Transfer* **115**(3), 785 (1993).
73B. W. M. Yan and C. Y. Soong, Numerical study of liquid film cooling along an inclined plate, *Wärme Stoffübertrag.* **28**(4), 233 (1993).
74B. Ru Yang and Derming Jou, Heat and mass transfer on the wavy film absorption, *Can. J. Chem. Engng* **71**(4), 533 (1993).

Fluid types

75B. C. E. Maneschy, M. Massoudi and A. Ghoneimy, Heat transfer analysis of a non-Newtonian fluid past a porous plate, *Int. J. Non Linear Mech.* **28**(2), 131 (1993).
76B. A. Nakayama and I. Pop, Momentum and heat transfer over a continuous moving surface in a non-Darcian fluid, *Wärme Stoffübertrag.* **28**(4), 177 (1993).
77B. T. A. Ozbelge, Location of peak heat transfer enhance-

ment in suspension flows, *Int. J. Multiphase Flow* **19**(3), 535 (1993).
78B. M. E. Tauber, L. Yang and J. Peterson, Flat surface heat-transfer correlations for Martian entry, *J. Spacecr. Rockets* **30**(2), 164 (1993).
79B. H. Usui and T. Saeki, Drag reduction and heat transfer reduction by cationic surfactants, *J. Chem. Engng Jpn* **26**(1), 103 (1993).
80B. D. C. Wadsworth, Slip effects in a confined rarefied gas—I. Temperature slip, *Phys. Fluids A* **5**(7), 1831 (1993).

Conjugate heat transfer
81B. I. Anteby and I. Shai, Modified conduction shape factors for isothermal bodies embedded in a semi-infinite medium, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 233 (1993).
82B. T. A. Badgwell, T. F. Edgar, I. Trachtenberg, G. Yetter, J. Kiefer Elliot and R. L. Anderson, *In-situ* measurement of wafer temperatures in a low pressure chemical vapor deposition furnace, *IEEE Trans. Semicond. Manuf.* **6**(1), 65 (1993).
83B. J. Filipovic, R. Viskanta, F. P. Incropera and T. A. Veslocki, Thermal behavior of a moving steel strip cooled by an array of planar water jets, *Steel Res.* **63**(10), 438 (1993).
84B. P. J. Gehrke and K. Bremhorst, Lateral velocity fluctuations and dissipation time scale ratios for prediction of mean and fluctuation temperature fields, *Int. J. Heat Mass Transfer* **36**(7), 1943 (1993).
85B. E. Georgiou and P. Razelos, Performance analysis and optimization of convective annular fins with internal heat generation, *Wärme Stoffübertrag.* **28**(5), 275 (1993).
86B. R.-M. Guo, Heat transfer of laminar flow cooling during strip acceleration on hot strip mill runout tables, *Iron Steelmaker* **20**(8), 49 (1993).
87B. V. Heidt and R. Jeschar, Influence of running water on the heat transfer in continuous casting, *Steel Res.* **64**(3), 157 (1993).
88B. R. A. Hodge, P. Raghuraman and A. L. Murray, Window cooling technology program, *J. Spacecr. Rockets* **30**(4), 466 (1993).
89B. I. Pop and D. B. Ingham, A note on conjugate forced convection boundary-layer flow past a flat plate, *Int. J. Heat Mass Transfer* **36**(15), 3873 (1993).
90B. A. Pozzi, E. Bassano and L. de Socio, Coupling of conduction and forced convection past an impulsively started infinite flat plate, *Int. J. Heat Mass Transfer* **36**(7), 1799 (1993).
91B. B. V. S. S. S. Prasad and S. Dey Sarkar, Conjugate laminar forced convection from a flat plate with imposed pressure gradient, *J. Heat Transfer Trans. ASME* **115**(2), 469 (1993).
92B. Xichen Yang, Tianxi Zheng, Naikun Zhang, Minlin Zhong, Yuji Lin and Shenli Gao, Convection and mass transfer in laser cladding on FeCrSiB alloy, *Acta Metall. Sin. Engl. Ed. Ser. B Process Metall. Misc.* **5B**(4), 315 (1993).

Measurements
93B. Haitao Chen, Shengjie Xia, Liyin Chen and Zexiang Chu, Laser interferometric measurement of temperature distribution in convective thermal transfer boundary layers, *Acta Mech. Sin.* **9**(3), 233 (1993).
94B. D. R. Smith and A. J. Smits, Simultaneous measurement of velocity and temperature fluctuations in the boundary layer of a supersonic flow, *Exper. Therm. Fluid Sci.* **7**(3), 221 (1993).

With combustion and reaction
95B. S. J. Baek and H. H. Lee, Transport effects in a class of nonisothermal multiphase catalytic reactions, *Chem. Engng Sci.* **48**(24), 4065 (1993).
96B. J. C. Hermanson and A. Vranos, Preferential thermal and multicomponent species transport effects in strained diffusion flames, *AIAA J.* **30**(12), 2982 (1993).
97B. V. R. Katta and W. M. Roquemore, Numerical method for simulating fluid–dynamic and heat-transfer changes in jet-engine injector feed-arm, *J. Thermophys. Heat Transfer* **7**(4), 651 (1993).
98B. P. A. Pozdeev, B. V. Togov and V. A. Sinel'shchikov, Modeling the boundary layer at a corundum wall in a flux of propane–air combustion products with added potassium—Theory and experiment, *High Temp.* **31**(3), 493 (1993).

CHANNEL FLOWS

Straight-walled circular and rectangular ducts
1C. T. Aihara, Joo-Kyun Kim, K. Okuyama and A. Lasek, Controllability of convective heat transfer of magnetic fluid in a circular tube, *J. Magn. Magn. Mater.* **122**(13), 297 (1993).
2C. H. H. Al-Ali and M. S. Selim, Momentum and heat transfer in the entrance region of a parallel plate channel: developing laminar flow with constant wall temperature, *Appl. Sci. Res.* **51**(4), 663 (1993).
3C. F. Chen and C. H. Wu, Unsteady convective flows in a vertical slot containing variable viscosity fluids, *Int. J. Heat Mass Transfer* **36**(17), 4233 (1993).
4C. T. Elperin and A. Fominykh, Heat and mass transfer during gas hydrate formation at the surface of rising slugs with small admixtures of inert gases, *Int. Commun. Heat Mass Transfer* **20**(6), 821 (1993).
5C. S. X. Gao and J. P. Hartnett, Analytical Nusselt number predictions for slug flow in rectangular duct, *Int. Commun. Heat Mass Transfer* **20**(5), 751 (1993).
6C. J.-C. Han, Y.-M. Zhang and K. Kalkuehler, Uneven wall temperature effect on local heat transfer in a rotating two-pass square channel with smooth walls, *J. Heat Transfer Trans. ASME* **115**(4), 912 (1993).
7C. I. Hosokawa, Y. Takaka and K. Yamamoto, Mixed convective flow with mass transfer in a horizontal rectangular duct heated from below simulated by the conditional Fourier spectral analysis, *Int. J. Heat Mass Transfer* **36**(12), 3029 (1993).
8C. G. J. Hwang, Y. C. Cheng and M. L. Ng, Developing laminar flow and heat transfer in a square duct with one-walled injection and suction, *Int. J. Heat Mass Transfer* **36**(9), 2429 (1993).
9C. T. Inagaki and K. Komori, Numerical prediction of turbulent heat transfer in combined forced and natural convection (aiding flow) in a uniformly vertical heated pipe: two-equation turbulence models for velocity and temperature, *Heat Transfer Jpn Res.* **22**(3), 213 (1993).
10C. Hong-Sen Kou and Kuen-Tzong Lu, Analytical solution of mixed convection in a vertical channel embedded in porous media with asymmetric wall heat fluxes, *Int. Commun. Heat Mass Transfer* **20**(5), 737 (1993).
11C. V. A. Kurganov and A. G. Kaptilnyi, Flow structure and turbulent transport of a super-critical pressure fluid in a vertical heated tube under the conditions of mixed convection—experimental data, *Int. J. Heat Mass Transfer* **36**(13), 3383 (1993).
12C. A. P. Kuryachii, Heat and mass transfer associated with low-velocity vapor flow in the plane channel of a thermal protection system of the radiative–evaporative type, *Fluid Dyn.* **27**(6), 772 (1993).
13C. Kuan-Tzong Lee and Wei-Mon Yan, Transient conjugated forced convection heat transfer with fully developed laminar flow in pipes, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 341 (1993).
14C. Kuan-Tzong Lee and Wei-Mon Yan, Transient con-

jugated forced convection heat transfer with fully developed laminar flow in pipes, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 341 (1993).

15C. Tsing-Fa Lin, Tsai-Shou Chang and Yu-Feng Chen, Development of oscillatory asymmetric recirculating flow in transient laminar opposing mixed convection in a symmetrically heated vertical channel, *J. Heat Transfer Trans. ASME* **115**(2), 343 (1993).

16C. A. I. Moshinskii, Dispersion of heat in a flow of liquid in cylindrical channels when there is heat exchange with the wall, *High Temp.* **30**(6), 924 (1993).

17C. W. F. N. Santos and J. S. Travelho, Transient conjugated forced convection in a parallel plate duct with convection from the ambient and periodic variation of inlet temperature, *Appl. Sci. Res.* **51**(3), 625 (1993).

18C. P. Schäfer and H. Herwig, Stability of plane Poiseuille flow with temperature dependent viscosity, *Int. J. Heat Mass Transfer* **36**(9), 2441 (1993).

19C. M. N. Schneider, Eddy cooling of heated channel in compressible gas, *High Temp.* **31**(3), 486 (1993).

20C. S. Shin, Y. I. Cho, W. K. Gringrich and W. Shyy, Numerical study of laminar heat transfer with temperature dependent fluid viscosity in a 2 : 1 rectangular duct, *Int. J. Heat Mass Transfer* **36**(18), 4365 (1993).

21C. M. S. Sodha, D. Buddhi and R. L. Sawhney, Optimization of pipe parameters of an underground air pipe cooling system, *Energy Convers. Manage.* **34**(6), 465 (1993).

22C. C. Taylor and J. Y. Xia, Finite element modelling of the 'near wall zone' of confined turbulent flows—Pt II, *Int. J. Numer. Methods Heat Fluid Flow* **3**(2), 121 (1993).

23C. M. Teitel and R. A. Antonia, Heat transfer in fully developed turbulent channel flow: comparison between experiment and direct numerical simulations, *Int. J. Heat Mass Transfer* **36**(6), 1701 (1993).

24C. E. P. Valueva, V. N. Popov and S. Yu. Romanova, Heat transfer under laminar pulsating flow in a round tube, *Therm. Engng* **40**(8), 624 (1993).

25C. Y. Zhu and R. A. Antonia, Temperature dissipation measurements in a fully developed turbulent channel flow, *Exp. Fluids* **15**(3), 191 (1993).

Irregular geometries

26C. A. Campo and J. C. Morales, Analytical–numerical prediction of the three-dimensional temperature variation in tubes having streamwise internal fins, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 319 (1993).

27C. J. M. Choi and N. K. Anand, Heat transfer in a serpentine channel with a series of right-angle turns, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 189 (1993).

28C. Z. F. Dong, M. A. Ebadian and E. Bigzadeh, Convective–radiative heat transfer in a square duct with a centered circular core, *Int. J. Heat Fluid Flow* **14**(1), 68 (1993).

29C. S. Dutta and S. Acharya, Heat transfer and flow past a backstep with the nonlinear k–ε turbulence model and the modified k–ε turbulence model, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 281 (1993).

30C. Maged A. I. El-Shaarawi and Mohsen Al-Attas, Transient induced flow through a vertical annulus, *JSME Int. J. Ser. B* **36**(1), 156 (1993).

31C. B. Farhanieh and B. Sunden, Numerical investigation of turbulent fluid flow and heat transfer characteristics in a streamwise-periodic corrugated duct with constant cross-sectional area, *Int. J. Numer. Methods Heat Fluid Flow* **3**(1), 15 (1993).

32C. B. Hong, B. F. Armaly and T. S. Chen, Laminar mixed convection in a duct with a backward-facing step: the effects of inclination angle and Prandtl number, *Int. J. Heat Mass Transfer* **36**(12), 3059 (1993).

33C. Yuan Mao Huang and C. H. Ho, Study of the fluid flow in the elliptical duct by the method of characteristics, *J. Press. Vessel Technol. Trans. ASME* **115**(1), 80 (1993).

34C. D. D. Joye, A. G. Hakun and C. D. Joye, Heat transfer in helical, curved rectangular channels—Comparison of Type I and Type II systems, *Int. J. Heat Mass Transfer* **36**(14), 3541 (1993).

35C. I. S. Kudryavtsev, B. M. Lekakh, E. D. Fedorovich and B. I. Gimpel'son, Temperature conditions at the heating surface of a coiled-steam generator in the region of deteriorated heat transfer, *Therm. Engng* **40**(11), 885 (1993).

36C. Michio Kurashige, Active cooling and thermal stress reduction by use of porous materials (hollow cylinder model), *JSME Int. J. Ser. A* **36**(1), 21 (1993).

37C. Yu. A. Kuzme-Kichta, A. S. Komendantov, A. A. Ovodkov, L. T. Vasil'eva and B. Yu. Sukhov, Effects of flow spiralling and a porous coating on heat-transfer characteristics at the heat-transfer crisis in an unevenly heated channel, *High Temp.* **30**(4), 635 (1993).

38C. M. Mahadevappa, K. V. C. Rao and V. M. K. Sastri, Experimental investigation for fluid flow and heat transfer in an elliptical duct rotating about a parallel axis, *Exp. Heat Transfer* **6**(2), 97 (1993).

39C. N. Saniel and S. Dini, Heat transfer characteristics in a wavy-walled channel, *J. Heat Transfer* **115**(3), 788 (1993).

40C. M. Sano and Y. Asako, Fluid flow and heat transfer in a periodically diverging–converging turbulent duct flow, *JSME Int. J. Ser. B* **36**(2), 207 (1993).

41C. Heiu-Jou Shaw, Laminar mixed convection heat transfer in three-dimensional horizontal channel with a heated bottom, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 445 (1993).

42C. L. I. Shub, Calculation of turbulent flow and heat transfer in a tube with a periodically varying cross-section, *Int. J. Heat Mass Transfer* **36**(4), 1085 (1993).

43C. B. Snyder, K. T. Li and R. A. Wirtz, Heat transfer enhancement in a serpentine channel, *Int. J. Heat Mass Transfer* **36**(12), 2965 (1993).

44C. H. Sugiyama, M. Akiyama, M. Hirata and S. Ueno, Heat and mass transfer analysis of three-dimensional turbulent flow in a distorted duct, *Heat Transfer Jpn Res.* **22**(2), 120 (1993).

45C. J. Vilemas, P. Poskas, V. Simonis and V. Sukys, Heat transfer and hydraulic drag in helical channels in gas flow, *Int. J. Heat Mass Transfer* **36**(6), 1693 (1993).

46C. S. N. Volkova, Yu. A. Migrov and V. B. Khabenskii, An equivalent representation of a multi-channel system in a mathematical model for thermo-hydraulic transients, *Therm. Engng* **40**(3), 228 (1993).

47C. O. Watanabe, K. Nakajima and H. Fujita, Characteristics of liquid-film thickness of air–water annular two-phase flow in helically coiled tubes, *Heat Transfer Jpn Res.* **22**(5), 447 (1993).

48C. G. Yang, Z. F. Dong and M. A. Ebadian, The effect of torsion on convective heat transfer in a helicoidal pipe, *J. Heat Transfer* **115**(3), 796 (1993).

49C. G. Yang and M. A. Ebadian, Convective heat transfer in a curved annular-sector duct, *J. Thermophys. Heat Transfer* **7**(3), 441 (1993).

50C. T. Yilmaz and E. Cihan, General equation for heat transfer for laminar flow in ducts of arbitrary cross-sections, *Int. J. Heat Mass Transfer* **36**(13), 3265 (1993).

51C. Xiao Zejun, Jia Dounan and Zhang Guiqin, Experimental research of heat transfer to high temperature liquid metal sodium in an annulus, *Heat Technol.* **10**(34), 95 (1993).

52C. Nengli Zhang, Wen-Jei Yang and C.-P. Lee, Heat transfer and friction loss performance in flow networks with multiple intersections, *Exp. Heat Transfer* **6**(3), 243 (1993).

Finned passages

53C. S. Acharya, S. Dutta, T. A. Myrum and R. S. Baker, Periodically developed flow and heat transfer in a ribbed duct, *Int. J. Heat Mass Transfer* **36**(8), 2069 (1993).
54C. A. K. Agrawal and S. Sengupta, Laminar fluid flow and heat transfer in a annulus with an externally enhanced inner tube, *Int. J. Heat Fluid Flow* **14**(1), 54 (1993).
55C. S. F. Al-Fahed, Z. H. Ayub, A. M. Al-Marafie and B. M. Soliman, Heat transfer and pressure drop in a tube with internal microfins under turbulent water flow conditions, *Exp. Therm. Fluid Sci.* **7**(3), 249 (1993).
56C. A. Campo and J. C. Morales, Analytical–numerical prediction of the three-dimensional temperature variation in tubes having streamwise internal fins, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 319 (1993).
57C. B. H. Chang and A. F. Mills, Turbulent flow in a channel with transverse rib heat transfer augmentation, *Int. J. Heat Mass Transfer* **36**(6), 1459 (1993).
58C. B. Farhanieh, C. Herman and B. Sundén, Numerical and experimental analysis of laminar fluid flow and forced convection heat transfer in a grooved duct, *Int. J. Heat Mass Transfer* **36**(6), 1609 (1993).
59C. J. Fukai and O. Miyatake, Laminar-flow heat transfer within parallel-plate channel with staggered baffles, *Heat Transfer Jpn Res.* **22**(2), 171 (1993).
60C. M. A. Habib, A. M. Mobarak, A. M. Attya and A. Z. Aly, Enhanced heat transfer in channels with staggered fins of different spacings, *Int. J. Heat Fluid Flow* **14**(2), 185 (1993).
61C. Je-Chin Han, J. Joy Huang and C. Pang Lee, Augmented heat transfer in square channels with wedge-shaped and delta-shaped turbulence promoters, *J. Enhanced Heat Transfer* **1**(1), 37 (1993).
62C. Ying-Jong Hong and Shou-Shing Hsieh, Heat transfer and friction factor measurements in ducts with staggered and in-line ribs, *J. Heat Transfer Trans. ASME* **115**(1), 58 (1993).
63C. J. M. Houghton, D. B. Ingham and P. J. Heggs, An application of the boundary element technique to periodic heat transfer in a fin assembly, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 379 (1993).
64C. S.-S. Hsieh and C.-C. Lin, An experimental study of laminar entrance flow and heat transfer in finned tube annuli, *Int. J. Heat Mass Transfer* **36**(9), 2457 (1993).
65C. Y. Jin, Ch. Ling, Z. Chen and Y. Tian, Heat transfer and pressure drop of a transversely finned concentric annulus with longitudinal flow, *Wärme Stoffübertrag.* **28**(5), 243 (1993).
66C. Nae-Hyun Kim and R. L. Webb, Analytic prediction of the friction and heat transfer for turbulent flow in axial internal fin tubes, *J. Heat Transfer* **115**(3), 553 (1993).
67C. Won T. Kim and R. F. Boehm, Laminar buoyancy-enhanced convection flows on repeated blocks with asymmetric heating, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **22**(4), 421 (1993).
68C. R. T. Kukreja, S. C. Lau and R. D. McMillin, Local heat–mass transfer distribution in a square channel with full and V-shaped ribs, *Int. J. Heat Mass Transfer* **36**(8), 2013 (1993).
69C. W. Li, S. Kakaç, F. F. Hatay and R. Oskay, Experimental study of unsteady forced convection in a duct with and without arrays of block-like electronic components, *Wärme Stoffübertrag.* **28**(12), 69 (1993).
70C. H. H. Lin and Y. H. Hung, Transient forced convection heat transfer in a vertical rib-heated channel using a turbulence promoter, *Int. J. Heat Mass Transfer* **36**(6), 1553 (1993).
71C. T.-M. Liou, J.-J. Hwang and S.-H. Chen, Simulation and measurement of enhanced turbulent heat transfer in a channel with periodic ribs on one principal wall, *Int. J. Heat Mass Transfer* **36**(2), 507 (1993).
72C. T.-M. Liou and J.-J. Hwang, Effect of ridge shapes on turbulent heat transfer and friction in a rectangular channel, *Int. J. Heat Mass Transfer* **36**(4), 931 (1993).
73C. S. S. Lue, H. Z. Huang and W. Q. Tao, Experimental study on heat transfer and pressure drop characteristics in the developing region for arrays of obliquely positioned plates of nonuniform length, *Exp. Therm. Fluid Sci.* **7**(1), 30 (1993).
74C. R. M. Manglik and A. E. Bergles, Heat transfer and pressure drop correlations for twisted-tape inserts in isothermal tubes—I. Laminar flows, *J. Heat Transfer Trans. ASME* **115**(4), 881 (1993).
75C. R. M. Manglik and A. E. Bergles, Heat transfer and pressure drop correlations for twisted-tape inserts in isothermal tubes—II. Transition and turbulent flows, *J. Heat Transfer Trans. ASME* **115**(4), 890 (1993).
76C. O. Miyatake, H. Omori and H. Iwashita, Laminar mixed convection heat transfer in axial fluid flow-through cylinders, *Heat Transfer Jpn Res.* **22**(2), 198 (1993).
77C. T. A. Myrum, X. Qiu and S. Acharya, Heat transfer enhancement in a ribbed duct using vortex generators, *Int. J. Heat Mass Transfer* **36**(14), 3497 (1993).
78C. Yu. G. Nazmeev, A. M. Konakhin, B. A. Kumirov, V. V. Olipiev and O. P. Shinkevich, Heat transfer and pressure drop for laminar flow of a viscous fluid in artificially roughened tubes, *Therm. Engng* **40**(4), 330 (1993).
79C. Yu. G. Nazmeev and I. A. Konakhina, Intensification of heat transfer in spirally knurled tubes under viscous fluid flow, *Therm. Engng* **40**(11), 881 (1993).
80C. C. B. Panchal and D. M. France, Heat transfer and pressure drop in large pitch spirally indented tubes, *Int. J. Heat Mass Transfer* **36**(3), 565 (1993).
81C. T. J. Rabas and B. Arman, Influence of the Prandtl number on the thermal performance of tubes with the separation and reattachment enhancement mechanisms, *J. Enhanced Heat Transfer* **1**(1), 5 (1993).
82C. T. J. Rabas, R. L. Webb, P. Thors and N.-K. Kim, Influence of roughness shape and spacing on the performance of three-dimensional helically dimpled tubes, *J. Enhanced Heat Transfer* **1**(1), 53 (1993).
83C. S. Sohrabpour and A. Razani, Optimization of convective fin with temperature-dependent thermal parameters, *J. Franklin Inst.* **330**(1), 37 (1993).
84C. H. Takasaki and T. Igarashi, Fluid flow and heat transfer around the rectangular blocks in a parallel duct flow, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(562), 2021 (1993).
85C. R. P. Taylor and B. K. Hodge, Validated procedure for the prediction of fully-developed Nusselt numbers and friction factors in pipes with 3-dimensional roughness, *J. Enhanced Heat Transfer* **1**(1), 23 (1993).
86C. St. Tiggelbeck, N. K. Mitra and M. Fiebig, Experimental investigations of heat transfer enhancement and flow losses in a channel with double rows of longitudinal vortex generators, *Int. J. Heat Mass Transfer* **36**(9), 2327 (1993).
87C. N. Zhang, J. Chiou, S. Fann and W.-J. Yang, Local heat transfer distribution in a rotating serpentine rib-roughened flow passage, *J. Heat Transfer* **115**(3), 560 (1993).
88C. J. X. Zhu, N. K. Mitra and M. Fiebig, Effects of

longitudinal vortex generators on heat transfer and flow loss in turbulent channel flows, *Int. J. Heat Mass Transfer* **36**(9), 2339 (1993).

Thermally developing and oscillatory flows

89C. R. F. Babus'haq, Forced-convection heat transfer in the entrance region of pipes, *Int. J. Heat Mass Transfer* **36**(13), 3343 (1993).
90C. A. V. Britan, V. G. Testov and A. N. Khmelevskii, Characteristics of flow of water vapor with heating by shock waves and cooling in supersonic nozzles, *High Temp.* **30**(4), 611 (1993).
91C. D. M. Brown, Weigong Li and S. Kakac, Numerical and experimental analysis of unsteady heat transfer with periodic variation of inlet temperature in circular ducts, *Int. Commun. Heat Mass Transfer* **20**(6), 883 (1993).
92C. B. T. F. Chung, Z. J. Zhang, G. Li and L. T. Yeh, Thermally developing convection from Newtonian flow in rectangular ducts with uniform heating, *J. Thermophys. Heat Transfer* **7**(3), 534 (1993).
93C. Z. F. Dong and M. A. Ebadian, Thermal developing flow in a curved duct with an elliptic cross section, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(2), 197 (1993).
94C. E. Evren-Selamet, V. S. Arpaci and C. Borgnakke, Simulation of laminar buoyancy-driven flows in a enclosure, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **22**(4), 401 (1993).
95C. T. Inaba and T. Kubo, Enhanced heat transfer through oscillatory flow, *Heat Transfer Jpn. Res.* **22**(5), 480 (1993).
96C. S. Y. Kim, B. H. Kang and J. M. Hyun, Heat transfer in the thermally developing region of a pulsating channel flow, *Int. J. Heat Mass Transfer* **36**(17), 4257 (1993).
97C. S. D. Kolev and W. E. van der Linden, Application of Laplace transforms for the solution of transient mass- and heat-transfer problems in flow systems, *Int. J. Heat Mass Transfer* **36**(1), 135 (1993).
98C. N. N. Kortikov and V. V. Nechaev, Heat and mass transfer and friction on curvilinear surfaces of nozzles and diffusers, *Therm. Engng* **40**(3), 176 (1993).
99C. A. S. Lavine, On the linear stability of mixed and free convection between inclined parallel plates with fixed heat flux boundary conditions, *Int. J. Heat Mass Transfer* **36**(5), 1373 (1993).
100C. K. R. Mutama and H. Iacovides, The investigation of developing flow and heat transfer in a long converging duct, *J. Heat Transfer Trans. ASME* **115**(4), 897 (1993).
101C. T. V. Nguyen, Incremental heat transfer number in the entry region of circular tubes, *Int. J. Heat Mass Transfer* **36**(14), 3659 (1993).
102C. B. V. Perepelitza and A. M. Nasibulov, Investigation of temperature statistic characteristics in turbulent water flow with unsteady heat transfer, *Exp. Therm. Fluid Sci.* **6**(4), 348 (1993).
103C. N. Saniei and S. Dini, Effect of height and geometry on local heat transfer and pressure drop in a channel with corrugated walls, *Heat Transfer Engng* **14**(4), 19 (1993).
104C. S. Schulz and F. Schwendig, Heat transfer in pipes under periodical compression and expansion, *Wärme Stoffübertrag.* **28**(4), 225 (1993).
105C. T. Shigechi, K. Araki and Y. Lee, Laminar heat transfer in the thermal entrance regions of concentric annuli with moving heated cores, *J. Heat Transfer Trans. ASME* **115**(4), 1061 (1993).
106C. B. Shome and M. K. Jensen, Correlations for simultaneously developing laminar flow and heat transfer in a circular tube, *Int. J. Heat Mass Transfer* **36**(10), 2710 (1993).
107C. C. Y. Soong and W. C. Hsueh, Mixed convection in a suddenly-expanded channel with effects of cold fluid injection, *Int. J. Heat Mass Transfer* **36**(6), 1477 (1993).
108C. Xiaoguo Tang and P. Cheng, Correlations of the cycle-averaged Nusselt number in a periodically reversing pipe flow, *Int. Commun. Heat Mass Transfer* **20**(2), 161 (1993).
109C. M. Teitel and R. A. Antonia, A step change in wall heat flux in a turbulent channel flow, *Int. J. Heat Mass Transfer* **36**(6), 1707 (1993).
110C. S. Torii, A. Shimuzu, S. Hasegawa and M. Higasa, Numerical analysis of laminarizing circular tube flows by means of a Reynolds stress turbulence model, *Heat Transfer Jpn Res.* **22**(2), 154 (1993).
111C. W.-M. Yan, Transient Conjugated heat transfer in channel flows with convection from the ambient, *Int. J. Heat Mass Transfer* **36**(5), 1295 (1993).
112C. C. Yucel, M. Hasnaoui, L. Robillard and E. Bilgen, Mixed convection heat transfer in open ended inclined channels with discrete isothermal heating, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(1), 109 (1993).

Miscellaneous duct flow

113C. V. G. Bashtovoi, V. A. Chernobai and Nguyen Quyet Thang, Experimental study of heat transfer control in rectangular channel with magnetofluid coating, *J. Magn. Magn. Mater.* **122**(13), 294 (1993).
114C. N. E. Burke, S. F. Kashou and P. C. Hawker, History matching of a North Sea flowline startup, *JPT J. Petrol. Technol.* **45**(5), 470 (1993).
115C. R. G. Carlisle and H. G. Wood, III, Computational study of coolant flow of liquid hydrogen through an externally heated duct, *J. Thermophys. Heat Transfer* **7**(3), 418 (1993).
116C. N. Datta, D. C. Dalal and S. K. Mishra, Unsteady heat transfer to pulsatile flow of a dusty viscous incompressible fluid in a channel, *Int. J. Heat Mass Transfer* **36**(7), 1783 (1993).
117C. W. M. Dziedzic, S. C. Jones, D. C. Gould and D. H. Petley, Analytical comparison of convective heat transfer correlations in supercritical hydrogen, *J. Thermophys. Heat Transfer* **7**(1), 68 (1993).
118C. D. Erickson, E. Buck and J. Kolts, Corrosion inhibitor transport in a wet-gas pipeline, *Mater. Perform.* **32**(9), 49 (1993).
119C. V. Féburie, M. Giot, S. Granger and J. M. Seynhaeve, A model for choked flow through cracks with inlet subcooling, *Int. J. Multiphase Flow* **19**(4), 541 (1993).
120C. P. J. Hensley and C. Savvidou, Modeling coupled heat and containment transport in groundwater, *Int. J. Numer. Anal. Methods Geomech.* **17**(7), 493 (1993).
121C. Kyung-Hoon Kim and F. Sadeghi, Three-dimensional temperature distribution in EHD lubrication—II. Point contact and numerical formulation, *J. Tribology* **115**(1), 36 (1993).
122C. V. I. Mal'kovskii, The conjugate problem of cooling of a plate for an internal pulse heat release, *Therm. Engng* **40**(4), 315 (1993).
123C. A. Nakayama and A. V. Shenoy, Non-Darcy forced convective heat transfer in a channel embedded in a non-Newtonian inelastic fluid-saturated porous medium, *Can. J. Chem. Engng* **71**(1), 168 (1993).
124C. C. Park and S. Yoon, Calculation of real-gas effects on airfoil aerodynamic characteristics, *J. Thermophys. Heat Transfer* **7**(4), 727 (1993).
125C. B. Ramaswamy and T. C. Jue, Analysis of thermocapillary and buoyancy-affected cavity flow using FEM, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **22**(4), 379 (1993).
126C. B. K. Rao, Turbulent heat transfer to viscoelastic

fluids in helical passages, *Exp. Heat Transfer* **6**(2), 189 (1993).
127C. N. Sugathan, K. Srinivasan, S. Srinivasa Murthy, Experiments on heat transfer in a cryogenic engine thrust chamber, *J. Propul. Power* **9**(2), 240 (1993).
128C. X. Tian and F. E. Kennedy, Temperature rise at the sliding contact interface for a coated semi-infinite body, *J. Tribology* **115**(1), 1 (1993).
129C. G. P. Ugrekhelidze and V. A. Nikolaev, Thc periodic treatment of heat-transfer surfaces with oxyethylidene diphosphonic acid to prevent carbonate sedimentation, *Therm. Engng* **40**(4), 323 (1993).
130C. G. C. Vradis, J. Dougher and S. Kumar, Entrance pipe flow and heat transfer for a Bingham plastic, *Int. J. Heat Mass Transfer* **36**(3), 543 (1993).
131C. B. Youn and A. F. Mills, Flow of supercritical hydrogen in a uniformly heated circular tube, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(1), 1 (1993).
132C. C. S. Yueh, C. I. Weng and C. C. Hwang, Heat transfer effects of tube wall on a parallel-loop thermosyphon, *Int. Commun. Heat Mass Transfer* **20**(2), 211 (1993).

FLOW WITH SEPARATED REGIONS

1D. H. I. Abu-Mulaweh, B. F. Armaly and T. S. Chen, Measurements in buoyancy-assisting laminar boundary layer flow over a vertical backward-facing step—Uniform wall heat flux case, *Exp. Therm. Fluid Sci.* **7**(1), 39 (1993).
2D. V. N. Afanasyev, Ya. P. Chudnovsky, A. I. Leontiev and P. S. Roganov, Turbulent flow friction and heat transfer characteristics for spherical cavities on a flat plate, *Exp. Therm. Fluid Sci.* **7**(1), 1 (1993).
3D. R. A. Antonia, Y. Zhou and M. Matsumura, Spectral characteristics on momentum and heat transfer in the turbulent wake of a circular cylinder, *Exp. Therm. Fluid Sci.* **6**(4), 371 (1993).
4D. S. Dutta and S. Acharya, Heat transfer and flow past a backstep with the nonlinear *k*–epsilon turbulence model and the modified *k*–epsilon turbulence model, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 281 (1993).
5D. Datta Gaitonde and J. S. Shang, Accuracy of flux-split algorithms in high-speed viscous flows, *AIAA J.* **31**(7), 1215 (1993).
6D. M. M. Gibson and T. Dakos, Production of temperature fluctuations in grid turbulence: Wiskind's experiment revisited, *Exp. Fluids* **16**(2), 146 (1993).
7D. A. Gopinath and A. F. Mills, Convective heat transfer from a sphere due to acoustic streaming, *J. Heat Transfer Trans. ASME* **115**(2), 332 (1993).
8D. M. Y. Ha, S. Yavuzkurt and K. C. Kim, Heat transfer past particles entrained in an oscillating flow with and without a steady velocity, *Int. J. Heat Mass Transfer* **36**(4), 949 (1993).
9D. J.-C. Han, L. Zhang and S. Ou, Influence of unsteady wake on heat transfer coefficient from a gas turbine blade, *J. Heat Transfer Trans. ASME* **115**(4), 904 (1993).
10D. Huai-Zhang Huang and Wen-Quan Tao, An experimental study on heat–mass transfer and pressure drop characteristics for arrays of nonuniform plate length positioned obliquely to the flow direction, *J. Heat Transfer* **115**(3), 568 (1993).
11D. Y. Kimura and R. H. Kraichnan, Statistics of an advected passive scalar, *Phys. Fluids A* **5**(9), 2264 (1993).
12D. A. Kondjoyan, J. D. Daudin and J. J. Bimbenet, Heat and mass transfer coefficients at the surface of elliptical cylinders placed in a turbulent air flow, *J. Food Engng* **20**(4), 339 (1993).
13D. V. B. Kuntysh and N. N. Stenin, Heat transfer and pressure drop in cross flow through mixed in-line-staggered finned-tube bundles, *Therm. Engng* **40**(2), 126 (1993).
14D. P. L. C. Lage, R. H. Rangel and C. M. Hackenberg, Multicomponent heat and mass transfer for flow over a droplet, *Int. J. Heat Mass Transfer* **36**(14), 3573 (1993).
15D. K. M. Lam, P. T. Y. Wong and N. W. M. Ko, Interaction of flows behind two circular cylinders of different diameters in side-by-side arrangement, *Exp. Therm. Fluid Sci.* **7**(3), 189 (1993).
16D. B. R. Lane, O. N. Mesquita, S. R. Meyers and J. P. Gollub, Probability distributions and thermal transport in a turbulent grid flow, *Phys. Fluids A* **5**(9), 2255 (1993).
17D. S. W. Ma and F. M. Gerner, Forced convection heat transfer from microstructures, *J. Heat Transfer Trans. ASME* **115**(4), 872 (1993).
18D. A. L. Makarov, Vortex structures with temperature inhomogeneity, *Fluid Dyn.* **28**(2), 188 (1993).
19D. M. Matsumura and R. A. Antonia, Momentum and heat transport in the turbulent intermediate wake of a circular cylinder, *J. Fluid Mech.* **250,** 651 (1993).
20D. K. Momose, H. Setokawa, T. Asami and Y. Hosokawa, Local characteristics of heat transfer from a vibrating cylinder, *Heat Transfer Jpn Res.* **22**(5), 462 (1993).
21D. D. B. Murray, A comparison of heat transfer in staggered and inline tube banks with a gas–particle crossflow, *Exp. Therm. Fluid Sci.* **6**(2), 177 (1993).
22D. H. Nishiyama, T. Ota, M. Hamada and Y. Takahashi, Temperature fluctuations in a slightly heated slot jet issuing into a crossflow, *Exp. Therm. Fluid Sci.* **6**(3), 252 (1993).
23D. S. Okamoto, K. Nakaso and I. Kawai, Effect of rows of two-dimensional square ribs on flow property along plane wall, *JSME Int. J. Ser. B* **36**(1), 121 (1993).
24D. D. L. R. Oliver and K. J. De Witt, High Peclet number heat transfer from a droplet suspended in an electric field: interior problem, *Int. J. Heat Mass Transfer* **36**(12), 3153 (1993).
25D. H. Papuccuoglu, Experimental investigation of hypersonic three-dimensional corner flow, *AIAA J.* **31**(4), 652 (1993).
26D. V. A. Petrov and M. M. Kulagina, Crossflow temperature head, *Therm. Engng* **40**(2), 154 (1993).
27D. S. Russ and P. J. Strykowski, Turbulent structure and entrainment in heated jets: the effect of initial conditions, *Phys. Fluids A* **5**(12), 3216 (1993).
28D. K. Rust, H. Tschiöke and D. Weinberg, Investigation into the occurrence of backflow effects in a heated rectangular channel during natural circulation, *Exp. Therm. Fluid Sci.* **7**(1), 61 (1993).
29D. V. Scherer, S. Wittig, G. Bittlinger and A. Pfeiffer, Thermographic heat transfer measurements in separated flows, *Exp. Fluids* **14**(12), 17 (1993).
30D. S. T. Smith and H. Haj-Hariri, Görtier vortices and heat transfer: a weakly nonlinear analysis, *Phys. Fluids A* **5**(11), 2815 (1993).
31D. A. I. Smorodin and V. Yu. Semenov, Features of heat exchangers with cross-flow tube bundles, *Therm. Engng* **40**(4), 334 (1993).
32D. S. Soudki et J.-L. Peube, Transfert de chaleur en écoulement pulsé au point d'arret d'un cylindre chaud, *Int. J. Heat Mass Transfer* **36**(13), 3237 (1993).
33D. K. Tatsutani, R. Devarakonda and J. A. C. Humphrey, Unsteady flow and heat transfer for cylinder pairs in a channel, *Int. J. Heat Mass Transfer* **36**(13), 3311 (1993).
34D. S. Torii and Wen-Jei Yang, Effects of the length scale

of free-stream turbulence and cylinder size on local heat transfer in laminar separated flows, *Exp. Heat Transfer* 6(2), 175 (1993).

35D. S. Y. Yoo, R. J. Goldstein and M. K. Chung, Effects of angle of attack on mass transfer from a square cylinder and its base plate, *Int. J. Heat Mass Transfer* **36**(2), 371 (1993).

36D. H. Yoshida, R. Echigo, K. Chujo and S. Nakano, Heat transfer mechanism of a fine-tube heat exchanger woven with threads, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1311 (1993).

HEAT TRANSFER IN POROUS MEDIA

Conduction and radiation

1DP. T. H. Bauer, A general analytical approach toward the thermal conductivity of porous media, *Int. J. Heat Mass Transfer* **36**(17), 4181 (1993).

2DP. K. G. T. Hollands and K. Iynkaran, Analytical model for the thermal conductance of compound honeycomb transparent insulation, with experimental validation, *Sol. Energy* **51**(3), 223 (1993).

3DP. K. Kamiuto, S. Saito and K. Ito, Numerical model for combined conductive and radiative heat transfer in annular packed beds, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 433 (1993).

4DP. K. Kamiuto, M. Iwamoto and Y. Nagumo, Combined conduction and correlated-radiation heat transfer in packed beds, *J. Thermophys. Heat Transfer* 7(3), 496 (1993).

5DP. M. Sahraoui and M. Kaviany, Slip and no-slip temperature boundary conditions at interface of porous, plain media: conduction, *Int. J. Heat Mass Transfer* **36**(4), 1019 (1993).

6DP. A. Sil, N. K. Samria, A. Chatterjee and D. S. Venkateswarlu, Estimation of dispenser cathode surface temperature of a practical potted heater cathode assembly, *IEEE Trans. Electron Devices* **40**(10), 1855 (1993).

7DP. Gourish Sirdeshpande and J. C. Khanpara, Heat transfer through elastomeric foams—A review *Rubber Chem. Technol.* **66**(3), 476 (1993).

8DP. Ts. Velinov, K. Bransalov and M. Mihovski, A thermal diffusivity study of the solid phase of porous samples, *Meas. Sci. Technol.* **4**(11), 1266 (1993).

9DP. A. L. Burka and V. V. Dudkin, Unsteady radiative–conductive heat transfer in a porous, permeable layer of a semitransparent medium, *J. Appl. Mech. Tech. Phys.* **33**(5), 696 (1993).

Forced convection (fixed bed)

10DP. T. Akiyama, R. Takahashi and J. Yagi, Measurements of heat transfer coefficients between gas and particles for a single sphere and for moving beds, *ISIJ Int.* **33**(6), 703 (1993).

11DP. J. G. H. Borkink, P. C. Borman and K. R. Westerterp, Modelling of radial heat transport in wall-cooled packed beds. Confidence intervals of estimated parameters and choice of boundary conditions, *Chem. Engng Commun.* **121**, 135 (1993).

12DP. S. A. Danilov and V. N. Fomin, Limiting thermal loads in porous heat exchangers, *High Temp.* **31**(3), 515 (1993).

13DP. R. M. Fand, M. Varahasamy and L. S. Greer, Empirical correlation equations for heat transfer by forced convection from cylinders embedded in porous media that account for the wall effect and dispersion, *Int. J. Heat Mass Transfer* **36**(18), 4407 (1993).

14DP. R. M. Fand, M. Sundaram and M. Varahasamy, Incompressible fluid flow through pipes packed with spheres at low dimension ratios, *J. Fluids Engng Trans. ASME* **115**(1), 169 (1993).

15DP. D. J. Gunn and M. M. A. Misbah, Bayesian estimation of heat transport parameters in fixed beds, *Int. J. Heat Mass Transfer* **36**(8), 2209 (1993).

16DP. S. C. Kranc, Performance of counterflow cooling towers with structured packings and maldistributed water flow, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 115 (1993).

17DP. V. V. Kuznetsov and S. B. Chikov, Heat transfer in longitudinal flow past a fuel element in a porous medium, *High Temp.* **31**(2), 334 (1993).

18DP. X. K. Lan and J. M. Khodadadi, Fluid flow and heat transfer through a porous medium channel with permeable walls, *Int. J. Heat Mass Transfer* **36**(8), 2242 (1993).

19DP. G. P. Peterson and X. F. Peng, Experimental investigation of capillary-induced rewetting in a flat porous wicking structure, *J. Energy Resour. Technol. Trans. ASME* **115**(1), 62 (1993).

20DP. A. V. Shenoy, Forced convection heat transfer to an elastic fluid of constant viscosity flowing through a channel filled with a Brinkman–Darcy porous medium, *Wärme Stoffübertrag.* **28**(5), 295 (1993).

21DP. M. Sozen and K. Vafai, Longitudinal heat dispersion in porous beds with real-gas flow, *J. Thermophys. Heat Transfer* 7(1), 153 (1993).

22DP. T. W. Tong, M. C. Sharatchandra and Z. Gdoura, Using porous inserts to enhance heat transfer in laminar fully-developed flows, *Int. Commun. Heat Mass Transfer* **20**(6), 761 (1993).

23DP. E. Tsotsas, Low Péclet number transient heat transfer in packed beds: re-evaluation of the data of Donnadieu, *Chem. Engng Sci.* **48**(19), 3434 (1993).

24DP. V. X. Tung and V. K. Dhir, Convective heat transfer from a sphere embedded in unheated porous media, *J. Heat Transfer Trans. ASME* **115**(2), 503 (1993).

25DP. B.-X. Wang and J.-H. Du, Forced convective heat transfer in a vertical annulus filled with porous media, *Int. J. Heat Mass Transfer* **36**(17), 4207 (1993).

26DP. R. J. Wijingaarden and K. R. Westerterp, A heterogeneous model for heat transfer in packed beds, *Chem. Engng Sci.* **48**(7), 1273 (1993).

27DP. Ruud J. Wijngaarden and K. Roel Westerterp, Pellet heat transfer coefficients in packed beds: global and local values, *Chem. Engng Technol.* **16**(6), 363 (1993).

28DP. L. B. Younis and R. Viskanta, Experimental determination of the volumetric heat transfer coefficient between stream of air and ceramic foam, *Int. J. Heat Mass Transfer* **36**(6), 1425 (1993).

Natural or mixed convection (fixed bed)

29DP. F. Alavyoon, On natural convection in vertical porous enclosures due to prescribed fluxes of heat and mass at the vertical boundaries, *Int. J. Heat Mass Transfer* **36**(10), 2479 (1993).

30DP. T. K. Aldoss, T. S. Chen and B. F. Armaly, Nonsimilarity solutions for mixed convection from horizontal surfaces in a porous medium—Variable surface heat flux, *Int. J. Heat Mass Transfer* **36**(2), 463 (1993).

31DP. T. K. Aldoss, T. S. Chen and B. F. Armaly, Nonsimilarity solutions for mixed convection from horizontal surfaces in a porous medium—Variable wall temperature, *Int. J. Heat Mass Transfer* **36**(2), 471 (1993).

32DP. P. G. Bedrikovetskii, D. G. Polonskii and A. A. Shapiro, Analysis of the convective instability of a binary mixture in a porous medium, *Fluid Dyn.* **28**(1), 82 (1993).

33DP. H. Beji and D. Gobin, Influence of thermal dispersion on natural convection heat transfer in porous media, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **22**(4), 487 (1993).

34DP. B. C. Chandrasekhara and P. Nagaraju, Composite heat transfer in a variable porosity medium bounded by an infinite flat plate, *Wärme Stoffübertrag.* **28**(8), 449 (1993).

35DP. W.-J. Chang and C.-F. Hsiao, Natural convection in a vertical cylinder filled with anisotropic porous media, *Int. J. Heat Mass Transfer* **36**(13), 3361 (1993).

36DP. F. Chen and C. Y. Wang, Convective instability in saturated porous enclosures with a vertical insulating baffle, *Int. J. Heat Mass Transfer* **36**(7), 1897 (1993).

37DP. Falin Chen and C. Y. Wang, Convective instability in a porous enclosure with a horizontal conducting baffle, *J. Heat Transfer* **115**(3), 810 (1993).

38DP. C. Y. Choi and F. A. Kulacki, Non-Darcian effects on mixed convection in a vertical packed-sphere annulus, *J. Heat Transfer Trans. ASME* **115**(2), 506 (1993).

39DP. D. M. Christopher and B.-X. Wang, Non-Darcy natural convection around a horizontal cylinder buried near the surface of a fluid-saturated porous medium, *Int. J. Heat Mass Transfer* **36**(15), 3663 (1993).

40DP. M. Chung and I. Catton, Steam injection into a slow water flow through porous media, *J. Heat Transfer* **115**(3), 734 (1993).

41DP. L. Dresner, Thermomechanical flow of He II through porous bodies, *Cryogenics* **33**(9), 842 (1993).

42DP. P. Dutta and K. N. Seetharamu, Free convection in a saturated porous medium adjacent to a vertical impermeable wall subjected to a non-uniform heat flux, *Wärme Stoffübertrag.* **28**(12), 27 (1993).

43DP. J. C. Hsieh, T. S. Chen and B. F. Armaly, Nonsimilarity solutions for mixed convection from vertical surfaces in porous media : variable surface temperature or heat flux, *Int. J. Heat Mass Transfer* **36**(6), 1485 (1993).

44DP. J. C. Hsieh, T. S. Chen and B. F. Armaly, Mixed convection along a nonisothermal vertical flat plate embedded in a porous medium: the entire regime, *Int. J. Heat Mass Transfer* **36**(7), 1819 (1993).

45DP. J.-Y. Jang and J.-L. Chen, Thermal dispersion and inertia effects on vortex instability of a horizontal mixed convection flow in a saturated porous medium, *Int. J. Heat Mass Transfer* **36**(2), 383 (1993).

46DP. J.-Y. Jang and J.-S. Leu, Variable viscosity effects on the vortex instability of free convection boundary layer flow over a horizontal surface in a porous medium, *Int. J. Heat Mass Transfer* **36**(5), 1287 (1993).

47DP. J.-Y. Jang and J.-L. Chen, Variable porosity effect on vortex instability of a horizontal mixed convection flow in a saturated porous medium, *Int. J. Heat Mass Transfer* **36**(6), 1573 (1993).

48DP. S. Kimura, Y. Masuda and K. Hayashi, Natural convection in an anisotropic porous medium heated from the side (effects of anisotropic properties of porous matrix), *Heat Transfer Jpn Res.* **22**(2), 139 (1993).

49DP. J. L. Lage, On the theoretical prediction of transient heat transfer within a rectangular fluid-saturated porous medium enclosure, *J. Heat Transfer Trans. ASME* **115**(4), 1069 (1993).

50DP. J. L. Lage, Effect of the convective inertia term on Bènard convection in a porous medium, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **22**(4), 469 (1993).

51DP. J. L. Lage, Natural convection within a porous medium cavity predicting tools for flow regime and heat transfer, *Int. Commun. Heat Mass Transfer* **20**(4), 501 (1993).

52DP. Kun-Nun Lie and Jiin-Yuh Jang, Boundary and inertia effects on vortex instability of a horizontal mixed convection flow in a porous medium, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 361 (1993).

53DP. C. Y. Lin, New approach for simulation of cyclic steam stimulation above fracture pressure by modifying a thermal simulator, *SPE Adv. Technol. Ser.* **1**(1), 90 (1993).

54DP. M. S. Malashetty, Anisotropic thermoconvective effects on the onset of double diffusive convection in a porous medium, *Int. J. Heat Mass Transfer* **36**(9), 2397 (1993).

55DP. A. Nakayama, Free convection from a horizontal line heat source in a power-law fluid-saturated porous medium, *Int. J. Heat Fluid Flow* **14**(3), 279 (1993).

56DP. A. Nakayama, A similarity solution for free convection from a point heat source embedded in a non-Newtonian fluid-saturated porous medium, *J. Heat Transfer Trans. ASME* **115**(2), 510 (1993).

57DP. D. A. Nield, Correlation formulas for mixed convection heat transfer in saturated porous media, *Int. J. Heat Fluid Flow* **14**(2), 206 (1993).

58DP. V. M. Polyaev and A. A. Genbach, Heat transfer in a porous system in the presence of both capillary and gravity forces, *Therm. Engng* **40**(7), 551 (1993).

59DP. V. Prasad, Flow instabilities and heat transfer in fluid overlying horizontal porous layers, *Exp. Therm. Fluid Sci.* **6**(2), 135 (1993).

60DP. K. Pruess and Yu-Shu Wu, New semi-analytical method for numerical simulation of fluid and heat flow in fractured reservoirs, *SPE Adv. Technol. Ser.* **1**(2), 63 (1993).

61DP. M. D. Abdus Sattar, Free and forced convection boundary layer flow through a porous medium with large suction, *Int. J. Energy Res.* **17**(1), 1 (1993).

62DP. R. C. Sharma and U. Gupta, Thermal instability of compressible fluids with Hall currents and suspended particles in porous medium, *Int. J. Engng Sci.* **31**(7), 1053 (1993).

63DP. A. K. Singh, E. Leonardi and G. R. Thorpe, Three-dimensional natural convection in a confined fluid overlying a porous layer, *J. Heat Transfer* **115**(3), 631 (1993).

64DP. A. K. Stubos, C. Satik and Y. C. Yortsos, Critical heat flux hysteresis in vapor–liquid counterflow in porous media, *Int. J. Heat Mass Transfer* **36**(1), 227 (1993).

65DP. A. K. Stubos, C. Satik and Y. C. Yortsos, Effects of capillary heterogeneity on vapor–liquid counterflow in porous media, *Int. J. Heat Mass Transfer* **36**(4), 967 (1993).

66DP. Jie Tang and Haim H. Bau, Feedback control stabilization of the no-motion state of a fluid confined in a horizontal porous layer heated from below, *J. Fluid Mech.* **257**, 485 (1993).

67DP. P. Vadasz, Three-dimensional free convection in a long rotating porous box: analytical solution, *J. Heat Transfer* **115**(3), 639 (1993).

68DP. P. Vadasz, C. Braester and J. Bear, The effect of perfectly conducting side walls on natural convection in porous media, *Int. J. Heat Mass Transfer* **36**(5), 1159 (1993).

69DP. P. Vasseur and L. Robillard, The Brinkman model for natural convection in a porous layer: effects of nonuniform thermal gradient, *Int. J. Heat Mass Transfer* **36**(17), 4199 (1993).

70DP. H. H. Vaziri and A. M. Britto, Theory and applications of a fully coupled thermo-hydro-mechanical finite-element model, *Soc. Pet. Engng AIME Pap. SPE*, **245** (1993).

71DP. C.-Y. Wang and C. Beckermann, A two-phase mixture model of liquid–gas flow and heat transfer in capillary porous media—I. Formulation, *Int. J. Heat Mass Transfer* **36**(11), 2747 (1993).

72DP. C.-Y. Wang and C. Beckermann, A two-phase mixture model of liquid–gas flow and heat transfer in capillary porous media—II. Application to pressure-driven boiling flow adjacent to a vertical heated plate, *Int. J. Heat Mass Transfer* **36**(11), 2759 (1993).

73DP. Y. Yamaguchi, Y. Asako, H. Nakamura and M. Faghri, Three-dimensional natural convection in a vertical porous layer with hexagonal honeycomb core of negligible thickness, *Int. J. Heat Mass Transfer* **36**(13), 3403 (1993).

74DP. X. Zhang, Natural convection and heat transfer in a vertical cavity filled with an ice-water saturated porous medium, *Int. J. Heat Mass Transfer* **36**(11), 2881 (1993).

Fluidized beds

75DP. H. B. R. Ackeskog, A. E. Almstedt and V. Zakkay, An investigation of fluidized-bed scaling: heat transfer measurements in a pressurized fluidized-bed combustor and a cold model bed, *Chem. Engng Sci.* **48**(8), 1459 (1993).

76DP. T. Aihara, S. Maruyama, K. Tanaka and J. Yamaguchi, Heat transfer and fluidization characteristics of a high-temperature shallow fluidized bed, *Exp. Therm. Fluid Sci.* **6**(3), 282 (1993).

77DP. R. C. Brown, Correction of systematic errors in measuring convection coefficients in a liquid-fluidized bed, *Chem. Engng Sci.* **48**(3), 521 (1993).

78DP. A. M. Buibenshikov, A. V. Starchenko and V. V. Stropus, Numerical modeling of aerodynamics and heat-and-mass transfer in the furnace of a steam boiler with a circulating fluidized bed, *Therm. Engng* **40**(9), 680 (1993).

79DP. Yu-Min Chang and Mei-Yen Chen, Industrial waste to energy by circulating fluidized bed combustion, *Resour. Conserv. Recycl.* **9**(4), 281 (1993).

80DP. C. Du and R. Turton, Theoretical study of the limiting heat transfer coefficient in fluidized beds, *Chem. Engng Commun.* **121,** 99 (1993).

81DP. T. A. Ebert, L. R. Glicksman and M. Lints, Determination of particle and gas convective heat transfer components in a circulating fluidized bed, *Chem. Engng Sci.* **48**(12), 2179 (1993).

82DP. H. El-Dessouky, Thermal and hydraulic performance of a three-phase fluidized bed cooling tower, *Exp. Therm. Fluid Sci.* **6**(4), 417 (1993).

83DP. R. S. Figliola and D. E. Beasley, A study of the particle convection contribution to heat transfer in gas fluidized beds, *Chem. Engng Sci.* **48**(14), 2901 (1993).

84DP. K. Findlay and S. D. Probert, Limiting NO_x and SO_2 emissions from an industrial-size fluidised-bed combustor, *Appl. Energy* **45**(1), 1 (1993).

85DP. Y. Flitris and P. Hatzikonstantinou, Numerical treatment of the heat transfer from wall to fluidized bed using the particle model, *Computers Chem. Engng* **17**(9), 885 (1993).

86DP. L. A. P. Freitas and J. T. Freire, Heat transfer in spouted beds, *Drying Technol.* **11**(2), 303 (1993).

87DP. A. H. George, Instantaneous local heat transfer coefficients and related frequency spectra for a horizontal cylinder in a high temperature fluidized bed, *Int. J. Heat Mass Transfer* **36**(2), 337 (1993).

88DP. J. S. Halow, G. E. Fasching, P. Nicoletti and J. L. Spenik, Observations of a fluidized bed using capacitance imaging, *Chem. Engng Sci.* **48**(4), 643 (1993).

89DP. D. J. Highgate, S. D. Probert, C. Ziane and J. K. Pedersen, Heat transfers through mechanically-stimulated particle beds, *Appl. Energy* **46**(4), 367 (1993).

90DP. R. Joulié and G. M. Rios, Theoretical analysis of heat and mass transfer phenomena during fluidized bed sublimation, *Drying Technol.* **11**(1), 157 (1993).

91DP. K. Kamiuto and Y. Tokita, Bed-to-wall radiative heat transfer in a gas–solid fluidized bed, *Energy* **18**(9), 893 (1993).

92DP. S. Kumar, K. Kusakabe and L.-S. Fan, Heat transfer in three-phase fluidized beds containing low-density particles, *Chem. Engng Sci.* **48**(13), 2407 (1993).

93DP. K. C. Leong and G. Q. Lu, Heat transfer in fluidized bed coating of copper cylinders, *Int. Commun. Heat Mass Transfer* **20**(5), 699 (1993).

94DP. H.-S. Li,. R.-Z. Qian, W.-D. Huang and K.-J. Bi, An investigation on instantaneous local heat transfer coefficients in high-temperature fluidized beds—II. Statistical analysis, *Int. J. Heat Mass Transfer* **36**(18), 4397 (1993).

95DP. T. M. Linjewile, A. S. Hull and P. K. Agarwall, Heat transfer to a large mobile particle in gas–fluidized beds of smaller particles, *Chem. Engng Sci.* **48**(21), 3671 (1993).

96DP. J. D. Lu, G. Flamant and P. Snabre, Towards a generalized model for vertical walls to Gas–Solid fluidized beds heat transfer—I. Particle convection and gas convection, *Chem. Engng Sci.* **48**(13), 2479 (1993).

97DP. L. A. Ochoa Martinez, J. G. Brennan and K. Niranjan, Drying of liquids in a spouted bed of inert particles: heat transfer studies, *J. Food Engng* **20**(2), 135 (1993).

98DP. M. Miyamoto, Y. Katoh and Y. Idei, Heat transfer and particle behavior around horizontal tube bundle in gas fluidized bed, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1291 (1993).

99DP. O. Molerus, Arguments on heat transfer in gas fluidized beds, *Chem. Engng Sci.* **48**(4), 761 (1993).

100DP. R. Z. Qian and S. C. Saxena, Heat transfer from an immersed surface in a magnetofluidized bed, *Int. Commun. Heat Mass Transfer* **20**(6), 859 (1993).

101DP. S. C. Saxena and N. S. Rao, Characteristics of a fluidized-bed incinerator for the combustion of solid wastes, *Energy Convers. Manage.* **34**(2), 81 (1993).

102DP. T. N. Tulasidas, T. Kudra, G. S. V. Raghavan and A. S. Mujumdar, Effect of bed height on simultaneous heat and mass transfer in a two-dimensional spouted bed dryer, *Int. Commun. Heat Mass Transfer* **20**(1), 79 (1993).

103DP. G. Visser and M. Valk, The porosity in a fluidized bed heat transfer model, *Int. J. Heat Mass Transfer* **36**(3), 627 (1993).

104DP. E. P. Volchkov, V. I. Terekhov, A. N. Kaidanik and A. N. Yadykin, Aerodynamics and heat and mass transfer of fluidized particle beds in vortex chambers, *Heat Transfer Engng* **14**(3), 36 (1993).

105DP. T. Watanabe, Yong Chen, M. Hasatani and I. Naruse, Gas–solid interfacial heat transfer in circulating fluidized beds, *Heat Transfer Jpn Res.* **22**(3), 269 (1993).

Heat transfer combined with mass transfer, chemical reactions or phase change

106DP. W. Blumberg and E.-U. Schlünder, Simultaneous vapor and liquid diffusion in partially wetted porous media, *Drying Technol.* **11**(1), 41 (1993).

107DP. B. A. Burakov, N. A. Obukhov, R. K. Faizullin, S. F. Saidu and S. M. Alatortsev, Complex mathematical modeling of the interaction of high-temperature two-phase flows with carbon–graphite heat shield materials, *High Temp.* **30**(5), 826 (1993).

108DP. F. Chen and C. F. Chen, Double-diffusive fingering convection in a porous medium, *Int. J. Heat Mass Transfer* **36**(3), 793 (1993).

109DP. G. Daccord, R. Lenormand and O. Liétard, Chemical dissolution of a porous medium by a reactive fluid—I. Model for the "Wormholing" phenomenon, *Chem. Engng Sci.* **48**(1), 169 (1993).

110DP. G. Daccord, O. Liétard and R. Lenormand, Chemical dissolution of a porous medium by a reactive fluid—II. Convection vs reaction, behavior diagram, *Chem. Engng Sci.* **48**(1), 179 (1993).

111DP. I. A. El-Osery, M. A. El-Osairy, A. M. Metwally, M. M. Keshk and M. El-Gammal, Dynamic simulation of the convective model for metal hydride hydrogen storage beds, *Energy Sources* **15**(3), 523 (1993).

112DP. M. M. Elsayed, H. N. Gari and A. M. Radhwan, Effectiveness of heat and mass transfer in packed beds of liquid dessicant system, *Renewable Energy* **3**(67), 661 (1993).

113DP. K. Hanamura, R. Echigo and S. A. Zhdanok, Superadiabatic combustion in a porous medium, *Int. J. Heat Mass Transfer* **36**(13), 3201 (1993).

114DP. P.-F. Hsu, J. R. Howell and R. D. Matthews, A numerical investigation of premixed combustion within porous inert media, *J. Heat Transfer* **115**(3), 744 (1993).

115DP. Bhaskar Joshi, S. L. Barbour, A. E. Krause and G. W. Wilson, Finite element model for the coupled flow of heat and moisture in soils under atmospheric forcing, *Finite Elem. Anal. Des.* **15**(1), 57 (1993).

116DP. F. Kallel, N. Galanis, B. Perrin and R. Javelas, Effects of moisture on temperature during drying of consolidated porous materials, *J. Heat Transfer* **115**(3), 724 (1993).

117DP. Y. A. Kilic, N. Kahveci, I. Dincer and T. Bardakci, Experimental and theoretical investigation of transient heat transfer between a spherical coal particle and air medium during devolatilization, *Int. Commun. Heat Mass Transfer* **20**(5), 711 (1993).

118DP. K. Matsumoto, M. Okada, M. Murukami and Y. Yabushita, Solidification of porous medium saturated with aqueous solution in a rectangular cell, *Int. J. Heat Mass Transfer* **36**(11), 2869 (1993).

119DP. C. H. A. Molenda, P. Crausse and D. Lemarchand, Heat and humidity transfer in non-saturated porous media: capillary hysteresis effects under cyclic thermal conditions, *Int. J. Heat Mass Transfer* **36**(12), 3077 (1993).

120DP. K. Muralidhar and M. Verghese, Analysis of adsorption and desorption processes in a porous medium, *Int. Commun. Heat Mass Transfer* **20**(1), 43 (1993).

121DP. M. Prat, Percolation Model of drying under isothermal conditions in porous media, *Int. J. Multiphase Flow* **19**(4), 691 (1993).

122DP. M. M. Rahman and A. Faghri, Transport in a thin liquid film on the outer surface of a wedge or cone embedded in a porous medium—I. Mathematical analysis, *Int. Commun. Heat Mass Transfer* **20**(1), 15 (1993).

123DP. S. K. Rastogi and D. Poulikakos, Double diffusion in a liquid layer underlying a permeable solid region, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(4), 427 (1993).

124DP. J. W. Ribeiro, R. M. Cotta and M. D. Mikhailov, Integral transform solution of Luikov's equations for heat and mass transfer in capillary porous media, *Int. J. Heat Mass Transfer* **36**(18), 4467 (1993).

125DP. K. Sasaguchi, K. Kusano and N. Nishimizu, Solid–liquid phase change heat transfer in porous media (effects of fins on the solidification process), *Heat Transfer Jpn Res.* **22**(4), 398 (1993).

126DP. M. Song, J. Choi and R. Viskanti, Upward solidification of a binary solution saturated porous medium, *Int. J. Heat Mass Transfer* **36**(15), 3687 (1993).

127DP. V. M. Soundalgekar, R. M. Lahurikar and S. G. Pohanerkar, Mass transfer effects on the unsteady forced and free convection flow through a porous medium past an infinite vertical isothermal plate, *J. Heat Transfer Trans. ASME* **115**(1), 276 (1993).

128DP. Y.-X. Tao and D. M. Gray, Validation of local thermal equilibrium in unsaturated porous media with simultaneous flow and freezing, *Int. Commun. Heat Mass Transfer* **20**(3), 323 (1993).

129DP. R. S. Telles and O. V. Trevisan, Dispersion in heat and mass transfer natural convection along vertical boundaries in porous media, *Int. J. Heat Mass Transfer* **36**(5), 1357 (1993).

130DP. J. L. Torero, A. C. Fernandez-Pello and M. Kitano, Opposed forced flow smoldering of polyurethane foam, *Combust. Sci. Technol.* **91**(13), 95 (1993).

131DP. K. Vafai, C. P. Desai and S. C. Chen, Investigation of heat transfer process in a chemically reacting packed bed, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(2), 127 (1993).

132DP. D. Vortmeyer and E. Haidegger, Authors' Reply to Comments by K. R. Westerterp *et al.*, *Chem. Engng Sci.* **48**(14), 2670 (1993).

133DP. K. M. Waananen, J. B. Litchfield and M. R. Okos, Classification of drying models for porous solids, *Drying Technol.* **11**(1), 1 (1993).

134DP. K. R. Westerterp, W. de Jong and G. H. W. van Benthem, Comments on "Discrimination of three approaches to evaluate heat fluxes for wall-cooled fixed bed chemical reactors", *Chem. Engng Sci.* **48**(14), 2669 (1993).

135DP. W.-P. Yu, B.-X. Wang and M.-H. Shi, Modeling of heat and mass transfer in unsaturated wet porous media with consideration of capillary hysteresis, *Int. J. Heat Mass Transfer* **36**(15), 3671 (1993).

136DP. Z.-G. Yuan and K. S. Udell, Steam distillation of a single component hydrocarbon liquid in porous media, *Int. J. Heat Mass Transfer* **36**(4), 887 (1993).

137DP. L. Zhang and P. J. Fryer, Models for the electrical heating of solid–liquid food mixtures, *Chem. Engng Sci.* **48**(4), 633 (1993).

EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION

Heat transfer measurements

1E. D. A. Aliaga, D. E. Klein and J. P. Lamb, Heat transfer measurements on a ribbed surface at constant heat flux using infrared thermography, *Exp. Heat Transfer* **6**(1), 17 (1993).

2E. D. N. Assanis and F. A. Friedmann, Thin film thermocouple for transient heat transfer measurements in ceramic-coated combustion chambers, *Int. Commun. Heat Mass Transfer* **20**(4), 459 (1993).

3E. C. Camci, K. Kim, S. A. Hippensteele and P. E. Poinsatte, Evaluation of a hue capturing based transient liquid crystal method for high-resolution mapping of convective heat transfer on curved surfaces, *J. Heat Transfer Trans. ASME* **115**(2), 311 (1993).

4E. A. Dasgupta, P. Guenard, J. S. Ultman, J. S. Kimbell and K. T. Morgan, A photographic method for the visualization of mass uptake patterns in aqueous systems, *Int. J. Heat Mass Transfer* **36**(2), 453 (1993).

5E. R. S. Figliola, M. Swaminathan and D. E. Beasley, A study of the dynamic response of a local heat flux probe, *Meas. Sci. Technol.* **4**(10), 1052 (1993).

6E. R. S. Graves, D. L. McElroy and T. G. Kollie, Evaluation of a commercial, computer-operated heat flow meter apparatus, *Rev. Scient. Instrum.* **64**(7), 1961 (1993).

7E. J. M. Hager, L. W. Langley, S. Onishi and T. E. Diller, Microsensors for high heat flux measurements, *J. Thermophys. Heat Transfer* 7(3), 531 (1993).

8E. B. E. Handy, S. B. Sharma, B. E. Spiewak and J. A. Dumesic, A Tian–Calvet heat-flux microcalorimeter for measurement of differential heats of adsorption, *Meas. Sci. Technol.* 4(12), 1350 (1993).

9E. M. Naci Inci, S. R. Kidd, J. S. Barton and J. D. C. Jones, High temperature miniature fibre optic interferometric thermal sensors, *Meas. Sci. Technol.* **4**(3), 382 (1993).

10E. S. R. Kidd, P. G. Sinha, J. S. Barton and J. D. C. Jones, Wind tunnel evaluation of novel interferometric optical fibre heat transfer gauges, *Meas. Sci. Technol.* 4(3), 362 (1993).

11E. S. R. Kidd, P. G. Sinha, J. S. Barton and J. D. C. Jones, Wind tunnel evaluation of novel interferometric optical fiber heat transfer gauges, *Engng Optics* **6**(2), 199 (1993).

12E. A. Kondjoyan and J. D. Daudin, Determination of transfer coefficients by psychrometry, *Int. J. Heat Mass Transfer* 36(7), 1807 (1993).

13E. S. Okuyama, Y. Nakamura and S. Kawamura, Cooling action of grinding fluid in shallow grinding, *Int. J. Mach. Tools Manuf.* 33(1), 13 (1993).

14E. M. Pons, P. Dantzer and J. J. Guilleminot, A measurement technique and a new model for the wall heat transfer coefficient of a packed bed of (reactive) powder without gas flow, *Int. J. Heat Mass Transfer* **36**(10), 2635 (1993).

15E. W. Roetzel, Xing Luo and Yimin Xuan, Measurement of heat transfer coefficient and axial dispersion coefficient using temperature oscillations, *Exp. Therm. Fluid Sci.* 7(4), 345 (1993).

16E. W. Roetzel, S. Prinzen and M. Wandelt, Temperature oscillation technique for determination of local convection heat transfer coefficients without fluid temperature measurement, *Chem. Engng Technol.* **16**(2), 89 (1993).

17E. G. Simeonides, J. P. Vermeulen and H. L. Boerrigter, Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography, *IEEE Trans. Aerosp. Electron. Syst.* **29**(3), 878 (1993).

18E. P. Thureau, New thermal fluxmeters using particular auxiliary walls and zero-balanced methods of measurement, *Sens. Actuators A Phys.* **36**(1), 57 (1993).

19E. J. von Wolfersdorf, R. Hoecker and T. Sattelmeyer, A hybrid transient step-heating heat transfer measurement technique using heater foils and liquid-crystal thermography, *J. Heat Transfer Trans. ASME* **115**(2), 319 (1993).

20E. D. M. Wang and J. M. Tarbell, An approximate solution for the dynamic response of wall transfer probes, *Int. J. Heat Mass Transfer* **36**(18), 4341 (1993).

Temperature measurements

21E. S. Ahuja and D. L. Miller, Design of a constant tension thermocouple rake suitable for flame studies, *Rev. Scient. Instrum.* **64**(5), 1358 (1993).

22E. S. Anita and N. Damean, A problem of measurement of temperature solved using the one-dimensional heat equation, *Int. J. Heat Mass Transfer* **36**(4), 1043 (1993).

23E. M. P. Arroyo and R. K. Hanson, Absorption measurements of water vapor concentration, temperature and line-shape parameters using a tunable InGaAsP diode laser, *Appl. Opt.* **32**(30), 6104 (1993).

24E. P. Beckman, R. P. Roy, K. Whitfield and A. Hasan, A fast-response microthermocouple, *Rev. Scient. Instrum.* **64**(10), 2947 (1993).

25E. R. Berman, P. Duggan, M. P. Le Flohic, A. D. May and J. R. Drummond, Spectroscopic technique for measuring the temperature and pressure cycle of a pressure modulator radiometer, *Appl. Opt.* **32**(31), 6280 (1993).

26E. L. M. Besley and Lu Hai, Measurements of internal heat transfer in germanium resistance thermometers, *Rev. Scient. Instrum.* **64**(3), 748 (1993).

27E. D. P. Brunco, J. A. Kittl, C. E. Otis, P. M. Goodwin, Michael O. Thompson and M. J. Aziz, Time-resolved temperature measurements during pulsed laser irradiation using thin film metal thermometers, *Rev. Scient. Instrum.* **64**(9), 2615 (1993).

28E. A. Cezairliyan, R. F. Chang, G. M. Foley and A. P. Miller, High-speed spatial scanning pyrometer, *Rev. Scient. Instrum.* **64**(6), 1584 (1993).

29E. H. Chehouani, S. Benet, S. Brunet and B. Armas, Heat transfer studies in cold CVD reactors using holographic interferometry, *J. Phys.* (Paris) 3(3), 83 (1993).

30E. Ji Ryong Cho and Kyung Chun Kim, A simple high-performance cold-wire thermometer, *Meas. Sci. Technol.* 4(12), 1346 (1993).

31E. P. J. Coetzer, B. M. Lacquet and P. L. Swart, An inexpensive alternative to manual temporal temperature profiling, *Meas. Sci. Technol.* **4**(12), 1512 (1993).

32E. R. B. Farrington, Infrared imaging results of an excited planar jet, *J. Sol. Energy Engng Trans. ASME* **115**(2), 85 (1993).

33E. J. R. Fincke, W. D. Swank, C. L. Jeffry and C. A. Mancuso, Simultaneous measurement of particle size, velocity and temperature, *Meas. Sci. Technol.* 4(5), 559 (1993).

34E. L. J. Forney, E. L. Meeks, J. Ma and G. C. Fralick, Measurement of frequency response in short thermocouple wires, *Rev. Scient. Instrum.* **64**(5), 1280 (1993).

35E. G. C. Fralick and L. J. Forney, Frequency response of a supported thermocouple wire: effects of axial conduction, *Rev. Scient. Instrum.* **64**(10), 3236 (1993).

36E. Lu Hai and L. M. Besley, Analysis of internal heat transfer in germanium resistance thermometers, *Rev. Scient. Instrum.* **64**(3), 741 (1993).

37E. R. Hernberg, J. Stenberg and B. Zethraeus, Simultaneous in-situ measurement of temperature and size of burning char particles in a fluidized bed furnace by means of fiberoptic pyrometry, *Combust. Flame* **95**(12), 191 (1993).

38E. M. J. Holcomb, J. P. Collman and W. A. Little, Thermal difference spectroscopy, *Rev. Scient. Instrum.* **64**(7), 1862 (1993).

39E. S. Kampmann, A. Leipertz, K. Döbbeling, J. Haumann and Th. Sattelmayer, Two-dimensional temperature measurements in a technical combustor with laser Rayleigh scattering, *Appl. Opt.* **32**(30), 6167 (1993).

40E. M. P. Lee, B. K. McMillan and R. K. Hanson, Temperature measurements in gases using planar laser-induced fluorescence imaging of NO, *Appl. Opt.* **32**(27), 5379 (1993).

41E. J. G. Liebeskind, R. K. Hanson and M. A. Cappelli, Laser-induced fluorescence diagnostic for temperature and velocity measurements in a hydrogen arcjet plume, *Appl. Opt.* **32**(30), 6117 (1993).

42E. O. R. Loesener, M. Auweter-Kurtz, M. Hartling and E. W. Messerschmid, Linear pyrometer for investigations of thermal protection systems, *J. Thermophys. Heat Transfer* 7(1), 82 (1993).

43E. V. A. Loshkarev, Diagnostics of near-wall boundary layers on the surface of ablating materials, *High Temp.* **31**(3), 501 (1993).

44E. B. J. Luff and P. D. Townsend, High sensitivity thermoluminescence spectrometer, *Meas. Sci. Technol.* **4**(1), 65 (1993).

45E. F. Mayinger, The 1991 Max Jakob Memorial Award Lecture: Image-forming optical techniques in heat transfer: revival by computer-aided data processing, *J. Heat Transfer Trans. ASME* **115**(4), 824 (1993).

46E. M. Megahed, Estimation of the potential of a fluorescence thermometer for diesel spray studies, *Appl. Opt.* **32**(25), 4790 (1993).

47E. P. C. Miles and F. C. Gouldin, Determination of the time constant of fine-wire thermocouples for compensated temperature measurements in premixed turbulent flames, *Combust. Sci. Technol.* **89**(14), 181 (1993).

48E. J. Houston Miller, S. Elreedy, B. Ahvazi, F. Woldu and P. Hassanzadeh, Tunable diode-laser measurement of carbon monoxide concentration and temperature in a laminar methane–air diffusion flame, *Appl. Opt.* **32**(30), 6082 (1993).

49E. M. Nishiguchi, M. Fujihara, A. Miki and H. Nishizawa, Precision comparison of surface temperature measurement techniques for GaAs IC's, *IEEE Trans. Compon. Hybrids Mfg Technol.* **16**(5), 543 (1993).

50E. L. Peng and L. M. Besley, The properties of Chinese standard rhodium–iron resistance thermometers, *Meas. Sci. Technol.* **4**(12), 1357 (1993).

51E. L. C. Philippe and R. K. Hanson, Laser diode wavelength-modulation spectroscopy for simultaneous measurement of temperature, pressure and velocity in shock-heated oxygen flows, *Appl. Opt.* **32**(30), 6090 (1993).

52E. T. Q. Qiu, C. P. Grigoropoulos and C. L. Tien, Novel technique for non-contact and microscale temperature measurements, *Exp. Heat Transfer* **6**(3), 231 (1993).

53E. W. Reckers, L. Hüwel, G. Grünefeld and P. Andresen, Spatially resolved multispecies and temperature analysis in hydrogen flames, *Appl. Opt.* **32**(6), 907 (1993).

54E. D. S. Rimai, R. Anne and R. C. Bowen, The fabrication of thin-film thermocouples for determining the temperature and thermal conductivity within a flexible material, *Rev. Scient. Instrum.* **64**(6), 1601 (1993).

55E. F. Z. Roissac, T. T. Osman and J. F. Sacadura, Surface temperature measurement in semitransparent media, *J. Thermophys. Heat Transfer* **7**(4), 608 (1993).

56E. K. Sahli, L. Hochard and A. M. Pointu, Temperature measurements in oxygen negative glow using a synthetic low-resolution spectrum, *Meas. Sci. Technol.* **4**(6), 685 (1993).

57E. J. Sakakibara, K. Hishida and M. Maeda, Measurements of thermally stratified pipe flow using image-processing techniques, *Exp. Fluids* **16**(2), 82 (1993).

58E. W. Smetana and J. Nicolics, Application of integrated thick-film thermocouples for a laser power detector, *Sens. Actuators A Phys.* **37/38**(2), 565 (1993).

59E. T. A. S. Srinivas, P. J. Timans, R. J. Butcher and H. Ahmed, Thermal and infrared performance of a free-standing microthermocouple, *Rev. Scient. Instrum.* **64**(12), 3602 (1993).

60E. T. Tajima and K. Kawahira, Liquid crystal techniques of visualization in rotating annulus experiments, *Exp. Fluids* **14**(12), 65 (1993).

61E. T. Varpula and H. Seppä, Inductive noise thermometer: practical realization, *Rev. Scient. Instrum.* **64**(6), 1593 (1993).

62E. N. Wending, J. Chaussy, P. Leay, J. Mazuer and J. Odin, Calibration of the thermocouple Au/AlSi 1 at.%: relative and absolute thermoelectric powers, *Meas. Sci. Technol.* **4**(6), 689 (1993).

63E. J. Zhang and L. A. Melton, Potential systematic errors in droplet temperatures obtained by fluorescence methods, *J. Heat Transfer Trans. ASME* **115**(2), 325 (1993).

64E. Da-Ming Zhu and Fengqi Lin, Fabrication of Ge–Au film thermometers using interfacial atomic diffusion, *Rev. Scient. Instrum.* **64**(9), 2624 (1993).

Velocity, concentration and flow visualization measurements—single phase

65E. R. S. Azad, Effect of hot-wire length and length–diameter ratio on spectral energy of turbulence, *Meas. Sci. Technol.* **4**(3), 405 (1993).

66E. J. L. Bailey, J. Vresk and M. Acharya, Evaluation of the performance characteristics of a thermal transient anemometer, *Exp. Fluids* **15**(1), 10 (1993).

67E. A. I. Bril', O. B. Zhdanovich, V. P. Kabashnikov, A. N. Kuz'min and Yu. V. Khodyko, Development of diagnostic methods for industrial discharges on the basis of radiometric measurements, *High Temp.* **31**(1), 136 (1993).

68E. B. Castaing, B. Chabaud, B. Hebral and J. Peinke, A hot wire anemometer for cryogenic hydrodynamic experiments, *Appl. Sci. Res.* **51**(12), 143 (1993).

69E. P. A. Daniels, Turbulence measured by anemometers, kites and turbine blade strain, *J. Sol. Energy Eng. Trans. ASME* **115**(4), 226 (1993).

70E. A. Demetriades, Frequency response of constant-current film anemometers, *Int. J. Heat Mass Transfer* **36**(1), 231 (1993).

71E. C. Deslouis, F. Huet, S. Robin and B. Tribollet, Spectral analysis of wall turbulence with photolithography devised electrochemical probes, *Int. J. Heat Mass Transfer* **36**(3), 823 (1993).

72E. G. P. Doggett and N. Chokani, Large-field laser holographic focusing Schlieren system, *J. Spacecr. Rockets* **30**(6), 742 (1993).

73E. J. W. Elsner, P. Domagala and W. Elsner, Effect of finite spatial resolution of hot-wire anemometry on measurements of turbulence energy dissipation, *Meas. Sci. Technol.* **4**(4), 517 (1993).

74E. Y. Era, Simultaneous measurement of concentration and velocity by applying hot-wire techniques—I, *Heat Transfer Jpn Res.* **22**(1), 14 (1993).

75E. Y. Era and A. Muramatsu, Simultaneous measurement of concentration and velocity by applying hot-wire techniques—II, *Heat Transfer Jpn Res.* **22**(1), 28 (1993).

76E. T. J. Gieseke and Y. G. Guezennec, An experimental approach to the calibration and use of triple hot-wire probes, *Exp. Fluids* **14**(5), 305 (1993).

77E. L. Gong, O. A. Plumb and W. C. Lee, Near-infrared measurement of surface moisture on porous materials, *Exp. Heat Transfer* **6**(3), 299 (1993).

78E. P.-A. Krogstad, R. A. Antonia and L. W. B. Browne, The use of orthogonal X-wire arrays for structure investigation in a turbulent boundary layer, *Exp. Fluids* **15**(45), 231 (1993).

79E. D. K. Lambert, Mass flow sensing with heat waves: the effect of gas pressure, *Int. J. Heat Mass Transfer* **36**(10), 2623 (1993).

80E. C. Magness, O. Robinson and D. Rockwell, Laser-scanning particle image velocimetry applied to a delta wing in transient maneuver, *Exp. Fluids* **15**(3), 159 (1993).

81E. B. Marasli, P. Nguyen and J. M. Wallace, A calibration technique for multiple-sensor hot-wire probes and its application to vorticity measurements in the wake of a circular cylinder, *Exp. Fluids* **15**(3), 209 (1993).

82E. A. Muramatsu and Y. Era, Simultaneous measurement of concentration and velocity by applying hot-wire techniques—III, *Heat Transfer Jpn Res.* **22**(1), 48 (1993).

83E. G. Papadopoulos and M. V. Ötügen, A simple automated hot-wire positioning technique for near-wall measurements, *Exp. Fluids* **15**(6), 459 (1993).

84E. L. Pompeo and H. Thomann, Quadruple hot-wire probes in a simulated wall flow, *Exp. Fluids* **14**(3), 145 (1993).

85E. D. Rockwell, C. Magness, J. Towfighi, O. Akin and T. Corcoran, High image-density particle image velocimetry using laser scanning techniques, *Exp. Fluids* **14**(3), 181 (1993).

86E. L. M. Sun, F. Meunier and J. Kärger, On the heat effect in measurements of sorption kinetics by the frequency response method, *Chem. Engng Sci.* **48**(4), 715 (1993).

87E. Ö. F. Turan, S. E. Semercigil and G. Chukkapalli, Effect of structural vibrations on hot-wire probe response, *Meas. Sci. Technol.* **4**(12), 1416 (1993).

88E. C. P. Yeung and L. C. Squire, Numerical calibration and verification tests of an orthogonal triple-hot-wire probe, *Meas. Sci. Technol.* **4**(12), 1446 (1993).

Multiphase flow measurements

89E. K. Bauckhage, Phase Doppler anemometry for balancing and modelling multiphase flow, *Chem. Ing. Tech.* **65**(8), 929 (1993).

90E. Y. Jiang and K. S. Rezkallah, An experimental study of the suitability of using a gamma densitometer for void fraction measurements in gas–liquid flow in a small diameter tube, *Meas. Sci. Technol.* **4**(4), 496 (1993).

91E. M. W. McDonough and A. Faghri, Ultrasonic measurement of interface positions during the solidification of an aqueous sodium carbonate solution around a vertical cylinder, *Exp. Heat Transfer* **6**(3), 215 (1993).

92E. S. T. Revankar and M. Ishii, Theory and measurement of local interfacial area using a four sensor probe in two-phase flow, *Int. J. Heat Mass Transfer* **36**(12), 2997 (1993).

93E. P. F. Vassallo, T. A. Trabold, W. E. Moore and G. J. Kirouac, Measurement of velocities in gas–liquid two-phase flow using laser doppler velocimetry, *Exp. Fluids* **15**(3), 227 (1993).

Properties

94E. E. A. Artyukhin, G. A. Ivanov and A. V. Nenarokomov, Determining the thermophysical characteristics of materials on the basis of nonsteady temperature measurements, *High Temp.* **31**(2), 269 (1993).

95E. G. Bastian and N. Al. Sheikh Hassan, Détermination instantanée de l'effusivité massique d'humidité d'un matériau hygroscopique, *Int. J. Heat Mass Transfer* **36**(3), 743 (1993).

96E. G. Benedetto, R. Spagnolo and L. Boarino, Photothermal displacement technique: a method to determine the variation of thermal conductivity vs temperature in silicon, *Rev. Scient. Instrum.* **64**(8), 2229 (1993).

97E. M. Bertolotti, R. Li Voti, G. Liakhou and C. Sibilia, On the photodeflection method applied to low thermal diffusivity measurements, *Rev. Scient. Instrum.* **64**(6), 1576 (1993).

98E. S. Bosch and J. Roca, A method for the measurement of reflectances of spherical surfaces, *Meas. Sci. Technol.* **4**(2), 190 (1993).

99E. P. J. Brannon, A technique for measuring radiation-induced infrared absorption in optical materials located in or near a nuclear reactor, *Rev. Scient. Instrum.* **64**(4), 1085 (1993).

100E. O. Budke and P. Dieska, Temperature dependence measurements of thermal parameters of solid samples by the relaxation method, *Int. J. Heat Mass Transfer* **36**(15), 3869 (1993).

101E. V. Calzona, M. R. Cimberle, C. Ferdeghini, G. Grasso, M. Putti and A. S. Siri, A new technique to obtain a fast thermocouple sensor for thermal diffusivity measurements in an extended temperature range, *Rev. Scient. Instrum.* **64**(12), 3612 (1993).

102E. M. Chung and J. W. Brill, Specific heats of type E thermocouple wires, *Rev. Scient. Instrum.* **64**(7), 2037 (1993).

103E. G. Goch, B. Schmitz, M. Reick and R. Hocken, Photothermal sensing techniques for measuring material properties and near-surface defects, *Ann. CIRP.* **42**(1), 623 (1993).

104E. J. E. Graebner, Simple method for measuring the thermal conductivity of a thin plate, *Rev. Scient. Instrum.* **64**(10), 3245 (1993).

105E. M. A. Havstad, W. McLean II and S. A. Self, Apparatus for the measurement of the optical constants and thermal radiative properties of pure liquid metals from 0.4 to 10 μm, *Rev. Scient. Instrum.* **64**(7), 1971 (1993).

106E. J. Heinrich, M. J. Clifton and H. Wagner, Use of in-situ conductivity measurements to calculate the flow field and heat transfer in continuous-flow electrophoresis, *Int. J. Heat Mass Transfer* **36**(15), 3703 (1993).

107E. S. O. Kasap and V. Mirchandani, Method and apparatus for thermoacoustimetry: applications to polymers and glasses, *Meas. Sci. Technol.* **4**(11), 1213 (1993).

108E. D. Leclercq and P. Thery, Utilization of the Peltier effect for measuring a fluid property. Application for designing new sensors, *Meas. Sci. Technol.* **4**(2), 158 (1993).

109E. T. Log, Transient one-dimensional heat flow technique for measuring thermal conductivity of solids, *Rev. Scient. Instrum.* **64**(7), 1956 (1993).

110E. T. Log, Transient hot-strip (THS) method for measuring thermal conductivity of thermally insulating materials, *Fire Mater.* **17**(3), 131 (1993).

111E. M. S. Miller and A. J. Kotlar, Technique for measuring thermal diffusivity–conductivity of small thermal-insulator specimens, *Rev. Scient. Instrum.* **64**(10), 2954 (1993).

112E. M. E. Shackleton and R. G. Green, On-line viscometer for measurement in the range 1–100 Pa s, *Meas. Sci. Technol.* **4**(3), 395 (1993).

113E. I. Shai, U. Laor and I. Gilad, Superposition of thermal loads model for measuring thermal diffusivity in solids, *Int. J. Heat Mass Transfer* **36**(4), 925 (1993).

114E. R. Taktak, J. V. Beck and E. P. Scott, Optimal experimental design for estimating thermal properties of composite materials, *Int. J. Heat Mass Transfer* **36**(12), 2977 (1993).

115E. O. V. Trevisan, S. Mohanty and M. A. Miller, Transient method for measuring thermal properties of saturated porous media, *Int. J. Heat Mass Transfer* **36**(10), 2565 (1993).

116E. A. Yu. Vorob'ev, A. V. Galaktionov, V. E. Titov and A. P. Chernyshev, Temperature-wave method for measuring absorptivity, *High Temp.* **31**(3), 549 (1993).

117E. C. J. Wormald, A new flow mixing calorimeter for operation on gases at high temperatures and pressures, *Meas. Sci. Technol.* **4**(11), 1219 (1993).

118E. Chen Shu Xia, Ge Xin Shi, Yao Cheng Cai, Gao Ju Wen and Zhang Yong Zhong, Research on the validity of the steady-state calorimeter for measuring the total hemispherical emissivity of solids, *Meas. Sci. Technol.* **4**(7), 721 (1993).

Miscellaneous methods

119E. W. Chakroun, R. P. Taylor, W. G. Steele and H. W. Coleman, Bias error reduction using ratios to baseline experiments—Heat transfer case study, *J. Thermophys. Heat Transfer* **7**(4), 754 (1993).

120E. Zhe-Hong Chen, T. Uchida and S. Minami, Real-time emissivity corrected infrared microthermography based on a double modulation technique, *Meas. Sci. Technol.* **4**(3), 288 (1993).

121E. P. Curtiss, An analysis of methods for deriving the constituent insolation components from multipyranometer array measurements, *J. Sol. Energy Engng Trans. ASME* **115**(1), 10 (1993).

122E. D. Faiman, D. Feuermann and A. Zemel, Site-independent algorithm for obtaining the direct beam isolation from a multipyranometer instrument, *Sol. Energy* **50**(1), 53 (1993).

123E. D. Feuermann and A. Zemel, Dust-induced degradation of pyronometer sensitivity, *Sol. Energy* **50**(6), 483 (1993).

124E. R. S. Jachowica and W. J. Makulski, Optimal measurement procedures for a dew point hygrometer system, *IEEE Trans. Instrum. Meas.* **42**(4), 828 (1993).

125E. G. P. Mantas and A. S. Rapti, Investigation of the aging rate of a star-type pyranometer due to the discoloration of the receiver, *Sol. Energy* **50**(1), 1 (1993).

126E. C. O'Morain, P. O'Keefe, S. Den and Y. Hayashi, Large-diameter plasma profile monitoring system using Faraday cup and Langmuir probe arrays, *Meas. Sci. Technol.* **4**(12), 1484 (1993).

127E. O. F. Petrov and A. A. Samaryan, Optical diagnostics of coal particles in a flowing combustion-product plasma, *High Temp.* **31**(2), 401 (1993).

128E. R. Philipona, A. Heimo and B. Hoegger, Investigations of solar radiation detectors using a laboratory test facility for solar radiation meteorological instruments, *Sol. Energy* **51**(2), 159 (1993).

129E. Manohar S. Sohal, Field testing of a probe to measure fouling in an industrial flue gas stream, *Heat Transfer Engng* **14**(2), 51 (1993).

130E. J. W. M. Spicer, M. G. Bevan, W. D. Kerns and H. S. Feldmesser, Thermal characterization of heat sink adhesive systems for spacecraft electronics by time-resolved infrared radiometry, *J. Electron. Packag.* **115**(1), 101 (1993).

131E. P. T. Tsinlingiris, Design of a submersible, low-cost, flat-response net radiometer, *Sol. Energy* **50**(4), 369 (1993).

132E. A. Zemel, Correction schemes for solar sensors with multiple time constants, *Sol. Energy* **51**(5), 377 (1993).

NATURAL CONVECTION—INTERNAL FLOWS

Horizontal layers heated from below

1F. M. Ruhul Amin, Natural convection heat transfer and fluid flow in an enclosure cooled at the top and heated at the bottom with roughness elements, *Int. J. Heat Mass Transfer* **36**(10), 2707 (1993).

2F. R. V. Birikh and R. N. Rudakov, Convective instability of a horizontal fluid layer with a heat-conducting permeable partition, *Fluid Dyn.* **28**(2), 281 (1993).

3F. M. A. Brown and S. W. Churchill, Transient behavior of an impulsively heated fluid, *Chem. Engng Technol.* **16**(2), 82 (1993).

4F. S. L. Christie and J. Andrzej Domaradzki, Numerical evidence for nonuniversality of the soft–hard turbulence classification for thermal convection, *Phys. Fluids A* **5**(2), 412 (1993).

5F. R. M. Clever and F. H. Busse, Convection in a fluid layer with asymmetric boundary conditions, *Phys. Fluids A* **5**(1), 99 (1993).

6F. T. Cortese and S. Balachandar, Vortical nature of thermal plumes in turbulent convection, *Phys. Fluids A* **5**(12), 3226 (1993).

7F. A. Davaille and C. Jaupart, Transient high-Rayleigh-number thermal convection with large viscosity variations, *J. Fluid Mech.* **253,** 141 (1993).

8F. J. C. Elicer Cortés and Doan-Kim Son, Turbulent natural convection in a dihedral cavity: influence of the angle and the temperature of the walls on the mean thermal field, *Exp. Heat Transfer* **6**(3), 205 (1993).

9F. B. J. Gluckman, H. Willaime and J. P. Gollub, Geometry of isothermal and isoconcentration surfaces in thermal turbulence, *Phys. Fluids A* **5**(3), 647 (1993).

10F. V. Kek and U. Müller, Low Prandtl number convection in layers heated from below, *Int. J. Heat Mass Transfer* **36**(11), 2795 (1993).

11F. R. E. Kelly and H.-C. Hu, The onset of Raleigh–Bénard convection in non-polar oscillatory flows, *J. Fluid Mech.* **249,** 373 (1993).

12F. H. Koizumi and I. Hosokawa, Unsteady behavior and mass transfer performance of the combined convective flow in a horizontal rectangular duct heated from below, *Int. J. Heat Mass Transfer* **36**(16), 3937 (1993).

13F. D. Mukutmoni and K. T. Yang, Rayleigh–Bénard convection in a small aspect ratio enclosure—I. Bifurcation to oscillatory convection, *J. Heat Transfer Trans. ASME* **115**(2), 360 (1993).

14F. D. Mukutmoni and K. T. Yang, Rayleigh–Bénard convection in a small aspect ratio enclosure—II. Bifurcation to chaos, *J. Heat Transfer Trans. ASME* **115**(2), 367 (1993).

15F. H. Murata and M. Osakabe, Heat-transfer characteristics in a horizontal fluid layer with honeycombs, *Heat Transfer Jpn Res.* **22**(2), 107 (1993).

16F. E. Ntibarufata, M. Hasnaoui, E. Bilgen and P. Vasseur, Natural convection in partitioned enclosures with localized heating, *Int. J. Numer. Methods Heat Fluid Flow* **3**(2), 133 (1993).

17F. B. Ramaswamy, Finite element analysis of two-dimensional Rayleigh–Bénard convection with gravity modulation effects, *Int. J. Numer. Methods Heat Fluid Flow* **3**(5), 429 (1993).

18F. M. A. Sattar and M. R. Islam, Flow instability in a large aspect ratio porous medium with an internal heat source, *Chaos Solitons Fractals* **3**(2), 149 (1993).

19F. G. Schubert, G. A. Glatzmaier and B. Travis, Steady, three-dimensional, internally heated convection, *Phys. Fluids A* **5**(8), 1928 (1993).

20F. Heiu-Jou Shaw, Laminar mixed convection heat transfer in three-dimensional horizontal channel with a heated bottom, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 445 (1993).

21F. F. Stella, G. Guj and E. Leonardi, The Rayleigh–Bénard problem in intermediate bounded domains, *J. Fluid Mech.* **254,** 375 (1993).

22F. V. N. Zabavin, B. V. Zamyshlyaev, B. I. Zaslavskii, A. T. Onufriev and M. D. Shcherbin, The structure of a rising thermal, *J. Appl. Mech. Tech. Phys.* **33**(5), 680 (1993).

Double-diffusive systems

23F. J. Chang, T. F. Lin and C. H. Chen, Unsteady thermosolutal opposing convection of a liquid–water mixture in a square cavity—I. Flow formation and heat and mass transfer-characteristics, *Int. J. Heat Mass Transfer* **36**(5), 1315 (1993).

24F. J. Chang and T. F. Lin, Unsteady thermosolutal opposing convection of liquid–water mixture in a square cavity—II. Flow structure and fluctuation analysis, *Int. J. Heat Mass Transfer* **36**(5), 1333 (1993).

25F. K. Kamakura and H. Ozoe, Experimental and numerical analyses of double diffusive natural convection heated and cooled from opposing vertical walls with an initial condition of a vertically linear concentration gradient, *Int. J. Heat Mass Transfer* **36**(8), 2125 (1993).

26F. K. Kamakura and H. Ozoe, Numerical analyses of transient formation and degradation process of multilayered roll cells with double-diffusive natural convection in an enclosure, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 61 (1993).

27F. K. Kamakura and H. Ozoe, Numerical analyses of transient formation and degradation process of multilayered roll cells with double-diffusive natural convection in an enclosure, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **23**(1), 61 (1993).

28F. L. B. Mullett, The role of buoyant thermals in salt gradient solar ponds and in convection more generally, *Int. J. Heat Mass Transfer* **36**(7), 1923 (1993).

29F. Y. Yamamuro Renardy, Pattern selection for the oscillatory onset in thermosolutal convection, *Phys. Fluids A* **5**(6), 1376 (1993).

Thermocapillary flows

30F. V. A. Batishchev, The thermocapillary effect and small oscillations of a liquid at large Marangoni numbers, *J. Appl. Mech. Tech. Phys.* **33**(6), 805 (1993).

31F. J.-C. Chen and F.-S. Hwu, Oscillatory thermocapillary flow in a rectangular cavity, *Int. J. Heat Mass Transfer* **36**(15), 3743 (1993).

32F. T. Doi and J. N. Koster, Thermocapillary convection in two immiscible liquid layers with free surface, *Phys. Fluids A* **5**(8), 1914 (1993).

33F. Ph. Géoris, M. Hennenberg, I. B. Simanovskii, A. Nepomniaschy, I. I. Wertgeim and J. C. Legros, Thermocapillary convection in a multilayer system, *Phys. Fluids A* **5**(7), 1575 (1993).

34F. S.-S. Hsieh and M.-Y. Wen, Numerical computation of thermocapillary-driven convection in an open cylindrical cavity with different aspect ratios, *Int. J. Heat Mass Transfer* **36**(18), 4351 (1993).

35F. H. Linde, Xiaolin Chu and M. G. Velarde, Oblique and head-on collisions of solitary waves in Marangoni–Bénard convection, *Phys. Fluids A* **5**(4), 1065 (1993).

36F. Q. S. Liu, G. Chen and B. Roux, Thermogravitational and thermocapillary convection in a cavity containing two superimposed immiscible liquid layers, *Int. J. Heat Mass Transfer* **36**(1), 101 (1993).

37F. D. Lozinski and M. Matalon, Thermocapillary motion in a spinning vaporizing droplet, *Phys. Fluids A* **5**(7), 1596 (1993).

38F. M. J. Lyell and M. J. Carpenter, The effect of residual contamination on Marangoni convection in a spherical liquid system, *Appl. Sci. Res.* **51**(4), 639 (1993).

39F. M. Mundrane and A. Zebib, Two- and three-dimensional buoyant thermocapillary convection, *Phys. Fluids A* **5**(4), 810 (1993).

40F. P. M. Parmentier, V. C. Regnier and G. Lebon, Buoyant-thermocapillary instabilities in medium-Prandtl-number fluid layers subject to a horizontal temperature gradient, *Int. J. Heat Mass Transfer* **36**(9), 2417 (1993).

41F. N. Ramachandran, Thermal buoyancy and Marangoni convection in a two fluid layered system, *J. Thermophys. Heat Transfer* **7**(2), 352 (1993).

42F. Huailiang Wei and R. Shankar Subramanian, Thermocapillary migration of a small chain of bubbles, *Phys. Fluids A* **5**(7), 1583 (1993).

Vertical ducts and differential heating

43F. S. Acharya and A. Mehrotra, Natural convection heat transfer smooth and ribbed vertical channels, *Int. J. Heat Mass Transfer* **36**(1), 236 (1993).

44F. N. Al-ani and M. W. Nansteel, Natural convection in a partial sector-shaped enclosure: experimental results, *J. Heat Transfer Trans. ASME* **115**(1), 133 (1993).

45F. M. A. Al-Nimr, Analytical solution for transient laminar fully developed free convection in vertical concentric annuli, *Int. J. Heat Mass Transfer* **36**(9), 2385 (1993).

46F. M. Ruhul Amin, Natural convection heat transfer in enclosures fitted with a periodic array of hot roughness elements at the bottom, *Int. J. Heat Mass Transfer* **36**(3), 755 (1993).

47F. M. Bargach and P. Vasseur, Natural convection in a shallow cavity containing two superimposed layers of immiscible liquids, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **24**(3), 357 (1993).

48F. G. A. Buck and B. D. Wood, A numerical investigation of the natural convection heat and mass transfer from uniformly heated falling films in vertical channels, *J. Sol. Energy Eng. Trans. ASME* **115**(1), 42 (1993).

49F. J.-C. Chen and C.-K. Hsieh, Linear stability of natural convection in a tall vertical slot with a moving sidewall, *Int. J. Heat Mass Transfer* **36**(6), 1471 (1993).

50F. P. G. Daniels, High Rayleigh number thermal convection in a shallow laterally heated cavity, *Proc. R. Soc. A* **440**(1909), 273 (1993).

51F. G. N. Facas, Natural convection in a cavity with fins attached to both vertical walls, *J. Thermophys. Heat Transfer* **7**(4), 555 (1993).

52F. W.-S. Fu and W.-J. Shieh, Transient thermal convection in an enclosure induced simultaneously by gravity and vibration, *Int. J. Heat Mass Transfer* **36**(2), 437 (1993).

53F. M. Fujii, S. Gima, T. Tomimura and Xing Zhang, Experimental study of natural convection from an array of vertical parallel plates, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(566), 3224 (1993).

54F. T. Fusegi, J. M. Hyun and K. Kuwahara, Three-dimensional natural convection in a cubical enclosure with walls of finite conductance, *Int. J. Heat Mass Transfer* **36**(7), 1993 (1993).

55F. A. Hadim and M. Ramot, Natural convection in an enclosure with discrete heat sources on the vertical walls, *J. Electron. Packag.* **115**(4), 444 (1993).

56F. K. Hanjalic and S. Vasic, Computation of turbulent natural convection in rectangular enclosures with an algebraic flux model, *Int. J. Heat Mass Transfer* **36**(14), 3603 (1993).

57F. R. A. W. M. Henkes and C. J. Hoogendoorn, Scaling of the laminar natural-convection flow in a 3D differentially heated cavity, *Int. J. Heat Mass Transfer* **36**(11), 2927 (1993).

58F. W. J. Hiller, St. Koch, T. A. Kowalewski and F. Stella, Onset of natural convection in a cube, *Int. J. Heat Mass Transfer* **36**(13), 3251 (1993).

59F. M. Ishikawa, T. Hirata and H. Tamaki, Heat transfer correlations of natural convection with density inversion in a vertical enclosure, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(558), 564 (1993).

60F. R. J. A. Janssen and R. A. W. M. Henkes, Accuracy of finite-volume discretizations for the bifurcating natural-convection flow in a square cavity, *Numer Heat Transfer Part B Fundam.* **24**(2), 191 (1993).

61F. Y. Joshi, O. Haukenes and S. B. Sathe, Natural convection liquid immersion cooling of a heat source flush mounted on a conducting substrate in a square enclosure, *Int. J. Heat Mass Transfer* **36**(2), 249 (1993).

62F. K. M. Kelkar and D. Choudhury, Numerical prediction of periodically fully developed natural convection in a vertical channel with surface mounted heat generating blocks, *Int. J. Heat Mass Transfer* **36**(5), 1133 (1993).

63F. J. A. Khan and G.-F. Yao, Comparison of natural convection of water and air in a partitioned rectangular enclosure, *Int. J. Heat Mass Transfer* **36**(12), 3107 (1993).

64F. A. La Pica, G. Rodono and R. Volpes, An experimental investigation on natural convection of air in a vertical channel, *Int. J. Heat Mass Transfer* **36**(3), 611 (1993).

65F. J. L. Lage and A. Bejan, The resonance of natural convection in an enclosure heated periodically from the side, *Int. J. Heat Mass Transfer* **36**(8), 2027 (1993).

66F. T. T. Lam, Thermocapillary convection in a cavity with heat input and a constant temperature wall on opposite sides, *Int. J. Heat Fluid Flow* **14**(4), 357 (1993).

67F. M. A. Langerman, A non-Boussinesq integral method for laminar free convection between vertical flat plates subject to a uniform wall heat flux, *Int. J. Heat Mass Transfer* **36**(14), 3429 (1993).

68F. A. M. Lankhorst, D. Angirasa and C. J. Hoogendoorn, LDV Measurements of buoyancy-induced flows in an enclosure at high Rayleigh numbers, *Exp. Therm. Fluid Sci.* **6**(1), 74 (1993).

69F. A. Moutsoglou and M. R. Park, Natural convection heat transfer in a three-dimensional duct, *J. Thermophys. Heat Transfer* **7**(2), 369 (1993).

70F. A. Nag, A. Sarkar and V. M. K. Sastri, Natural convection in a differentially heated square cavity with a horizontal partition plate on the hot wall, *Comput. Methods Appl. Mech. Engng* **110**(12), 143 (1993).

71F. V. E. Nakoryakov, M. P. Reznichenko and V. M. Chupin, Influence of Prandtl number and slot height on free convection in a narrow slot, *Exp. Therm. Fluid Sci.* **7**(2), 103 (1993).

72F. D. Naylor and J. D. Tarasuk, Natural convective heat transfer in a divided vertical channel—I. Numerical study, *J. Heat Transfer Trans. ASME* **115**(2), 377 (1993).

73F. D. Naylor and J. D. Tarasuk, Natural convective heat transfer in a divided vertical channel—II. Experimental study, *J. Heat Transfer Trans. ASME* **115**(2), 388 (1993).

74F. J. D. Nicolas and M. W. Nansteel, Natural convection in a rectangular enclosure with partial heating of the lower surface: experimental results, *Int. J. Heat Mass Transfer* **36**(16), 4067 (1993).

75F. K. Okada and H. Ozoe, Various computational conditions of oscillatory natural convection of zero Prandtl number fluid in an open boat heated and cooled from opposing vertical walls, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 171 (1993).

76F. P. Payvar, Free convection in a vertical duct of square cross section with variable viscosity, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 247 (1993).

77F. Y. F. Rao and E. K. Glakpe, Three-dimensional natural convection in an enclosed vertical rod bundle with mixed boundary conditions, *Int. J. Heat Mass Transfer* **36**(6), 1517 (1993).

78F. R. K. Sahoo, A. Sarkar and V. M. K. Sastri, Effect of an obstruction on natural convection heat transfer in vertical channels. A finite element analysis, *Int. J. Numer. Methods Heat Fluid Flow* **3**(3), 267 (1993).

79F. W. Tong and J. N. Koster, Coupling of natural convection flow across a vertical density inversion interface, *Wärme Stoffübertrag.* **28**(8), 471 (1993).

80F. W. Tong and J. N. Koster, Natural convection of water in a rectangular cavity including density inversion, *Int. J. Heat Fluid Flow* **14**(4), 366 (1993).

81F. S. Ushijima, S. Moriya and N. Tanaka, Internal standing waves in a cylindrical vessel and their near-wall features, *J. Heat Transfer* **115**(3), 613 (1993).

82F. I. A. Vatutin, V. F. Vinokurov, O. G. Martynenko, P. P. Khramtsov and I. A. Shikh, Vortical structures and temperature fields in unsteady-state natural convection within a horizontal tube, *Exp. Heat Transfer* **6**(1), 69 (1993).

83F. V. F. Vinokurov, S. V. Volkov, O. G. Martynenko, P. P. Khramtsov and I. A. Shikh, Some aspects of free-convective heat transfer in eddy flow through a horizontal tube, *Int. J. Heat Mass Transfer* **36**(18), 4487 (1993).

84F. G.-F. Yao and J. A. Khan, A numerical study of two-dimensional high Rayleigh number natural convection between two reservoirs connected by a horizontal duct, *J. Heat Transfer* **115**(3), 800 (1993).

Horizontal tubes and annuli

85F. A. Arkadyev, P. Bar-Yoseph, A. Solan and K. G. Roesner, Thermal effects on axisymmetric vortex breakdown in a spherical gap, *Phys. Fluids A* **5**(5), 1211 (1993).

86F. John C. Chai and Suhas V. Patankar, Laminar natural convection in internally finned horizontal annuli, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **24**(1), 67 (1993).

87F. J. Y. Choi and M.-U. Kim, Three-dimensional linear stability of natural convective flow between concentric horizontal cylinders, *Int. J. Heat Mass Transfer* **36**(17), 4173 (1993).

88F. H.-S. Chu and T.-S. Lee, Transient natural convection heat transfer between concentric spheres, *Int. J. Heat Mass Transfer* **36**(13), 3159 (1993).

89F. H. E. S. Fath and M. Khodheer, Natural convection heat transfer in horizontal annulus with an open trough—Black body solar energy receiver, *Int. Commun. Heat Mass Transfer* **20**(5), 729 (1993).

90F. S. Gianoulakis and D. E. Klein, Combined natural convection and surface radiation in the annular region between a volumetrically heated inner tube and a finite conducting outer tube, *Nucl. Technol.* **104**(2), 241 (1993).

91F. C. J. Ho, W. S. Chang and C. C. Wang, Natural convection between two horizontal cylinders in an adiabatic circular enclosure, *J. Heat Transfer Trans. ASME* **115**(1) 158 (1993).

92F. F. Moukalled and H. Diab, Laminar natural convection in a horizontal rhombic annulus, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **24**(1), 89 (1993).

93F. B. B. Rogers and L. S. Yao, Natural convection in a heated annulus, *Int. J. Heat Mass Transfer* **36**(1), 35 (1993).

94F. B. V. K. Satya sai, K. N. Seetharamu and P. A. Aswatha Narayana, Finite element analysis of the effect of radius ratio on natural convection in an annular cavity, *Int. J. Numer. Methods Heat Fluid Flow* **3**(4), 305 (1993).

95F. T. Sawada, H. Kikura, A. Saito and T. Tanahashi, Natural convection of a magnetic fluid in concentric horizontal annuli under nonuniform magnetic fields, *Exp. Therm. Fluid Sci.* **7**(3), 212 (1993).

96F. K. G. TeBeest, S. A. Trogdon and R. W. Douglass, Natural convection within spherical annuli by symbolic algebra, *J. Heat Transfer* **115**(3), 807 (1993).

97F. M. A. Hossain and A. Nakayama, Non-Darcy free convective flow along a vertical cylinder embedded in a porous medium with surface mass flux, *Int. J. Heat Fluid Flow* **14**(4), 385 (1993).

Porous media

98F. D. K. Lin, Unsteady natural convection heat and mass transfer in a saturated porous enclosure, *Wärme Stoffübertrag.* **28**(12), 49 (1993).

99F. D. M. Manole and J. L. Lage, The inertial effect on the natural convection flow within a fluid-saturated porous medium, *Int. J. Heat Fluid Flow* **14**(4), 376 (1993).

100F. M. Mbaye, E. Bilgen and P. Vasseur, Natural-convection heat transfer in an inclined porous layer boarded by a finite-thickness wall, *Int. J. Heat Fluid Flow* **14**(3), 284 (1993).

101F. P. Payvar, Free convection in a vertical duct of square cross section with variable viscosity, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **23**(2), 247 (1993).

102F. I. Pop, D. B. Ingham and P. Cheng, Transient free convection between two concentric spheres filled with a porous medium, *J. Thermophys. Heat Transfer* **7**(4), 724 (1993).

Thermosyphons

103F. G. S. E. Lock and Jialin Fu, Observations on an evaporative, elbow thermosyphon, *J. Heat Transfer Trans. ASME* **115**(2), 501 (1993).

104F. E. Arquis, N. Richard, J. P. Caltagirone, O. Amiel and R. Salmon, Mixed convection in a spherical enclosure, *J. Heat Transfer Trans. ASME* **115**(4), 1066 (1993).

Mixed convection

105F. T.-S. Chang and T.-F. Lin, Steady and oscillatory opposing mixed convection in a symmetrically heated vertical channel with a low-Prandtl number fluid, *Int. J. Heat Mass Transfer* **36**(15), 3783 (1993).

106F. Chin-Hsiang Cheng and Chun-Jen Weng, Developing flow of mixed convection in a vertical rectangular duct with one heating wall, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(4), 479 (1993).

107F. R. L. Mahajan and D. Angirasa, Combined heat and mass transfer by natural convection with opposing buoyancies, *J. Heat Transfer* **115**(3), 606 (1993).

108F. A. Moutsoglou and Y. D. Kwon, Laminar mixed convection flow in a vertical tube, *J. Thermophys. Heat Transfer* **7**(2), 361 (1993).

109F. U. Narusawa, Numerical analysis of mixed convection at the entrance region of a rectangular duct heated from below, *Int. J. Heat Mass Transfer* **36**(9), 2375 (1993).

110F. H. D. Nguyen, S. Paik and J. N. Chung, Unsteady mixed convection heat transfer from a solid sphere: the conjugate problem, *Int. J. Heat Mass Transfer* **36**(18), 4443 (1993).

111F. E. Papanicolaou and Y. Jaluria, Mixed convection from a localized heat source in a cavity with conducting walls: a numerical study, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 463 (1993).

112F. B. B. Rogers and L. S. Yao, Finite-amplitude instability of mixed-convection in a heated vertical pipe, *Int. J. Heat Mass Transfer* **36**(9), 2305 (1993).

113F. Chaomin Zhang and Zengyuan Guo, Fast stable marching scheme for calculating mixed convection in a vertical rotating annulus, *J. Therm. Sci.* **2**(1), 50 (1993).

114F. T. Alboussiere, J. P. Garandet and R. Moreau, Buoyancy-driven convection with a uniform magnetic field—I. Asymptotic analysis, *J. Fluid Mech.* **253,** 545 (1993).

Miscellaneous

115F. C. Balaji and S. P. Venkateshan, Interaction of surface radiation with free convection in a square cavity, *Int. J. Heat Fluid Flow* **14**(3), 260 (1993).

116F. C. Y. Choi and A. Ortega, Mixed convection in an inclined channel with a discrete heat source, *Int. J. Heat Mass Transfer* **36**(12), 3119 (1993).

117F. M. J. Coates and J. C. Patterson, Unsteady natural convection in a cavity with non-uniform absorption of radiation, *J. Fluid Mech.* **256,** 133 (1993).

118F. H. C. de Groh, III and M. Kassemi, Effect of radiation on convection in a top-heated enclosure, *J. Thermophys. Heat Transfer* **7**(4), 561 (1993).

119F. S. A. Demchuk, Heat transfer in narrow gaps filled with magnetorheological suspensions, *J. Magn. Magn. Mater.* **122**(13), 312 (1993).

120F. G. N. Facas, Laminar free convection in a nonrectangular inclined cavity, *J. Thermophys. Heat Transfer* **7**(3), 447 (1993).

121F. K. Fujimura and R. E. Kelly, Mixed mode convection in an inclined slot, *J. Fluid Mech.* **246,** 545 (1993).

122F. G. A. Glatzmaier, Highly supercritical thermal convection in a rotating spherical shell: centrifugal vs radial gravity, *Geophys. Astrophys. Fluid Dyn.* **70**(14), 113 (1993).

123F. T. Hirata, Y. Makino and Y. Kaneko, Analysis of natural convection melting inside isothermally heated horizontal rectangular capsule, *Wärme Stoffübertrag.* **28**(12), 1 (1993).

124F. C. J. Ho and J. Y. Chang, Conjugate natural-convection–conduction heat transfer in enclosures divided by horizontal fins, *Int. J. Heat Fluid Flow* **14**(2), 177 (1993).

125F. K. D. Kihm, J. H. Kim and L. S. Fletcher, Investigation of natural convection heat transfer in converging channel flows using a Specklegram technique, *J. Heat Transfer Trans. ASME* **115**(1), 140 (1993).

126F. H. Kikura, T. Sawada and T. Tanahashi, Natural convection of a magnetic fluid in a cubic enclosure, *J. Magn. Magn. Mater.* **122**(13), 315 (1993).

127F. R. A. Kuyper, Th. H. van der Meer, C. J. Hoogendoorn and R. A. W. M. Henkes, Numerical study of laminar and turbulent natural convection in an inclined square cavity, *Int. J. Heat Mass Transfer* **36**(11), 2899 (1993).

128F. M. A. Langerman and R. J. Mackinnon, Estimating natural convection in low Prandtl cavity flows, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **24**(2), 221 (1993).

129F. M. Net, I. Mercader, E. Knobloch and H. F. Goldstein, Rotating convection in a finite cylinder, *Appl. Sci. Res.* **51**(12), 61 (1993).

130F. M. Peric, Natural convection in trapezoidal cavities, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A* **24**(2), 213 (1993).

131F. D. Y. Shang and B.-X. Wang, The deviation of heat transfer calculation for laminar free convection of gas due to ignoring the variable thermophysical properties, *Wärme Stoffübertrag.* **28**(12), 33 (1993).

132F. R. A. Showole and J. D. Tarasuk, Experimental and numerical studies of natural convection with flow separation in upward-facing inclined open cavities, *J. Heat Transfer* **115**(3), 592 (1993).

133F. S. O. Talabi and U. Nwabuko, Numerical solution of natural convective heat transfer in parabolic enclosures, *Int. J. Heat Mass Transfer* **36**(17), 4275 (1993).

134F. M. Venkatachalappa and C. K. Subbaraya, Natural convection in a rectangular, enclosure in the presence of a magnetic field with uniform heat flux from the side walls, *Acta Mech.* **96**(14), 13 (1993).

135F. L. Cai, W. E. Stewart, Jr. and C. W. Sohn, Turbulent buoyant flows into a two-dimensional storage tank, *Int. J. Heat Mass Transfer* **36**(17), 4247 (1993).

Applications

136F. D. Gupta, S. C. Solanki and J. S. Saini, Heat and fluid flow in rectangular solar air heater ducts having transverse rib roughness on absorber plates, *Sol. Energy* **51**(1), 31 (1993).

137F. N. Higuchi, K. Kaiho, I. Ishii, S. Sekine, N. Natori,

K. Arai, H. Nomura, H. Tateishi, T. Onishi, M. Kumagai and T. Aiba, Study on stabilities of rotating magnets for superconducting generators, *Appl. Supercond.* **1**(1012), 1731 (1993).

138F. M. H. Novak and E. S. Novak, Natural convection heat transfer in slender window cavities, *J. Heat Transfer Trans. ASME* **115**(2), 476 (1993).

139F. M. N. A. Said, S. A. Barakat and E. A. Whidden, Interzonal natural convective heat and mass flow through doorway-like apertures in buildings: experimental results, *J. Sol. Energy Eng. Trans. ASME* **115**(2), 69 (1993).

140F. B. Sunden and J. Svantesson, Thermal hydraulic performance of some standard multilouvered surfaces, *Heat Technol.* **10**(34), 16 (1993).

NATURAL CONVECTION—EXTERNAL FLOWS

Vertical flat plate

1FF. R. Bennacer, L. Y. Sun, Y. Toguyeni, D. Gobin et C. Benard, Structure d'écoulement et transfert de chaleur par convection naturelle au voisinage du maximum de densité, *Int. J. Heat Mass Transfer* **36**(13), 3329 (1993).

2FF. T. S. Chen, W. P. Buchanan and B. F. Armaly, Natural convection on vertical and horizontal plates with vectored surface mass transfer, *Int. J. Heat Mass Transfer* **36**(2), 479 (1993).

3FF. E. M. A. Elbashbeshy and F. N. Ibrahim, Steady free convection flow with variable viscosity and thermal diffusivity along a vertical plate, *J. Phys. D* **26**(12), 2137 (1993).

4FF. W. R. Ferreira, M. Fortes and C. Durou, A numerical and experimental study of natural convective heat and mass transfer from a vertical porous plate—II. Holographic interferometry experimental analysis, *Drying Technol.* **11**(7), 1685 (1993).

5FF. P. S. Hiremath and P. M. Patil, Free convection effects on the oscillatory flow of a couple stress fluid through a porous medium, *Acta Mech.* **98**(14), 143 (1993).

6FF. Y. Hwang, N. D. Kazarinoff and J. C. Mollendorf, Hydrodynamic stability of multiple steady-states of vertical buoyancy-induced flows in cold pure water, *Int. J. Heat Mass Transfer* **36**(2), 423 (1993).

7FF. Peixue Jiang, Peize Ren and Buxuan Wang, Natural convective heat and mass transfer of water with corrosion products at super-critical pressures under cooling conditions, *J. Therm. Sci.* **2**(1), 25 (1993).

8FF. M. H. Kim, M.-U. Kim and C. H. Cho, Natural convection near a corner of an arbitrary angle formed by two vertical flat plates with uniform surface heat flux, *Int. J. Heat Mass Transfer* **36**(5), 1241 (1993).

9FF. M. J. M. Krane and B. Gebhart, The hydrodynamic stability of a one-dimensional transient buoyancy-induced flow, *Int. J. Heat Mass Transfer* **36**(4), 977 (1993).

10FF. S. Lee and M. M. Yovanovich, Linearization method for buoyancy induced flow over a nonisothermal vertical plate, *J. Thermophys. Heat Transfer* **7**(1), 158 (1993).

11FF. T. Misumi and K. Kitamura, Heat transfer enhancement of natural convection and development of a high-performance heat transfer plate, *JSME Int. J. Ser. B* **36**(1), 143 (1993).

12FF. D.-Y. Shang, B.-X. Wang, Y. Wang and Y. Quan, Study on laminar free convection with consideration of variable thermophysical properties, *Int. J. Heat Mass Transfer* **36**(14), 3411 (1993).

13FF. G. Tanda, Natural convection heat transfer from a staggered vertical plate array, *J. Heat Transfer Trans. ASME* **115**(4), 938 (1993).

14FF. R. K. Tripathi and G. Nath, Unsteady natural convection flow over a vertical plate embedded in a stratified medium, *Int. J. Heat Mass Transfer* **36**(4), 1125 (1993).

15FF. H. Vogt, Thermal effect on liquid-phase free convection at gas evolving electrodes, *Int. J. Heat Mass Transfer* **36**(17), 4115 (1993).

16FF. X. Yuan, A. Moser and P. Suter, Wall functions for numerical simulation of turbulent natural convection along vertical plates, *Int. J. Heat Mass Transfer* **36**(18), 4477 (1993).

17FF. D. Angirasa and R. L. Mahajan, Natural convection from L-shaped corners with adiabatic and cold isothermal horizontal walls, *J. Heat Transfer Trans. ASME* **115**(1), 149 (1993).

Horizontal and inclined plates

18FF. F. J. Higuera, Natural convection below heated horizontal rectangular plates, *Int. J. Heat Mass Transfer* **36**(14), 3565 (1993).

19FF. J.-Y. Jang and K.-N. Lie, Effects of blowing–suction on vortex instability of horizontal free convection flows, *J. Thermophys. Heat Transfer* **7**(4), 749 (1993).

20FF. H. Linde, X.-L. Chu, M. G. Velarde and W. Waldheim, Wall reflections of solitary waves in Marangoni–Bénard convection, *Phys. Fluids A* **5**(12), 3162 (1993).

21FF. G. Pétré, M. A. Azouni and K. Tshinyama, Marangoni convection at alcohol aqueous solutions–air interfaces, *Appl. Sci. Res.* **50**(2), 97 (1993).

Channels

22FF. A. Bejan, Al. M. Morega, S. W. Lee and S. J. Kim, The cooling of a heat-generating board inside a parallel-plate channel, *Int. J. Heat Fluid Flow* **14**(2), 170 (1993).

23FF. Zeng-Yuan Guo and Xiao-Bo Wu, Thermal drag and critical heat flux for natural convection of air in vertical parallel plates, *J. Heat Transfer Trans. ASME* **115**(1), 124 (1993).

24FF. A. Nakayama, F. Kuwahara and H. Koyama, Transient non-Darcy free convection between parallel vertical plates in a fluid-saturated porous medium, *Appl. Sci. Res.* **50**(1), 29 (1993).

25FF. W. Shyy and M. M. Rao, Simulation of transient natural convection around an enclosed vertical channel, *J. Heat Transfer Trans. ASME* **115**(4), 946 (1993).

26FF. A. G. Straatman, J. D. Tarasuk and J. M. Floryan, Heat transfer enhancement from a vertical, isothermal channel generated by the chimney effect, *J. Heat Transfer Trans. ASME* **115**(2), 395 (1993).

Cylinders

27FF. H. M. Badr and K. Shamsher, Free convection from an elliptic cylinder with major axis vertical, *Int. J. Heat Mass Transfer* **36**(14), 3593 (1993).

28FF. R. Dötzer and W. Schoepe, Thermal impedance between a thick-film resistor and liquid helium below 1 K, *Cryogenics* **33**(10), 936 (1993).

29FF. A. Hedayatpour, B. N. Antar and M. Kawaji, Cool-down of a vertical line with liquid nitrogen, *J. Thermophys. Heat Transfer* **7**(3), 426 (1993).

30FF. D. M. McEligot, C. M. Stoots, W. A. Christenson, D. C. Mecham and W. G. Luss, Turbulent natural convection from a vertical cylinder to an array of cooled tubes, *J. Heat Transfer Trans. ASME* **115**(4), 928 (1993).

31FF. T. Saitoh, T. Sajiki and K. Maruhara, Bench mark solutions to natural convection heat transfer problem around a horizontal circular cylinder, *Int. J. Heat Mass Transfer* **36**(5), 1251 (1993).

32FF. R. K. Tripathi and G. Nath, Unsteady boundary layer free convection flow over horizontal cylinder and sphere embedded in a stratified medium, *J. Heat Transfer Trans. ASME* **115**(1), 130 (1993).

33FF. K. Velusamy and V. K. Garg, Leading edge effect during transient buoyancy induced flow adjacent to a vertical cylinder, *Int. J. Heat Mass Transfer* **36**(7), 1853 (1993).

Bodies of revolution, cones and spheres

34FF. D. J. Cha and S. S. Cha, Three-dimensional natural convection flow around an isothermal cube, *Int. Commun. Heat Mass Transfer* **20**(5), 619 (1993).

35FF. F. J. Higuera and A. Liñán, Pressure gradient effect in natural convection boundary layers, *Phys. Fluids A* **5**(10), 2443 (1993).

36FF. Cheng-Ren Lin and Cha'o-Kuang Chen, Free convection flow from a vertical isothermal cone with temperature-dependent viscosity, *Polym. Plast. Technol. Engng* **32**(4), 277 (1993).

37FF. H. S. Takhar, M. Kumari and G. Nath, Unsteady free convection flow under the influence of a magnetic field, *Arch. Appl. Mech.* **63**(45), 313 (1993).

Buoyant plumes

38FF. R. Ganapathy, On buoyancy induced heat and mass transfer from a concentrated point source, *Fluid Dyn. Res.* **11**(5), 187 (1993).

39FF. K. Kapoor and Y. Jaluria, Penetration convection of a plane turbulent wall jet in a two-layer thermally stable environment: a problem in enclosure fires, *Int. J. Heat Mass Transfer* **36**(1), 155 (1993).

40FF. J. C. F. Pereira and J. M. P. Rocha, Numerical computation of convective dispersion in turbulent buoyant jets, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 399 (1993).

41FF. L. N. Persen, H. Oiann and H. P. Mazumdar, The round thermal jet: undisturbed and in cross-flow, *Int. J. Heat Mass Transfer* **36**(6), 1589 (1993).

42FF. I. Pop, J. K. Lee and R. S. R. Gorla, Convective wall plume in power-law fluids, *Int. J. Heat Mass Transfer* **36**(3), 593 (1993).

43FF. R. M. C. So and H. Aksoy, On vertical turbulent buoyant jets, *Int. J. Heat Mass Transfer* **36**(13), 3187 (1993).

Mixed convection

44FF. H. I. Abu-Mulaweh, B. F. Armaly and T. S. Chen, Measurements of laminar mixed convection in boundary-layer flow over horizontal and inclined backward-facing steps, *Int. J. Heat Mass Transfer* **36**(7), 1883 (1993).

45FF. H. I. Abu-Mulaweh, B. F. Armaly and T. S. Chen, Measurements of laminar mixed convection flow over a horizontal forward-facing step, *J. Thermophys. Heat Transfer* **7**(4), 569 (1993).

46FF. R. A. Ahmad and Z. H. Qureshi, Buoyancy effects on forced convection from a horizontal cylinder in a crossflow, *J. Thermophys. Heat Transfer* **7**(4), 574 (1993).

47FF. B. J. Baek, B. F. Armaly and T. S. Chen, Measurements in buoyancy-assisting separated flow behind a vertical backward-facing step, *J. Heat Transfer Trans. ASME* **115**(2), 403 (1993).

48FF. J. E. Daskalakis, Mixed free and forced convection in the incompressible boundary layer along a rotating vertical cylinder with fluid injection, *Int. J. Energy Res.* **17**(8), 689 (1993).

49FF. L. N. Hjellming, P. A. Tolley and J. S. Walker, Melt motion in a czochralski crystal puller with a non-uniform axisymmetric magnetic field: isothermal motion, *J. Fluid Mech.* **249**, 1 (1993).

50FF. C. J. Ho and F. H. Lin, Mixed convective heating of a moving plate in a parallel duct, *J. Thermophys. Heat Transfer* **7**(4), 751 (1993).

51FF. M.-J. Huang and B.-L. Lin, Mixed convection from a vertical plate to power-law fluids, *J. Thermophys. Heat Transfer* **7**(1), 171 (1993).

52FF. R. Iwatsu, J. M. Hyun and K. Kuwahara, Mixed convection in a driven cavity with a stable vertical temperature gradient, *Int. J. Heat Mass Transfer* **36**(6), 1601 (1993).

53FF. A. T. Jones and D. B. Ingham, Combined convection flow in a vertical duct with wall temperatures that vary linearly with depth, *Int. J. Heat Fluid Flow* **14**(1), 37 (1993).

54FF. M. Kumari, H. S. Takhar and G. Nath, Non-axisymmetric unsteady motion over a rotating disk in the presence of free convection and magnetic field, *Int. J. Engng Sci.* **31**(12), 1659 (1993).

55FF. M. Kumari and G. Nath, Simultaneous heat and mass transfer under unsteady mixed convection along a vertical slender cylinder embedded in a porous medium, *Wärme Stoffübertrag.* **28**(12), 97 (1993).

56FF. M. Kumari, G. Nath and I. Pop, Non-Darcy mixed convection flow with thermal dispersion on a vertical cylinder in a saturated porous medium, *Acta Mech.* **100**(12), 69 (1993).

57FF. H.-T. Lin, K.-Y. Wu and K.-L. Hoh, Mixed convection from an isothermal horizontal plate moving in parallel or reversely to a free stream, *Int. J. Heat Mass Transfer* **36**(14), 3547 (1993).

58FF. A. Nakayama and A. V. Shenoy, Combined forced and free convection heat transfer in power-law fluid-saturated porous media, *Appl. Sci. Res.* **50**(1), 83 (1993).

59FF. V. N. Popov and E. I. Korkina, Influence of free thermoconcentration convection on turbulent transfer in a horizontal boundary layer, *High Temp.* **31**(2), 275 (1993).

60FF. M. T. Quazzani, J. K. Platten and A. Mojtabi, Intermittent patterns in mixed convection, *Appl. Sci. Res.* **51**(4), 677 (1993).

61FF. W. R. Risbeck, T. S. Chen and B. F. Armaly, Laminar mixed convection over horizontal flat plates with power-law variation in surface temperature, *Int. J. Heat Mass Transfer* **36**(7), 1859 (1993).

62FF. B. B. Rogers and L. S. Yao, The importance of Prandtl number in mixed-convection instability, *J. Heat Transfer Trans. ASME* **115**(2), 482 (1993).

63FF. K. Vajravelu and J. Nayfeh, Convective heat transfer at a stretching sheet, *Acta Mech.* **96**(14), 47 (1993).

64FF. Tian-Yih Wang, Mixed convection heat transfer from a horizontal plate to non-Newtonian fluids, *Int. Commun. Heat Mass Transfer* **20**(3), 431 (1993).

65FF. Tian-Yih Wang, Mixed convection heat transfer from a horizontal plate to non-Newtonian fluids, *Int. Commun. Heat Mass Transfer* **20**(6), 845 (1993).

CONVECTION FROM ROTATING SURFACES

Rotating disks

1G. F. J. Bayley, C. A. Long and A. B. Turner, Discs and drums: the thermo-fluid dynamics of rotating surfaces, *Proc. Instn Mech. Engrs Part C* **27**(2), 73 (1993).

2G. B. S. Dandapat and P. C. Ray, Flow of a thin liquid film over a cold–hot rotating disk, *Int. J. Non Linear Mech.* **28**(5), 489 (1993).

3G. V. K. Garg and A. Z. Szeri, Fluid flow and heat transfer between finite rotating disks, *Int. J. Heat Fluid Flow* **14**(2), 155 (1993).

4G. M. M. Rahman and A. Faghri, Gas absorption and solid dissolution in a thin liquid film on a rotating disk, *Int. J. Heat Mass Transfer* **36**(1), 189 (1993).

5G. X. Ruiz, M. Aguiló, J. Massons and F. Diaz, Numerical and experimental study of the forced convection inside a rotating disk–cylinder configuration, *Exp. Fluids* **14**(5), 333 (1993).

6G. C. Y. Soong and W. M. Yan, Numerical study of mixed convection between two corotating symmetrically heated disks, *J. Thermophys. Heat Transfer* **7**(1), 165 (1993).

Rotating channels

7G. M. C. Hall and J. S. Walker, Heat and mass transfer through a liquid metal in an infinitely long, rotating cylinder with a uniform, transverse magnetic field, *Int. J. Heat Mass Transfer* **36**(14), 3509 (1993).

8G. P. C. Ivey and J. M. Owen, Self-induced flow and heat transfer in a rotating tube, *Int. J. Heat Fluid Flow* **14**(1), 27 (1993).

9G. S. M. Kozlov, N. M. Levchenko, S. V. Nozdrin, K. V. Rusanov and E. G. Tyurina, Effect of centrifugal acceleration on heat transfer during cooling of metal-oxide ceramics with liquid nitrogen, *Cryogenics* **33**(9), 851 (1993).

10G. G. S. H. Lock and L. Zhao, Impeded natural convection in a rotating radial tube, *Int. J. Heat Mass Transfer* **36**(5), 1231 (1993).

11G. D. G. Neilson and F. P. Incropera, Effect of rotation on fluid motion and channel formation during unidirectional solidification of a binary alloy, *Int. J. Heat Mass Transfer* **36**(2), 489 (1993).

12G. B. Ozerdem and M. Toksoy, An experimental study of convective heat transfer in a partially filled and horizontally rotating cylinder, *Int. Commun. Heat Mass Transfer* **20**(4), 579 (1993).

13G. C. Y. Soong and G. J. Hwang, Effects of stress work on similarity solutions of mixed convection in rotating channels with wall-transpiration, *Int. J. Heat Mass Transfer* **36**(4), 845 (1993).

14G. L. Zhao and G. S. H. Lock, Impeded behavior of an eccentric thermosyphon rotating about a vertical axis, *Int. J. Heat Fluid Flow* **14**(1), 18 (1993).

15G. Litong Zhao and G. S. H. Lock, Impeded natural convection in a square tube rotating about its own axis, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(3), 323 (1993).

Fluid layers

16G. H. F. Bauer, Marangoni-convection in a rotating liquid container, *Wärme Stoffübertrag.* **28**(3), 131 (1993).

17G. H. F. Goldstein, E. Knobloch, I. Mercader and M. Net, Convection in a rotating cylinder—I. Linear theory for moderate Prandtl numbers, *J. Fluid Mech.* **248,** 583 (1993).

18G. H. Iacovides and J. W. Chew, The computation of convective heat transfer in rotating cavities, *Int. J. Heat Fluid Flow* **14**(2), 146 (1993).

19G. G. Kawashima and Wen-Jei Yang, Natural convection in rotating drums with inner surface heating, *Exp. Heat Transfer* **6**(3), 287 (1993).

20G. R. Schiestel, L. Elena and T. Rezoug, Numerical modeling of turbulent flow and heat transfer in rotating cavities, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(1), 45 (1993).

21G. Keke Zhang and D. Gubbins, Convection in a rotating spherical fluid shell with an inhomogeneous temperature boundary condition at infinite Prandtl number, *J. Fluid Mech.* **250,** 209 (1993).

22G. Fang Zhong, R. E. Ecke and V. Steinberg, Rotating Rayleigh–Bénard convection: asymmetric modes and vortex states, *J. Fluid Mech.* **249,** 135 (1993).

Annuli

23G. C. J. Ho and F. J. Tu, An investigation of transient mixed convection heat transfer of cold water in a tall vertical annulus with a heated rotating inner cylinder, *Int. J. Heat Mass Transfer* **36**(11), 2847 (1993).

24G. M. Prud'homme, L. Robillard and M. Hilal, Natural convection in an annular fluid layer rotating at weak angular velocity, *Int. J. Heat Mass Transfer* **36**(6), 1529 (1993).

25G. H. J. Sung, W. K. Cho and J. M. Hyun, Double-diffusive convection in a rotating annulus with horizontal temperature and vertical solutal gradients, *Int. J. Heat Mass Transfer* **36**(15), 3773 (1993).

Cylinders, spheres and bodies of revolution

26G. C. C. Chiou and S. L. Lee, Forced convection on a rotating cylinder with an incident air jet, *Int. J. Heat Mass Transfer* **36**(15), 3841 (1993).

27G. H. W. Kim and A. J. Esseniyi, Forced convection of power-law fluids flow over a rotating nonisothermal body, *J. Thermophys. Heat Transfer* **7**(4), 581 (1993).

28G. M. Prud'homme, T. Hung Nguyen et P. G. Mao, Étude numérique du changement de phase autour d'un cylindre isotherme en rotation, *Int. J. Heat Mass Transfer* **36**(11), 2837 (1993).

29G. S. M. Tieng and A. C. Yan, Experimental investigation on convective heat transfer of heated spinning sphere, *Int. J. Heat Mass Transfer* **36**(3), 599 (1993).

30G. T.-Y. Wang, Convective heat transfer from a rotating or nonrotating axisymmetric body, *Int. J. Heat Fluid Flow* **14**(4), 333 (1993).

31G. H. Q. Yang, Diffusion-controlled mass transfer from a rotating cylinder, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 303 (1993).

COMBINED HEAT AND MASS TRANSFER

Transpiration–ablation

1H. S. Bröcker, A new general approximate solution for the heat and mass transfer in laminar multicomponent boundary layers of the flat plate, *Wärme Stoffübertrag.* **28**(6), 329 (1993).

2H. N. N. Pilyugin and R. F. Talipov, Heat transfer on blunt cones in nonuniform supersonic flow with injection from the surface, *High Temp.* **31**(1), 119 (1993).

3H. Xueshi Yang, Jingyuan Yu and Guangtian Zhu, Recent advances in research of the distributed parameters control system with moving boundary, *Chin. J. Syst. Engng Electron.* **4**(3), 47 (1993).

Film cooling

4H. A. J. Humber, E. W. Grandmaison and A. Pollard, Mixing between a sharp-edged rectangular jet and a transverse cross flow, *Int. J. Heat Mass Transfer* **36**(18), 4307 (1993).

5H. A. B. Mehendale and J.-C. Han, Reynolds number effect on leading edge film effectiveness and heat transfer coefficient, *Int. J. Heat Mass Transfer* **36**(15), 3723 (1993).

6H. K. Oyakawa, T. Koike and I. Mabuchi, Studies of heat transfer control by using jet discharge at reattachment region downstream of a backward-facing step (1st Report, Effect of jet locations and jet velocities), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(558), 543 (1993).

7H. W.-M. Yan and C.-Y. Soong, Numerical study of liquid film cooling in a turbulent gas stream, *Int. J. Heat Mass Transfer* **36**(16), 3877 (1993).

Submerged and free jet cooling

8H. C. Bartoli, P. Di Marco and S. Faggiani, Impingement heat transfer at a circular cylinder due to a submerged slot jet of water, *Exp. Therm. Fluid Sci.* **7**(4), 279 (1993).

9H. S. Bröcker, Consideration of flow normal to a plate in heat and mass transfer in the laminar boundary layer of a flat plate, *Chem. Ing. Tech.* **65**(7), 836 (1993).

10H. D. Cooper, D. C. Jackson, B. E. Launder and G. X. Liao, Impinging jet studies for turbulence model assessment—I. Flow-field experiments, *Int. J. Heat Mass Transfer* **36**(10), 2675 (1993).

11H. T. J. Craft, L. J. W. Graham and B. E. Launder, Impinging jet studies for turbulence model assessment—II. An examination of the performance of four turbulence models, *Int. J. Heat Mass Transfer* **36**(10), 2685 (1993).

12H. A. Faghri, S. Thomas and M. M. Rahman, Conjugate heat transfer from a heated disk to a thin liquid film formed by a controlled impinging jet, *J. Heat Transfer Trans. ASME* **115**(1), 116 (1993).

13H. L. G. Hansen and B. W. Webb, Air jet impingement heat transfer from modified surfaces, *Int. J. Heat Mass Transfer* **36**(4), 989 (1993).

14H. K. Ichimiya and T. Nasu, Heat transfer characteristics of an oblique impinging jet with confined wall, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(561), 270 (1993).

15H. S. Kohli, J. Srinivasan and H. S. Mukunda, Heat transfer to a horizontal disc using a buoyancy-induced jet, *Int. J. Heat Mass Transfer* **36**(16), 4049 (1993).

16H. P. W. Li and W. Q. Tao, Numerical and experimental investigations on heat–mass transfer of slot-jet impingement in a rectangular cavity, *Int. J. Heat Fluid Flow* **14**(3), 246 (1993).

17H. X. Liu and J. H. Lienhard V, Extremely high heat fluxes beneath impinging liquid jets, *J. Heat Transfer Trans. ASME* **115**(2), 472 (1993).

18H. Xin Liu, L. A. Gabour and J. H. Lienhard, V, Stagnation-point heat transfer during impingement of laminar liquid jets: analysis, *J. Heat Transfer Trans. ASME* **115**(1), 99 (1993).

19H. C. F. Ma, V. P. Gan, Y. C. Tian, D. H. Lei and T. Gomi, Liquid jet impingement heat transfer with or without boiling, *J. Therm. Sci.* **2**(1), 32 (1993).

20H. A. K. Mohanty and A. A. Tawfek, Heat transfer due to a round jet impinging normal to a flat surface, *Int. J. Heat Mass Transfer* **36**(6), 1639 (1993).

21H. I. Bedii Özdemir and J. H. Whitelaw, Impingement of an unsteady two-phase jet on unheated and heated flat plates, *J. Fluid Mech.* **252**, 499 (1993).

22H. M. R. Pais, L. C. Chow and E. T. Mahefkey, Multiple jet impingement cooling, *J. Thermophys. Heat Transfer* **7**(3), 435 (1993).

23H. S. Polat, Heat and mass transfer in impingement drying, *Drying Technol.* **11**(6), 1147 (1993).

24H. J. Stevens and B. W. Webb, Measurements of flow structure in the radial layer of impinging free-surface liquid jets, *Int. J. Heat Mass Transfer* **36**(15), 3751 (1993).

25H. J. Stevens and B. W. Webb, Measurements of flow structure in the stagnation zone of impinging free-surface liquid jets, *Int. J. Heat Mass Transfer* **36**(17), 4283 (1993).

26H. H. Sun, C. F. Ma and W. Nakayama, Local characteristics of convective heat transfer from simulated microelectronic chips to impinging submerged round water jets, *J. Electron. Packag.* **115**(1), 71 (1993).

27H. R. Viskanta, Heat transfer to impinging isothermal gas and flame jets, *Exp. Therm. Fluid Sci.* **6**(2), 111 (1993).

28H. Y. B. Wang, C. Chaussavoine and F. Teyssandier, Two-dimensional modelling of a non-confined circular impinging jet reactor—Fluid dynamics and heat transfer, *Int. J. Heat Mass Transfer* **36**(4), 857 (1993).

29H. D. J. Womac, S. Ramadhyani and F. P. Incropera, Correlating equations for impingement cooling of small heat sources with single circular liquid jets, *J. Heat Transfer Trans. ASME* **115**(1), 106 (1993).

30H. D. A. Zumbrunnen and M. Aziz, Convective heat transfer enhancement due to intermittency in a impinging jet, *J. Heat Transfer Trans. ASME* **115**(1), 91 (1993).

Spray cooling

31H. C. Arcoumanis and J.-C. Chang, Heat transfer between a heated plate and an impinging transient diesel spray, *Exp. Fluids* **16**(2), 105 (1993).

32H. Yu. A. Buevich, V. N. Mankevich and K. N. Agafonov, Jet cooling of heated surfaces by a flow of a drop aerosol, *High Temp.* **30**(5), 793 (1993).

33H. N. Hatta, H. Fujimoto and H. Takuda, Numerical analysis of flow pattern of impinging liquid sprays in a cold model for cooling a hot flat plate, *Appl. Sci. Res.* **50**(2), 129 (1993).

34H. J. P. Hollman and C. M. Kendall, Extended studies of spray cooling with Freon-113, *Int. J. Heat Mass Transfer* **36**(8), 2239 (1993).

35H. S. N. Kondepudi, A simplified analytical method to evaluate the effects of roof spray evaporative cooling, *Energy Convers. Manage.* **34**(1), 7 (1993).

36H. N. Ladommatos, Mechanisms of heat transfer to liquid films in the manifold of port-injected petrol engines, *Proc. Instn Mech. Engrs Part D* **207**(3), 211 (1993).

37H. M. H. Shi, T. C. Bai and J. Yu, Dynamic behavior and heat transfer of a liquid droplet impinging on a solid surface, *Exp. Therm. Fluid Sci.* **6**(2), 202 (1993).

38H. Jidong Yang, M. R. Pais and L. C. Chow, Critical heat flux limits in secondary gas atomized liquid spray cooling, *Exp. Heat Transfer* **6**(1), 55 (1993).

Drying

39H. V. O. Aimiuwu, A ceramic storage system based on evaporative cooling, *Energy Convers. Manage.* **34**(8), 707 (1993).

40H. M. C. Asensio, J. Seyed-Yagoobi and A. D. Stevens, Measurements of thermal contact conductance for a paper–metal interface and effective conductivity of machine samples, *Drying Technol.* **11**(6), 1371 (1993).

41H. V. A. F. Costa and A. R. A. Figueiredo, Numerical technique for solving partial differential equations system for the simulation of a fixed bed dryer, *Computers Chem. Engng.* **17**(11), 1129 (1993).

42H. M. J. Cunningham, Moisture transfer in roof sections under cyclic conditions and constant air pressure difference—Laboratory and modelling studies, *Build. Envir.* **28**(3), 323 (1993).

43H. R. El Diasty, P. Fazio and I. Budaiwi, Dynamic modelling of moisture absorption and desorption in buildings, *Build. Envir.* **28**(1), 21 (1993).

44H. A. S. Markowski, Quality interaction in a jet spouted bed dryer for bio-products, *Drying Technol.* **11**(2), 369 (1993).

45H. P. Perre, M. Moser and M. Martin, Advances in transport phenomena during convective drying with superheated steam and moist air, *Int. J. Heat Mass Transfer* **36**(11), 2725 (1993).

46H. Y. Saito, Regeneration characteristics of adsorbent in the integrated desiccant–collector, *J. Sol. Energy Engng Trans. ASME* **115**(3), 169 (1993).

47H. F. Zagrouba, M. A. Roques, T. Szentmariay and A. Szalay, Effects of high frequency electromagnetic field on heat sensitive media—II. Drying kinetics and simulation, *Hung. J. Ind. Chem.* **21**(2), 149 (1993).

48H. B. Fredlund, Modelling of heat and mass transfer in wood structures during fire, *Fire Safety J.* **20**(1), 39 (1993).

Miscellaneous

49H. L. P. Kholpanov and E. Ya. Kenig, Coupled mass and heat transfer in a multicomponent turbulent falling liquid film, *Int. J. Heat Mass Transfer* **36**(14), 3647 (1993).

50H. A. E. M. A. Mohamed, A. R. F. Elhefnawy and Y. D. Mahmoud, Nonlinear electrohydrodynamic Rayleigh–Taylor instability with mass and heat transfer. Effect of a tangential field, *Physica A* **195**(12), 74 (1993).

51H. Yu. V. Polezhaev, I. V. Repin and D. S. Mikhatulin, Heat transfer in a heterogeneous supersonic flow, *High Temp.* **30**(6), 949 (1993).

52H. P. Sebastian, J. P. Nadeau and J. R. Puiggali, Les nombres d'unités de transfert, thermique, massique, outils rapides de simulation de séchoirs, *Int. J. Heat Mass Transfer* **36**(7), 1773 (1993).

53H. W. Zheng and W. W. Worek, Numerical simulation of combined heat and mass transfer processes in a rotary dehumidifier, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 211 (1993).

CHANGE OF PHASE—BOILING

Droplet and film evaporation

1J. K. Annamalai, W. Ryan and S. Chandra, Evaporation of multicomponent drop arrays, *J. Heat Transfer Trans. ASME* **115**(3), 707 (1993).

2J. Y. Bayazitoglu and R. Cerny, Electromagnetic vaporization of molten-metal drops, *Int. J. Heat Mass Transfer* **36**(2), 277 (1993).

3J. Y. Bayazitoglu and R. Cerny, Nonequilibrium evaporation of molten-metal drops in an alternating magnetic field, *Int. J. Heat Mass Transfer* **36**(14), 3449 (1993).

4J. R. Bhatia and W. A. Strignano, Convective burning of a droplet containing a single metal particle, *Combust. Flame* **93**(3), 215 (1993).

5J. I. N. Bobrov and A. P. Kuryachii, Characteristics of the heat and mass transfer in evaporative thermal protection with variation of the external pressure, *Fluid Dyn.* **28**(1), 98 (1993).

6J. H. J. H. Brouwers, The combined effects of fog formation and Stefan flow on nickel and iron evaporation into helium, *Int. J. Heat Mass Transfer* **36**(1), 241 (1993).

7J. A. V. Butkovskii, Study of intensive vaporization of a drop of a water aerosol during laser heating with allowance for thermal expansion, *High Temp.* **30**(5), 783 (1993).

8J. H. C. Chebaro and K. P. Hallinan, Boundary conditions for an evaporating thin film for isothermal interfacial conditions, *J. Heat Transfer Trans. ASME* **115**(3), 816 (1993).

9J. C. H. Chiang and W. A. Sirignano, Interacting, convecting, vaporizing fuel droplets with variable properties, *Int. J. Heat Mass Transfer* **36**(4), 875 (1993).

10J. S. DasGupta, J. A. Schonberg and P. C. Wayner, Jr, Investigation of an evaporating extended meniscus based on the augmented Young–Laplace equation, *J. Heat Transfer Trans. ASME* **115**(1), 201 (1993).

11J. L. A. Dekhtyarenko, N. I. Zverev and N. N. Smirnov, Condensed gas evaporation into the atmosphere, *Int. J. Heat Mass Transfer* **36**(13), 3393 (1993).

12J. J.-P. Delplanque and W. A. Sirignano, Numerical study of the transient vaporization of an oxygen droplet at sub- and super-critical conditions, *Int. J. Heat Mass Transfer* **36**(2), 303 (1993).

13J. M. di Marzo, P. Tartarini, Y. Liao, D. Evans and H. Baum, Evaporative cooling due to a gently deposited droplet, *Int. J. Heat Mass Transfer* **36**(17), 4133 (1993).

14J. P. J. Erens and A. A. Dreyer, Modelling of indirect evaporative air coolers, *Int. J. Heat Mass Transfer* **36**(1), 17 (1993).

15J. G. Gorelik, N. Paylyukevich, S. Zalenskiy, S. Radev and S. Stefanov, Kinetics of intense evaporative mass transfer through a porous layer, *Int. J. Heat Mass Transfer* **36**(13), 3369 (1993).

16J. D. Y. Goswami, G. D. Mathur and S. M. Kulkarni, Experimental investigation of performance of a residential air conditioning system with an evaporatively cooled condenser, *J. Sol. Energy Engng Trans. ASME* **115**(4), 206 (1993).

17J. R. J. Gribben, Turbulent model of a falling film evaporator, *Math. Engng Industry* **4**(1), 49 (1993).

18J. M. Hariki, Applications of spray and mist cooling techniques to iron and steel manufacturing processes and some expected problems, *Sumitomo Met.* **45**(6), 130 (1993).

19J. J. P. Hartfield and P. V. Farrell, Droplet vaporization in a high-pressure gas, *J. Heat Transfer Trans. ASME* **115**(3), 699 (1993).

20J. S.-S. Hsieh and N.-H. Kuo, Analysis of evaporation in the presence of composition–temperature gradient induced natural convection, *Int. J. Heat Mass Transfer* **36**(4), 1097 (1993).

21J. H. Jia and G. Gogos, High pressure droplet vaporization; effects of liquid-phase gas solubility, *Int. J. Heat Mass Transfer* **36**(18), 4419 (1993).

22J. E. L. Kitanin, M. Yu. Osherova and A. S. Dobrovol'skii, Heat and mass transfer in film-evaporating mixture-Preparation systems of gas turbine plants, *Therm. Engng* **40**(3), 180 (1993).

23J. C. Kleinstreuer, J. K. Comer and H. Chiang, Fluid dynamics and heat transfer with phase change of multiple spherical droplets in a laminar axisymmetric gas stream, *Int. J. Heat Fluid Flow* **14**(3), 292 (1993).

24J. R. Kneer, M. Schneider, B. Noll and S. Wittig, Diffusion controlled evaporation of a multicomponent droplet: theoretical studies on the importance of variable liquid properties, *Int. J. Heat Mass Transfer* **36**(9), 2403 (1993).

25J. T. A. Kowalewski, W. J. Hiller and M. Behnia, An experimental study of evaporating small diameter jets, *Phys. Fluids A* **5**(8), 1883 (1993).

26J. A. N. Kucherov, Vaporization and explosion of a superheated droplet under isobaric conditions, *High Temp.* **30**(4), 625 (1993).

27J. I. A. Kuznetsova and A. A. Yushkanov, Boundary conditions for intense evaporation of a spherical particle into a vacuum, *High Temp.* **31**(1), 87 (1993).

28J. P. L. C. Lage, C. M. Hackenberg and R. H. Rangel, Non-ideal vaporization of dilating binary droplets with variable properties, *Int. J. Heat Mass Transfer* **36**(15), 3731 (1993).

29J. P. L. C. Lage and R. H. Rangel, Single droplet vaporization including thermal radiation absorption, *J. Thermophys. Heat Transfer* **7**(3), 502 (1993).

30J. S. Lee, Vaporization wave structure of dense bimodal sprays, *Int. J. Multiphase Flow* **19**(2), 391 (1993).

31J. S. V. Mani, M. Kulmala and T. Vesala, Evaporation of polydisperse ethanol aerosols in humid environment, *Int. J. Heat Mass Transfer* **36**(3), 705 (1993).

32J. M. J. Miketinac, S. Sokhansanj and Z. Tutek, Determination of heat and mass transfer coefficients in thin layer drying of grain, *Trans ASAE* **35**(6), 1853 (1993).

33J. J. Muhidong, L. H. Chen and D. B. Smith, Thin-layer drying of kenaf, *Trans. ASAE* **35**(6), 1941 (1993).

34J. H. D. Nguyen and J. N. Chung, Evaporation from a translating drop in an electric field, *Int. J. Heat Mass Transfer* **36**(15), 3797 (1993).

35J. A. N. Osiptsov and Ye. G. Shapiro, Heat transfer in the boundary layer of a 'gas-evaporating drops' two-phase mixture, *Int. J. Heat Mass Transfer* **36**(1), 71 (1993).

36J. M. Renksizbulut and M. Bussmann, Multicomponent droplet evaporation at intermediate Reynolds numbers, *Int. J. Heat Mass Transfer* **36**(11), 2827 (1993).

37J. D. Sibold and H. M. Urbassek, Monte Carlo study of Knudsen layers in evaporation from elemental and binary media, *Phys. Fluids A* **5**(1), 243 (1993).

38J. Y. Sone and H. Sugimoto, Kinetic theory analysis of steady evaporating flows from a spherical condensed phase into a vacuum, *Phys. Fluids A* **5**(6), 1491 (1993).

39J. T. D. Tang, M. T. Pauken, S. M. Jeter and S. I. Abdel-Khalik, On the use of monolayers to reduce evaporation from stationary water pools, *J. Heat Transfer Trans. ASME* **115**(1), 209 (1993).

40J. T. Vesala, On droplet evaporation in the presence of a condensing substance: the effect of internal diffusion, *Int. J. Heat Mass Transfer* **36**(3), 695 (1993).

41J. R. K. Wanchoo, Evaporation of drops in direct contact with an immiscible liquid. bubble growth, *Int. Commun. Heat Mass Transfer* **20**(1), 53 (1993).

42J. W.-M. Yan, Binary diffusion and heat transfer in mixed convection pipe flows with film evaporation, *Int. J. Heat Mass Transfer* **36**(8), 2115 (1993).

43J. Wei-Mon Yan, Mixed convection heat and mass transfer in a vertical channel with film evaporation, *Can. J. Chem. Engng* **71**(1), 54 (1993).

44J. J. B. Young, The condensation and evaporation of liquid droplets at arbitrary Knudsen number in the presence of an inert gas, *Int. J. Heat Mass Transfer* **36**(11), 2941 (1993).

Bubble characteristics and boiling incipience

45J. A. A. Avdeev and N. S. Halme, Heat transfer in bubble layers at elevated pressures, *Exp. Therm. Fluid Sci.* **6**(4), 341 (1993).

46J. A. A. Avdeev, Laws of heat transfer in a bubble layer, *High Temp.* **30**(5), 801 (1993).

47J. P. Deligiannis and J. W. Cleaver, Influence of surrounding bubbles on the rate of nucleation, *Int. J. Heat Mass Transfer* **36**(15), 3697 (1993).

48J. E. Elias and P. L. Chambre, Flashing inception in water during rapid decompression, *J. Heat Transfer Trans. ASME* **115**(1), 231 (1993).

49J. Z. C. Feng and L. G. Leal, On energy transfer in resonant bubble oscillations, *Phys. Fluids A* **5**(4), 826 (1993).

50J. S. L. Gavrilyuk, Propagation of a signal in a liquid with a continuous distribution of bubble sizes, *J. Appl. Mech. Tech. Phys.* **33**(4), 526 (1993).

51J. Mark J. Harper, Calculation of recoil ion effective track lengths in neutron-radiation-induced nucleation, *Nucl. Sci. Engng* **114**(2), 118 (1993).

52J. Y. Iida, K. Okuyama and K. Sakurai, Peculiar bubble generation on a film heater submerged in ethyl alcohol and imposed a high heating rate over 107 K s^{-1}, *Int. J. Heat Mass Transfer* **36**(10), 2699 (1993).

53J. T. Kotoyori, Critical temperatures for the thermal explosion of liquids, *Combust. Flame* **95**(3), 307 (1993).

54J. M. Kumagai, H. Ishizaki and K. Endoh, Penetration depth of bubble swarm entrained by a plunging water jet, *J. Chem. Engng Jpn* **26**(2), 217 (1993).

55J. S. Kumar, K. Kusakabe and L.-S. Fan, Heat transfer in three-phase fluidization and bubble-columns with high gas holdups, *A.I.Ch.E.Jl*, **39**, 1399 (1993).

56J. Wei-Ming Lu, Ruey-Chi Hsu, Wen-Chen Chien and Li-Chang Lin, Measurement of local bubble diameters and analysis of gas dispersion in an aerated vessel with disk-turbine impeller, *J. Chem. Engng Jpn* **26**(5), 551 (1993).

57J. Toshiro Miyahara and Shuichi Yamanaka, Mechanics of motion and deformation of a single bubble rising through quiescent highly viscous Newtonian and non-Newtonian media, *J. Chem. Engng Jpn* **26**(3), 297 (1993).

58J. K. Okada, S. Shibano and Y. Akagi, Turbulent properties in bubble-flow region in external-loop airlift bubble column, *J. Chem. Engng Jpn* **26**(6), 637 (1993).

59J. M.-H. Shi, J. Ma and B.-X. Wang, Analysis on hysteresis in nucleate pool boiling heat transfer, *Int. J. Heat Mass Transfer* **36**(18), 4461 (1993).

60J. T. S. Shin and O. C. Jones, Nucleation and flashing in nozzles—I. A distributed nucleation model, *Int. J. Multiphase Flow* **19**(6), 943 (1993).

61J. B. R. Stanmore and M. Desai, Steam explosions in boiler ash hoppers, *Proc. Instn Mech. Engng Part A* **207**(2), 133 (1993).

62J. K. Takahashi and A. W. Nienow, Bubble sizes and coalescence rates in an aerated vessel agitated by a Rushton turbine, *J. Chem. Engng Jpn* **26**(5), 536 (1993).

63J. F. E. Torres and E. Herbolzheimer, Temperature gradients and drag effects produced by convection of interfacial internal energy around bubbles, *Phys. Fluids A* **5**(3), 537 (1993).

64J. K. Ueyama, M. Saeki and M. Matsukata, Development of system for measuring bubble coalescence time by using a laser, *J. Chem. Engng Jpn* **26**(3), 308 (1993).

65J. R. K. Wanchoo, Terminal velocity equation for a two-phase bubble in an immiscible liquid medium, *Chem. Engng Commun.* **120,** 111 (1993).

66J. F. Yamashita, Effects of partition plates on gas holdup in a bubble column with and without a draught tube, *J. Chem. Engng Jpn* **26**(6), 742 (1993).

67J. L. Z. Zeng, J. F. Klausner and R. Mei, A unified model for the prediction of bubble detachment diameters in boiling systems—I. Pool boiling, *Int. J. Heat Mass Transfer* **36**(9), 2261 (1993).

68J. L. Z. Zeng, J. F. Klausner, D. M. Bernhard and R. Mei, A unified model for the prediction of bubble detachment diameters in boiling systems—II. Flow boiling, *Int. J. Heat Mass Transfer* **36**(9), 2271 (1993).

Pool boiling

69J. Y. Abe, Pool boiling under microgravity, *Microgravity Sci. Technol.* **6**(4), 229 (1993).

70J. M. Azimi and R. C. Jaeger, A microelectronic test structure and numerical algorithm for characterization of liquid immersion heat transfer, *IEEE Trans. Compon. Hybrids Mfg Technol.* **16**(3), 253 (1993).

71J. V. G. Bashtovoi, G. Challant and O. Yu. Volkova, Boiling heat transfer in magnetic fluids, *J. Magn. Magn. Mater.* **122**(13), 305 (1993).

72J. F. Bonetto, A. Clausse and J. Converti, Two-phase flow in the localized boiling field adjacent to a heated wall, *Int. J. Heat Mass Transfer* **36**(5), 1367 (1993).

73J. Y. S. Cha, R. C. Niemann and J. R. Hull, Thermodynamic analysis of helium boil-off experiments with pressure variations, *Cryogenics* **33**(7), 675 (1993).

74J. J.-F. Chen, M.-H. Liu and Y.-M. Yang, Critical heat flux in pool boiling of binary mixtures as determined by the quenching method, *Int. J. Heat Mass Transfer* **36**(16), 4071 (1993).

75J. T. Y. Chu, A correlational approach to turbulent saturated film boiling, *J. Heat Transfer Trans. ASME* **115**(4), 993 (1993).

76J. P. Di Marco and W. Grassi, Saturated pool boiling enhancement by means of an electric field, *J. Enhanced Heat Transfer* **1**(1), 99 (1993).

77J. M. R. Duignan, G. A. Greene and T. F. Irvine, Jr, The effect of surface gas injection on film boiling heat transfer, *J. Heat Transfer Trans. ASME* **115**(4), 986 (1993).

78J. A. J. Fletcher and W. D. Griffiths, Quenching of steel plates in sodium polyacrylate solutions, *Mater. Sci. Technol.* **9**(2), 176 (1993).

79J. J. Fukai, N. Kato and O. Miyatake, Measurement of cooling rates and boiling curves of a thin plate during quenching, *Heat Transfer Jpn Res.* **22**(3), 281 (1993).

80J. E. Hahne and K. Shi, How to obtain pool boiling heat transfer coefficients for tubes from wire experiments, *Int. Commun. Heat Mass Transfer* **20**(3), 361 (1993).

81J. W. R. Hamburgen and J. S. Fitch, Packaging a 150-W bipolar ECL microprocessor, *IEEE Trans. Compon. Hybrids Mfg Technol.* **16**(1), 28 (1993).

82J. J.-T. Hsu, C.-S. Lin and M.-K. Jensen, Boiling heat transfer mechanisms in a horizontal tube bundle, *Exp. Heat Transfer* **6**(3), 259 (1993).

83J. S. Inada and W.-J. Yang, Effects of heating surface materials on a liquid–solid contact state in a sessile drop-boiling system, *J. Heat Transfer Trans. ASME* **115**(1), 222 (1993).

84J. E. Ishibashi, Zhen-Hua Liu, T. Chirifu and N. Murakami, Pool boiling heat transfer characteristics of the surface-worked heat transfer tubes in narrow space under reduced pressure conditions, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(557), 198 (1993).

85J. R. L. Judd and A. Chopra, Interaction of the nucleation processes occurring at adjacent nucleation sites, *J. Heat Transfer Trans. ASME* **115**(4), 955 (1993).

86J. S. M. Kozlov, O. S. Komarevsky, K. V. Rusanov, J. Tenbrink and H. Krauth, Heat transfer during helium cooling of $Bi_2Sr_2Ca_1Cu_2O_{9+x}$/Ag composite tapes, *Cryogenics* **33**(9), 846 (1993).

87J. T. Y. Tom Lee, M. Mahalingam and P. J. C. Normington, Subcooled pool boiling critical heat flux in dielectric liquid mixtures, *J. Electron. Packag.* **115**(1), 134 (1993).

88J. Rui-Qing Li and R. Harris, On the dominant unstable wavelength during film boiling on a horizontal cylinder of small diameter, *J. Heat Transfer Trans. ASME* **115**(2), 498 (1993).

89J. L. Likhterov, High frequency asymptotics of acoustical nucleate pool boiling noise spectrum in compressible viscous liquids, *Int. J. Heat Mass Transfer* **36**(16), 3931 (1993).

90J. W. J. Miller and B. Gebhart, Boiling on micro-configured surfaces in liquid nitrogen, *Int. Commun. Heat Mass Transfer* **20**(3), 375 (1993).

91J. I. Mudawar and T. M. Anderson, Optimization of enhanced surfaces for high flux chip cooling by pool boiling, *J. Electron. Packag.* **115**(1), 89 (1993).

92J. S. Nishio and H. Ohtake, Vapor-film-unit model and heat transfer correlation for natural-convection film boiling with wave motion under subcooled conditions, *Int. J. Heat Mass Transfer* **36**(10), 2541 (1993).

93J. H. Ogata, Steady-state heat transfer in transition boiling of helium on copper surfaces, *Cryogenics* **33**(6), 640 (1993).

94J. J. Ogata and A. Yabe, Basic study on the enhancement of nucleate boiling heat transfer by applying electric fields, *Int. J. Heat Mass Transfer* **36**(3), 775 (1993).

95J. J. Ogata and A. Yabe, Augmentation of boiling heat transfer by utilizing the EHD effect—EHD behaviour of boiling bubbles and heat transfer characteristics, *Int. J. Heat Mass Transfer* **36**(3), 783 (1993).

96J. D. M. Pachosa and J. N. Chung, Dielectrophoresis-driven nucleate boiling in a simulated microgravity environment, *J. Heat Transfer Trans. ASME* **115**(2), 495 (1993).

97J. K. O. Pasamehmetoglu, P. R. Chappidi, C. Unal and R. A. Nelson, Saturated pool nucleate boiling mechanisms at high heat fluxes, *Int. J. Heat Mass Transfer* **36**(15), 3859 (1993).

98J. U. V. Polezhaev and S. A. Kovalev, Enhanced boiling heat exchange, *High Temp.* **30**(5), 845 (1993).

99J. P. S. Ramesh and K. E. Torrance, Boiling in a porous layer heated from below: effects of natural convection and a moving liquid two-phase interface, *J. Fluid Mech.* **257**, 289 (1993).

100J. A. Skoczylas and A. Urbanski, Hydrodynamics and heat transfer at the boiling of liquids in thin-layer evaporator with vibrating element, *Chem. Engng Commun.* **121**, 165 (1993).

101J. J. Straub, M. Zell and B. Vogel, What we learn from boiling under microgravity, *Microgravity Sci. Technol.* **6**(4), 239 (1993).

102J. K. Sundmacher and U. Hoffmann, Activity evaluation of a catalytic distillation packing for MTBE production, *Chem. Engng Technol.* **16**(4), 279 (1993).

103J. M. Takahashi, K. Shinbo, R. Ohkawa, M. Matsuzaki and A. Inoue, Nucleate pool boiling heat transfer of magnetic fluid in a magnetic field, *J. Magn. Magn. Mater.* **122**(13), 301 (1993).

104J. M. Takahashi, A. Inoue, M. Matsuzaki and R. Ohkawa, Saturated pool boiling heat transfer of toluene-solvent magnetic fluid on a horizontal surface (effects of field gradient, concentration of particles and pressure), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1271 (1993).

105J. M. Takahashi, A. Inoue and K. Shinbo, Saturated pool boiling heat transfer of toluene-solvent magnetic fluid on a vertical cylindrical surface (effects of field gradient and concentration of particles), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(562), 2015 (1993).

106J. M. Takahashi, A. Inoue and K. Shinbo, Saturated pool boiling heat transfer of hexane-solvent magnetic fluid on a horizontal surface (comparison with toluene-solvent magnetic fluid), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(562), 2007 (1993).

107J. N. Tamada, S. Fuchino, N. Natori, I. Ishii and M. Okano, Optical measurement of transient phenomenon of liquid helium boiling under very high centrifugal operation, *Cryogenics* **33**(11), 1023 (1993).

108J. A. H. Tarrad and B. M. Burnside, Pool boiling tests on plain and enhanced tubes using a wide-boiling-range mixture, *Exp. Heat Transfer* **6**(1), 83 (1993).

109J. C. Unal, P. Sadasivan and R. A. Nelson, On the hot-spot-controlled critical heat flux mechanism in saturated pool boiling—II. The influence of contact angle and nucleation site density, *J. Heat Transfer Trans. ASME* **115**(3), 813 (1993).

110J. S. V. Vershinin, Yu. G. Ferstater and Yu. F. Maidanik, Effect of the thermal contact resistance on heat transfer during boiling from fine porous capillary structures, *High Temp.* **30**(4), 668 (1993).

111J. C. H. Wang and V. K. Dhir, Effect of surface wettability on active nucleation site density during pool boiling of water on a vertical surface, *J. Heat Transfer Trans. ASME* **115**(3), 659 (1993).

112J. C. H. Wang and V. K. Dhir, On the gas entrapment and nucleation site density during pool boiling of saturated water, *J. Heat Transfer Trans. ASME* **115**(3), 670 (1993).

113J. R. H. Yeh and S. P. Liaw, Optimum configuration of a fin for boiling heat transfer, *J. Franklin Inst.* **330**(1), 153 (1993).

Flow boiling

114J. T. Aihara, J.-K. Kim, K. Suzuki and K. Kasahara, Boiling heat transfer of a micro-impinging jet of liquid nitrogen in a very slender cryoprobe, *Int. J. Heat Mass Transfer* **36**(1), 169 (1993).

115J. M. Aritomi, T. Miyata, M. Horiguchi and A. Sudi, Thermo-hydraulics of boiling two-phase flow in high conversion light water reactors (thermo-hydraulics at low velocities), *Int. J. Multiphase Flow* **19**(1), 51 (1993).

116J. G. P. Celata, M. Cumo and A. Mariani, Burnout in highly subcooled water flow boiling in small diameter tubes, *Int. J. Heat Mass Transfer* **36**(5), 1269 (1993).

117J. G. P. Celata, M. Cumo and T. Setaro, Forced convective boiling in binary mixtures, *Int. J. Heat Mass Transfer* **36**(13), 3299 (1993).

118J. G. P. Celata, M. Cumo, A. Mariani, H. Nariai and F. Inasaka, Influence of channel diameter on subcooled flow boiling burnout at high heat fluxes, *Int. J. Heat Mass Transfer* **36**(13), 3407 (1993).

119J. K. E. Crowe and P. Griffith, Intermittent flow dryout limit in heated horizontal tubes, *Int. J. Multiphase Flow* **19**(4), 575 (1993).

120J. B. Donevski, J. S. Chang and D. C. Groeneveld, Prediction methods for interfacial parameters used in inverted annular film boiling, *Heat Technol.* **10**(34), 43 (1993).

121J. J. Filipovic, R. Viskanta and F. P. Incropera, Similarity solution for laminar film boiling over a moving isothermal surface, *Int. J. Heat Mass Transfer* **36**(12), 2957 (1993).

122J. J. E. Galloway and I. Mudawar, CHF mechanism in flow boiling from a short heated wall—I. Examination of near-wall conditions with the aid of photomicrography and high-speed video imaging, *Int. J. Heat Mass Transfer* **36**(10), 2511 (1993).

123J. J. E. Galloway and I. Mudawar, CHF mechanism in flow boiling from a short heated wall—II. Theoretical CHF model, *Int. J. Heat Mass Transfer* **36**(10), 2527 (1993).

124J. C. O. Gersey and I. Mudawar, Nucleate boiling and critical heat flux from protruded chip arrays during flow boiling, *J. Electron. Packag.* **115**(1), 78 (1993).

125J. C. O. Gersey and I. Mudawar, Orientation effects on critical heat flux from discrete, in-line heat sources in a flow channel, *J. Heat Transfer Trans. ASME* **115**(4), 973 (1993).

126J. Z. R. Gorbis, A. Rene Raffray and M. A. Abdou, High-heat-flux removal by phase-change fluid and particulate flow, *Fusion Technol.* **23**(4), 435 (1993).

127J. Y. A. Hassan and L. L. Raja, Simulation of loss of RHR during midloop operations and the role of steam generators in decay heat removal using the RELPA-5/MOD3 code, *Nucl. Technol.* **103**(3), 310 (1993).

128J. R. E. Henry, J. P. Burelbach, R. J. Hammersley, C. E. Henry and G. T. Klopp, Cooling of core debris within the reactor vessel lower head, *Nucl. Technol.* **101**(3), 385 (1993).

129J. Wei-Hsiao Ho, Kuan-Chywan Tu, Bau-Shei Pei and Chin-Jang Chang, Theoretical critical heat flux model for low-pressure, low-mass-flux and low-steam-quality conditions, *Nucl. Technol.* **103**(3), 332 (1993).

130J. M. A. Hoffman and B. R. Springsteen, A forced convection subcooled boiling model for nonuniform axial heat fluxes, *Int. J. Heat Mass Transfer* **36**(18), 4375 (1993).

131J. X. C. Huang and G. Bartsch, About the second-order instability on an electrically heated temperature-controlled test section under forced convective boiling conditions, *Int. J. Heat Mass Transfer* **36**(10), 2601 (1993).

132J. X. C. Huang, P. Weber and G. Bartsch, Comparison of transient and steady-state boiling curves for forced upflow of water in a circular tube at medium pressure, *Int. Commun. Heat Mass Transfer* **20**(3), 383 (1993).

133J. T. Iwamura, H. Watanabe, T. Okubo, F. Araya and Y. Murao, CHF experiments under steady-state and transient conditions for tight lattice core with nonuniform axial power distribution, *J. Nucl. Sci. Technol.* **30**(5), 413 (1993).

134J. J. F. Klausner, R. Mei, D. M. Bernhard and L. Z. Zeng, Vapor bubble departure in forced convection boiling, *Int. J. Heat Mass Transfer* **36**(3), 651 (1993).

135J. J. C. Lai and B. Farouk, Numerical simulation of subcooled boiling and heat transfer in vertical ducts, *Int. J. Heat Mass Transfer* **36**(6), 1541 (1993).

136J. Chien-Hsiung Lee and Kuo-Wei Lin, Experimental investigation of flow transient critical heat flux at light water reactor conditions, *Int. Commun. Heat Mass Transfer* **20**(4), 477 (1993).

137J. Si Y. Lee, New flooding correlation development and its critical heat flux predictions under low air–water flow conditions in Savannah River site assembly channels, *Nucl. Technol.* **104**(1), 64 (1993).

138J. J. E. Leland and L. C. Chow, Forced convection boiling from a nonflush simulated electronic chip, *J. Thermophys. Heat Transfer* **7**(4), 588 (1993).

139J. R. W. Lyczkowski, H. M. Domanus, M. Bottoni and W. T. Sha, Analysis of critical and subcritical flow boiling, *Int. J. Heat Mass Transfer* **36**(15), 3813 (1993).

140J. B. Mavko, S. Petelin and O. Gortner, RELAP5 Modeling of the Westinghouse model D4 steam generator, *Nucl. Technol.* **101**(2), 181 (1993).

141J. W. R. McGillis and V. P. Carey, Subcooled convective boiling of binary mixtures over an array of heated elements, *J. Thermophys. Heat Transfer* **7**(2), 346 (1993).

142J. K. Murata and K. Hashizume, Forced convection boiling of nonazeotropic refrigerant mixtures inside tubes, *J. Heat Transfer Trans. ASME* **115**(3), 680 (1993).

143J. C. H. Oh and S. B. Englert, Critical heat flux for low flow boiling in vertical uniformly heated thin rectangular channels, *Int. J. Heat Mass Transfer* **36**(2), 325 (1993).

144J. M. Ozawa, H. Umekawa, Y. Yoshioka and A. Tomiyama, Dryout under oscillatory flow condition in vertical and horizontal tubes—experiments at low velocity and pressure conditions, *Int. J. Heat Mass Transfer* **36**(16), 4076 (1993).

145J. M. Packo, H. Kusiak and M. Pietrzyk, Modelling water cooling of steel strip during hot rolling, *Steel Res.* **64**(2), 128 (1993).

146J. X. F. Peng and B.-X. Wang, Forced convection and flow boiling heat transfer for liquid flowing through microchannels, *Int. J. Heat Mass Transfer* **36**(14), 3421 (1993).

147J. R. A. Riemke, Modification to Unal's subcooled flow boiling bubble model, *Nucl. Technol.* **102**(3), 416 (1993).

148J. R. P. Roy, A. Hasan and S. P. Kalra, Temperature and velocity fields in turbulent liquid flow adjacent to a bubbly boiling layer, *Int. J. Multiphase Flow* **19**(5), 765 (1993).

149J. S. W. Ruan, G. Bartsch and S. M. Yang, Characteristics of the critical heat flux for downward flow in a vertical tube at low flow rate and low pressure conditions, *Exp. Therm. Fluid Sci.* **7**(4), 296 (1993).

150J. N. Savkin, Z. Mesarkishvili and G. Bartsch, Experimental study of void fraction and heat transfer under upward and downward flow boiling conditions, *Int. Commun. Heat Mass Transfer* **20**(6), 783 (1993).

151J. A. O. Skomorokhov, Adaptive learning networks in APL2, *APL Quote Quad* **24**(1), 219 (1993).

152J. Y. Sudo and M. Kaminaga, A new CHF correlation scheme proposed for vertical rectangular channels heated from both sides in nuclear research reactors, *J. Heat Transfer Trans. ASME* **115**(2), 426 (1993).

153J. R. M. Tain, S. C. Cheng and D. C. Groeneveld, Critical heat flux measurements in a round tube for CFCs and CFC alternatives, *Int. J. Heat Mass Transfer* **36**(8), 2039 (1993).

154J. H. Takamatsu, S. Momoki and T. Fujii, A correlation for forced convective boiling heat transfer of pure refrigerants in a horizontal smooth tube, *Int. J. Heat Mass Transfer* **36**(13), 3351 (1993).

155J. H. Takamatsu, S. Momoki and T. Fujii, A correlation for forced convective boiling heat transfer of non-azeotropic refrigerant mixture of HCFC22/CFC114 in a horizontal smooth tube, *Int. J. Heat Mass Transfer* **36**(14), 3555 (1993).

156J. M. W. Wambsganss, D. M. France, J. A. Jendrzejczyk and T. N. Tran, Boiling heat transfer in a horizontal small-diameter tube, *J. Heat Transfer Trans. ASME* **115**(4), 963 (1993).

157J. L. Z. Zeng and J. F. Klausner, Nucleation site density in forced convection boiling, *J. Heat Transfer Trans. ASME* **115**(1), 215 (1993).

Two-phase thermohydraulic phenomena

158J. M. Aritomi, T. Miyata, M. Horiguchi and A. Sudi, Thermo-hydraulics of boiling two-phase flow in high convection light water reactors (thermo-hydraulics at low velocities), *Int. J. Multiphase Flow* **19**(1), 51 (1993).

159J. M. A. Chaiko and P. A. Blythe, Influence of nuclear heating on two-phase channel instabilities, *Int. J. Engng Sci.* **31**(2), 271 (1993).

160J. Songhua Chen, Fangfang Qin, Kyung-Hoe Kim and A. Ted Watson, NMR imaging of multiphase flow in porous media, *A.I.Ch.E.Jl* **39,** 925 (1993).

161J. Yu. P. Filippov, A. I. Alexeyev, A. V. Ivanov and B. V. Lunkin, Expanding application of cryogenic void fraction sensors, *Cryogenics* **33**(8), 828 (1993).

162J. E. Hahne, K. Spindler and H. Skok, A new pressure drop correlation for subcooled flow boiling of refrigerants, *Int. J. Heat Mass Transfer* **36**(17), 4267 (1993).

163J. A. Huang and D. D. Joseph, Stability of liquid–vapor flow down an inclined channel with phase change, *Int. J. Heat Mass Transfer* **36**(3), 663 (1993).

164J. I. Naot, D. R. Lewin and S. J. Wajc, Steady-state multiplicity in boiling fluid pipe flow, *Int. J. Heat Mass Transfer* **36**(18), 4497 (1993).

165J. M. Parlar, M. Zeybek and Y. C. Yortsos, Analysis of steady-state, vapor–liquid concurrent flow, *SPE Adv. Technol. Ser.* **1**(2), 17 (1993).

166J. A. J. N. Vreenegoor and J. A. Geurst, Two-phase bubbly flow through vertical tube: void-fraction distribution and velocity profiles, *Physica A* **192**(3), 410 (1993).

CHANGE OF PHASE—CONDENSATION

Surface geometry and material effects

1JJ. S. A. Yang and C. K. Chen, Laminar film condensation on a horizontal elliptical tube with uniform surface heat flux and suction at the porous wall, *Chung-Kuo Chi Hsueh Ch'eng Hsueh Pao* **14**(1), 93 (1993).

2JJ. M. Hassib Jaber and R. L. Webb, Enhanced tubes for steam condensers, *Exp. Heat Transfer* **6**(1), 35 (1993).

3JJ. Y. T. Lin, Li Chung, M. Choi and R. Greif, An analysis of the effect of the solid layer for the modified chemical vapor deposition process, *Wärme Stoffübertrag.* **28**(4), 169 (1993).

4JJ. D. R. Mirth and S. Ramadhyani, Prediction of cooling-coil performance under condensing conditions, *Int. J. Heat Fluid Flow* **14**(4), 391 (1993).

5JJ. T. J. Rabas and R. Schaefer, Enhanced surface condensers improve heat rates, *Power Engng* (Barrington Ill) **97**(7), 36 (1993).

6JJ. K. J. Renken and M. Aboye, Analysis of film condensation within inclined thin porous-layer coated surfaces, *Int. J. Heat Fluid Flow* **14**(1), 48 (1993).

7JJ. K. J. Renken and M. Aboye, Experiments on film condensation promotion within thin inclined porous coatings, *Int. J. Heat Mass Transfer* **36**(5), 1347 (1993).

8JJ. K. J. Renken and C. D. Mueller, Measurements of enhanced film condensation utilizing a porous metallic coating, *J. Thermophys. Heat Transfer* **7**(1), 148 (1993).

Global geometry and thermal boundary condition effects

9JJ. P. A. Andreev, B. F. Balunov, D. G. Govyadko, T. S. Zhivitskaya and V. I. Kiselev, Intensity of vapor condensation on the surface of a vertical top-sealed duct, *Therm. Engng* **40**(3), 222 (1993).

10JJ. B. Bella, A. Cavallini, G. A. Longo and L. Rossetto, Pure vapour condensation of refrigerants 11 and 113 on a horizontal integral finned tube at high vapour velocity, *J. Enhanced Heat Transfer* **1**(1), 77 (1993).

11JJ. V. N. Grebennikov, Z. L. Miropol'skii and R. I. Shneerova, Heat transfer during condensation of superheated and saturated steam inside pipes, *Therm. Engng* **40**(6), 480 (1993).

12JJ. H. Kazeminejad, Effect of vapour drag on laminar film condensation on a vertical rectangular fin, *Proc. Instn Mech. Engrs Part C* **207**(1), 63 (1993).

13JJ. M. P. Maric, D. D. Gvozdenac and M. P. Stakie, Condensation intensity in vapour–gas mixture, *Wärme Stoffübertrag.* **28**(3), 147 (1993).

14JJ. S. B. Memory, W. C. Lee and J. W. Rose, Forced convection film condensation on a horizontal tube—Effect of surface temperature variation, *Int. J. Heat Mass Transfer* **36**(6), 1671 (1993).

15JJ. B. I. Nigmatulin, N. I. Vasiliev and V. V. Guguchkin, Interaction between liquid droplets and heated surface, *Wärme Stoffübertrag.* **28**(6), 313 (1993).

16JJ. K. J. Renken, M. Aboye, M. Carneiro and K. Meechan, Effect of vapor velocity on film condensation along a surface embedded in a porous medium, *Int. Commun. Heat Mass Transfer* **20**(1), 1 (1993).

17JJ. T. Shigechi, N. Kawae, Y. Tokita and T. Yamada, Film-condensation heat transfer on a finite-size horizontal plate facing upward, *Heat Transfer Jpn Res.* **22**(1), 66 (1993).

18JJ. A. B. Vatazhin, V. A. Likhter and V. I. Shul'gin, Corona in a turbulent jet with condensation, *Fluid Dyn.* **27**(4), 470 (1993).

19JJ. N. E. Wijeysundera, B. F. Zheng, M. Iqbal and E. G. Hauptmann, Effective thermal conductivity of flat-slab and round-pipe insulations in the presence of condensation, *J. Therm. Insul. Build. Envelopes* **17,** 1065 (1993).

20JJ. S.-A. Yang and C.-K. Chen, Role of surface tension and ellipticity in laminar film condensation on a horizontal elliptical tube, *Int. J. Heat Mass Transfer* **36**(12), 3135 (1993).

21JJ. S.-A. Yang and C.-K. Chen, Filmwise condensation on nonisothermal horizontal elliptical tubes with surface tension, *J. Thermophys. Heat Transfer* **7**(4), 729 (1993).

Analysis techniques

22JJ. B. D. Boyer, J. W. Hartzell, S. Lider, G. E. Robinson, A. J. Baratta and A. J. Roscioli, Modeling condensation steam quenching effects in an MSIV closure transient using Retran-02-Mod002 with and without nonequilibrium pressurizer model option and Trac-BF1, *Nucl. Technol.* **103**(2), 206 (1993).

23JJ. S. L. Chen and M. T. Ke, Forced convective film condensation inside vertical tubes, *Int. J. Multiphase Flow* **19**(6), 1045 (1993).

24JJ. H.-M. Hellmann, Predicting the performance of evaporative coolers and condensers, *Wärme Stoffübertrag.* **28**(5), 299 (1993).

25JJ. I. Kotcioglu, A. V. Uyarel, K. Kaygusuz, S. Gullapoglu and I. Dincer, Approach to heat and mass transfer analysis during film condensation inside a vertical tube, *Int. Commun. Heat Mass Transfer* **20**(2), 265 (1993).

26JJ. A. K. Leont'ev, A condensation technique for analysis of the moisture content in producer-gases, *Therm. Engng* **40**(4), 311 (1993).

27JJ. E. Stuhlträger, Y. Naridomi, A. Miyara and H. Uehara, Flow dynamics and heat transfer of a condensate film on a vertical wall—I. Numerical analysis and flow dynamics, *Int. J. Heat Mass Transfer* **36**(6), 1677 (1993).

28JJ. Zhong-Zheng Wang and Zhen-Nan Zhao, Analysis of performance of steam condensation heat transfer and pressure drop in plate, *Heat Transfer Engng* **14**(4), 32 (1993).

29JJ. K. K. Yau and J. W. Rose, Prediction of the performance of domestic 'condensing boilers', *Gas Engng Manage.* **33**, 198 (1993).

Free surface condensation

30JJ. C. F. Delale, G. H. Schnerr and J. Zierep, Asymptotic solution of transonic nozzle flows with homogeneous condensation—I. Subcritical flows, *Phys. Fluids A* **5**(11), 2969 (1993).

31JJ. C. F. Delale, G. H. Schnerr and J. Zierep, Asymptotic solution of transonic nozzle flows with homogeneous condensation—II. Supercritical flows, *Phys. Fluids A* **5**(11), 2982 (1993).

32JJ. Y. Utaka, A. Saito and T. Seki, Gas hydrate cold storage using direct-contact heat transfer of liquid–vapor phase change and natural circulation of refrigerant in closed vessel, *JSME Int. J. Ser.* **B36**(1), 150 (1993).

33JJ. F. Zangrando and D. Bharanthan, Direct-contact condensation of low-density steam on seawater at high inlet noncondensable concentrations, *J. Heat Transfer* **115**(3), 690 (1993).

Transient effects including nucleation

34JJ. G. J. Bom, Energy losses through entrance condensation in small vapour engines, *Sol. Energy* **50**(3), 223 (1993).

35JJ. M. Iguchi, H. Tokunaga, H. Tatemichi and Z. Morita, The mechanism of thermal accretion (mushroom) formation and the bubble and flow characteristics during cold gas injection, *Int. J. Multiphase Flow* **19**(1), 173 (1993).

36JJ. H. Shinagawa, T. Hamada and K. Okuyama, Heterogeneous nucleation characteristics of mixed vapor of benzene and cyclohexane on a cold substrate, *J. Chem. Engng Jpn* **26**(2), 173 (1993).

Binary mixtures

37JJ. B. V. Derjaguin, Iu. S. Kurghin, L. A. Rosenweig and V. A. Fedoseyev, Study of passivation of condensation growth of drops of water and salt solution, *Prog. Surf. Sci.* **43**(14), 310 (1993).

38JJ. T. Fujii, K. Shinzato and J. B. Lee, Various formulas and their accuracy concerning convective heat and mass transfer in the vapor boundary layer in the case of laminar film condensation of binary vapor mixtures, *Int. J. Heat Mass Transfer* **36**(1), 27 (1993).

39JJ. Y. A. Hassan and L. L. Raja, Analysis of experiments for steam condensation in the presence of noncondensable gases using the RELAPS/M0D3 Code, *Nucl. Technol.* **104**(1), 76 (1993).

40JJ. H. Kosuge, T. Mamyoda and K. Asano, Simulation of condensation of binary vapor mixture on a vertical flat plate, *J. Chem. Engng Jpn* **26**(3), 315 (1993).

41JJ. S. M. Sami and J. Schnotale, Prediction of forced convective condensation of non-azeotropic refrigerant mixtures inside enhanced surface tubing, *Appl. Sci. Res.* **50**(2), 149 (1993).

42JJ. M. Siddique, M. W. Golay and M. S. Kazimi, Local heat transfer coefficients for forced-convection condensation of steam in a vertical tube in the presence of a noncondensable gas, *Nucl. Technol.* **102**(3), 386 (1993).

43JJ. J. Stinnesbeck and H. Herwig, Film condensation with a non-condensable gas from an asymptotic point of view, *Wärme Stoffübertrag.* **28**(3), 159 (1993).

CHANGE OF PHASE—FREEZING AND MELTING

Stefan problem

1JM. V. A. Kalistratov and S. P. Okhezin, The optimization model for the Stefan problem, *Prikladnaya Matematika Mekhanika* **57**(3), 34 (1993).

Solidification in alloys/casting

2JM. H. S. Chiou, R. H. Yen, M. D. Chu and Y. N. Pan, Solidification pattern of an aluminum alloy in step-plate castings, *Chung-Kuo Chi Hsueh Ch'eng Hsueh Pao* **14**(1), 53 (1993).

3JM. G. P. Borisov, Casting under adjustable heat power effect, *Liteinoe Proizvodstvo* (9), 25 (1993).

4JM. Q. Z. Diao and H. L. Tsai, The formation of negative- and positive-segregated bands during solidification of aluminum–copper alloys, *Int. J. Heat Mass Transfer* **36**(18), 4299 (1993).

5JM. W. Fix, H. Jacobi and K. Wuennenberg, Collision-controlled growth of composites in casting nozzles, *Steel Res.* **64**(1), 71 (1993).

Solidification: crystals

6JM. X. Liang and E. J. Lavernia, Solidification and microstructure evolution during spray atomization and deposition of NiAl, *Mater. Sci. Engng A. Struct. Mater. Prop. Microstruct. Process. A* **161**(2), 221 (1993).

7JM. Wen-Ming Chang, W. R. Wilcox and L. Regel, Floating-zone melting of CdTe, *Mater. Sci. Eng B Solid State Adv. Technol. B* **16**(13), 23 (1993).

8JM. J. H. Chen and H. L. Tsai, Inverse segregation for a unidirectional solidification of aluminum–copper alloys, *Int. J. Heat Mass Transfer* **36**(12), 3069 (1993).

9JM. K. Davey, Analytical solution for the unidirectional solidification problem, *Appl. Math. Model.* **17**(12), 658 (1993).

10JM. R. Derebail, W. R. Wilcox and L. L. Regel, Influence of gravity on the directional solidification of indium antimonide, *J. Spacecr. Rockets* **30**(2), 202 (1993).

11JM. M. H. Hsieh, C. C. Chieng, K. H. Lie and Y. D. Guo, For the growth of 3-inch D-shaped GaAs crystals by a modified horizontal Bridgman process, *Proc. Instn Mech. Engrs Part C* **207**(3), 185 (1993).

12JM. M. Kruse and J. Ulrich, Crystal growth in solution crystallisation as a three-stage model, *Chem. Ing. Tech.* **65**(1), 60 (1993).

13JM. P. G. McCormick, Yinong Liu and S. Miyazaki, Intrinsic thermal–mechanical behaviour associated with the stress-induced martensitic transformation in NITI, *Mater. Sci. Engng A Struct. Mater. Prop. Microstruct. Process. A* **167**(12), 51 (1993).

14JM. S. C. Sharma, T. Volkmann and D. M. Herlach, Microstructural development in drop-tube-solidified Al–3.6wt.%Fe droplets: an analysis, *Mater. Sci. Engng A. Struct. Mater. Prop. Microstruct. Process. A* **171**(12), 169 (1993).

15JM. Ch. Steer, M. Hage-Ali, J. M. Koebel and P. Siffert, Computer simulation of CdTe crystal growth and application, *Mater. Sci. Engng B Solid State Adv. Technol. B* **16**(13), 48 (1993).

16JM. V. I. Yliseev, Yu. P. Sovit and L. A. Fleer, Heat exchange of complex filaments in terms of crystallization, *Khimicheskie Volokna* (3), 26 (1993).

Freezing and melting: frost, ice and snow

17JM. A. J. Fowler and A. Bejan, Contact melting during sliding on ice, *Int. J. Heat Mass Transfer* **36**(5), 1171 (1993).

18JM. Ruochuan Gu and H. G. Stefan, Submerged warm water jet discharge in an ice-covered reservoir or lake, *Cold Reg. Sci. Technol.* **21**(2), 151 (1993).

19JM. T. Hirata, S. Ando and M. Ishikawa, Onset conditions for enhancement of ice accumulation associated with heat conductor plates located perpendicularly to heat transfer surfaces (1st Report, analysis for still water), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1303 (1993).

20JM. C. J. Ho and C. H. Chu, The melting process of ice from a vertical wall with time–periodic temperature perturbation inside a rectangular enclosure, *Int. J. Heat Mass Transfer* **36**(13), 3171 (1993).

21JM. K. Sasaguchi and H. Takeo, Solid–liquid phase change heat transfer in porous media (effect of the orientation of a hot wall with fins on the melting process), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(561), 250 (1993).

22JM. K. Sasaguchi, K. Kusano and N. Nisimizu, Solid–liquid phase change heat transfer in porous media (effects of fins on the solidification process), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(561), 284 (1993).

23JM. M. Sugawara and S. Sasaki, Melting of snow with double effect of temperature and concentration, *J. Heat Transfer* **115**(3), 771 (1993).

24JM. M. Tago, S. Fukusako, M. Yamada and A. Horibe, An experimental study of ice-layer transition phenomena in a rectangular duct containing water flow, *Wärme Stoffübertrag.* **28**(12), 37 (1993).

25JM. M. Toner, E. G. Cravalho and M. Karel, Cellular response of mouse oocytes to freezing stress: prediction of intracellular ice formation, *J. Biomech. Engng Trans. ASME* **115**(2), 169 (1993).

26JM. B. Weigand and H. Beer, Ice-formation phenomena for water flow inside a cooled parallel plate channel: an experimental and theoretical investigation of wavy ice layers, *Int. J. Heat Mass Transfer* **36**(3), 685 (1993).

27JM. M. Yamada, S. Fukusako, H. Morizane and Myoung-Hwan Kim, Melting heat transfer along a horizontal heated tube immersed in liquid ice, *JSME Int. J. Ser. B* **36**(2), 343 (1993).

28JM. C.-H. Yang, S. K. Rastogi and D. Poulikakos, Freezing of a water-saturated inclined packed bed of beads, *Int. J. Heat Mass Transfer* **36**(14), 3583 (1993).

Influence of convection and flow

29JM. Fully-developed plume convection of ammonium chloride solutions cooled from below, *Chung-Kuo Chi Hsueh Kung Ch'eng Hsueh Pao* **14**(2), 207 (1993).

30JM. M. A. Eftyuchiou, T. L. Bergman and G. Y. Masada, A detailed thermal model of the infrared reflow soldering process, *J. Electron. Packag.* **115**(1), 55 (1993).

31JM. S. A. Kirillov, V. V. Klubovich, I. M. Kotin and M. M. Kulak, Convective mass transfer under action of mass forces in SpHTS process, *Fizika Goreniya Vzryva* **29**(2), 54 (1993).

32JM. G. P. Neitzel, K.-T. Chang, D. F. Jankowski and H. D. Mittelmann, Linear-stability theory of thermocapillary convection in a model of the float-zone crystal-growth process, *Phys. Fluids A* **5**(1), 108 (1993).

33JM. P. J. Prescott and F. P. Incropera, Magnetically damped convection during solidification of a binary metal alloy, *J. Heat Transfer Trans. ASME* **115**(2), 302 (1993).

34JM. V. Yu. Semenov and A. I. Smorodin, Characteristic features of convective heat release on the 'fluid–solid body' phase transition interface, *Inzhenerno-Fizicheskii Zhurnal* **64**(5), 619 (1993).

Continuous casting process

35JM. J. V. Dubrawski and J. M. Camplin, Crystallization of mould powders used in the continuous casting of steel, *J. Therm. Anal.* **40**(1), 329 (1993).

36JM. K. Nakajima, S. Hiraki, M. Kawamoto and T. Kanazawa, Melting, lubrication, and heat transfer behavior of mold powder in mold at high speed continuous casting of steel slabs, *Sumitomo Metals* **45**(3), 8 (1993).

37JM. A. Saito, S. Okawa, K. Kaneko and H. Kaneko, Simulation on continuous casting process (reconsideration of heat balance and improvement of efficiency in continuous casting process), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(565), 2890 (1993).

38JM. K. Takatani, Y. Sirota, Y. Higuchi and Y. Tanizawa, Fluid flow, heat transfer and the behavior of inclusion in the process of continuous casting, *Sumitomo Metals* **45**(3), 19 (1993).

Method/models and analysis and simulation techniques

39JM. A. N. Alexandrou, Robert Elden and Jeff McConnell, Inverse approach to three-dimensional solidification problems, *Int. J. Numer. Methods Engng* **36**(1), 135 (1993).

40JM. M. R. Barone and D. A. Caulk, A new method for thermal analysis of die casting, *J. Heat Transfer Trans. ASME* **115**(2), 284 (1993).

41JM. J. C. Bischof and B. Rubinsky, Microscale heat and mass transfer of vascular and intracellular freezing in the liver, *J. Heat Transfer Trans. ASME* **115**(4), 1029 (1993).

42JM. J. R. Boehmer, F. N. Fett and G. Funk, Analysis of high-temperature behaviour of solidified material within a continuous casting machine, *Computers Structures* **47**(45), 683 (1993).

43JM. Wenzhen Chen and Shangmo Cheng, Analysis of contact melting of phase changing material inside rectangular capsule, *Taiyangneng Xuebao* **14**(3), 202 (1993).

44JM. B. T. F. Chung, S. Gulati and A. K. Dalmia, Solidification of a flowing liquid inside a pipe subject to radiation and convection, *J. Heat Transfer Trans. ASME* **115**(1), 269 (1993).

45JM. C. P. Desai and K. Vafai, A unified examination of the melting process within a two-dimensional rectangular cavity, *J. Heat Transfer Trans. ASME* **115**(4), 1072 (1993).

46JM. T. Endoh and E. Hasegawa, On the steady melting of a phase-change material due to a heated horizontal plate with a finite width, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(562), 2043 (1993).

47JM. M. Epstein and H. K. Fauske, Kinetic and heat transfer-controlled solidification of highly supercooled droplets, *Int. J. Heat Mass Transfer* **36**(12), 2987 (1993).

48JM. I. Heschel and G. Rau, Numerical calculation of the course of solidification in aqueous salt solutions, with reference to cryobiology, *Chem. Ing. Tech.* **65**(1), 63 (1993).

49JM. C. J. Ho and C. H. Chu, Periodic melting within a square enclosure with an oscillatory surface temperature, *Int. J. Heat Mass Transfer* **36**(3), 725 (1993).

50JM. H. Hong and A. Saito, Numerical method for direct contact melting in transient process, *Int. J. Heat Mass Transfer* **36**(8), 2093 (1993).

51JM. Dong-Ying Ju and T. Inoue, Analysis of heat and fluid flow incorporating solidification and its application to thin slab continuous casting process, *Nippon Kikai Gakkai Ronbunshu A Hen* **59**(565), 2189 (1993).

52JM. C.-J. Kim and S. T. Ro, Shrinkage formation during the solidification process in an open rectangular cavity, *J. Heat Transfer Trans. ASME* **115**(4), 1078 (1993).

53JM. C.-J. Kim, S. T. Ro, J. S. Lee and M. G. Kim, Two-dimensional freezing of water filled between vertical concentric tubes involving density anomaly and volume expansion, *Int. J. Heat Mass Transfer* **36**(10), 2647 (1993).

54JM. S. Kotake and M. Kuroki, Molecular dynaymics study of solid melting and vaporization by laser irradiation, *Int. J. Heat Mass Transfer* **36**(8), 2061 (1993).

55JM. M. K. Anjan Kumar and S. P. Mehrotra, Mathematical model of single roll strip caster based on microscopic heat balance, *Ironmaking Steelmaking* **19**(1), 55 (1993).

56JM. M. Lacroix, Numerical simulation of melting and resolidification of a phase change material around two cylindrical heat exchangers, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(2), 143 (1993).

57JM. M. Lacroix and A. Arsenault, Analysis of natural convection melting of a subcooled pure metal, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 21 (1993).

58JM. A. Liu, T. E. Voth and T. L. Bergman, Pure material melting and solidification with liquid phase buoyancy and surface tension forces, *Int. J. Heat Mass Transfer* **36**(2), 411 (1993).

59JM. J. I. Lombraña, C. De Elvira and M. C. Villaran, Simulation and design of heating profiles in heat controlled freeze-drying of pharmaceuticals in vials by the application of a sublimation cylindrical model, *Drying Technol.* **11**(1), 85 (1993).

60JM. K. G. Mahmoud, Heat transfer with a moving boundary—application to transient solidification of a warm liquid on a moving cold plate, *Computers Chem. Engng* **17**(7), 705 (1993).

61JM. Al. M. Morega, A. M. Filip, A. Bejan and P. A. Tyvand, Melting around a shaft rotating in a phase-change material, *Int. J. Heat Mass Transfer* **36**(10), 2499 (1993).

62JM. R. R. Namburu and K. K. Tamma, Effective modeling/analysis of isothermal phase change problems with emphasis on representative enthalpy architectures and finite elements, *Int. J. Heat Mass Transfer* **36**(18), 4493 (1993).

63JM. D. G. Neilson and F. P. Incropera, Three-dimensional considerations of unidirectional solidification in a binary liquid, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 1 (1993).

64JM. S. Petrescu and C. Fetecau, Liquid–fluid heat transfer at direct contact, accompanied by solidification, *Acta Mech.* **99**(14), 213 (1993).

65JM. M. Prud'homme, T. Hung Nguyen and P. G. Mao, Numerical simulation of melting inside a rotating cylindrical enclosure, *Int. J. Heat Mass Transfer* **36**(1), 57 (1993).

66JM. Y. Rabin and E. Korin, An efficient numerical solution for the multidimensional solidification (or melting) problem using a micro-computer, *Int. J. Heat Mass Transfer* **36**(3), 673 (1993).

67JM. Yimin Ruan, J. C. Liu and O. Richmond, Deforming finite element method for analysis of alloy solidification problems, *Finite Elem. Anal. Des.* **13**(1), 49 (1993).

68JM. S. R. Runnels and G. F. Carey, A domain-decomposition strategy for finite-element simulation of phase change, *Numer. Heat Transfer Part B Fundam.* **24**(2), 181 (1993).

69JM. B. Sarler, B. Mavko and G. Kuhn, Mixture continuum formulation of convection–conduction energy transport in multiconstituent solid–liquid phase change systems for BEM solution techniques, *Engng Anal. Boundary Elements* **11**(2), 109 (1993).

70JM. D. Sheng, K. B. Axelsson and S. Knutsson, Finite element analysis for convective heat diffusion with phase change, *Comput. Methods Appl. Mech. Engng* **104**(1), 19 (1993).

71JM. A. A. Shugai, High-velocity penetration of a melting solid by a slender body, *Fluid Dyn.* **27**(6), 789 (1993).

72JM. S. K. Sinha, T. Sundararajan and V. K. Garg, A study of the effects of macrosegregation and buoyancy-driven flow in binary mixture solidification, *Int. J. Heat Mass Transfer* **36**(9), 2349 (1993).

73JM. A. D. Solomon, V. Alexiades and G. K. Jacobs, Heat transfer analysis of a field-scale melting experiment, *Int. Commun. Heat Mass Transfer* **20**(6), 793 (1993).

74JM. A. L. Taran, G. A. Nosov and K. Annadif, The method to determine the rate of formation of conversion centers by thermal-analysis data, *Teoreticheskie Osnovy Khimicheskoi Tekhnologii* **27**(2), 148 (1993).

75JM. A. M. Tayer, A simulation model for a phase-change energy storage system: experimental and verification, *Energy Convers. Manage.* **34**(4), 243 (1993).

76JM. N. Tiedje and E. W. Langer, Numerical modelling of heat transfer and solidification of continuously cast billets, *Scand. J. Metall.* **22**(2), 55 (1993).

77JM. B. Vick and D. J. Nelson, The boundary element method applied to freezing and melting problems, *Numer. Heat Transfer Part B Fundam.* **24**(3), 263 (1993).

78JM. V. R. Voller and C. R. Swaminathan, Treatment of discontinuous thermal conductivity in control-volume solutions of phase-change problems, *Numer. Heat Transfer Part B Fundam.* **24**(2), 161 (1993).

79JM. B. Weigand, W. Höhn and H. Beer, A perturbation analysis of transient freezing of a laminar liquid flow in a cooled two-dimensional channel, *J. Heat Transfer Trans. ASME* **115**(2), 294 (1993).

80JM. Chuansong Wu, Zhenning Cao and Lin Wu, Numerical analysis of three-dimensional fluid flow and heat transfer in TIG weld pool with full penetration, *Acta Metall. Sin. Engl. Ed. Ser. B Process. Metall. Misc.* **6B**(2), 130 (1993).

81JM. Yong Ke Wu and M. Lacroix, Numerical study of natural convection dominated melting within an isothermal vertical cylinder, *Trans. Can. Soc. Mech. Engng* **17**(3), 281 (1993).

82JM. Yongke Wu and M. Lacroix, Numerical study of melting of scrap metal, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(4), 413 (1993).

83JM. Yongke Wu and M. Lacroix, Analysis of natural convection melting of a vertical ice cylinder involving density anomaly, *Int. J. Numer. Methods Heat Fluid Flow* **3**(5), 445 (1993).

84JM. Minwu Yao and A. Chait, An alternative formulation of the apparent heat capacity method for phase-change problems, *Numer. Heat Transfer Part B Fundam.* **24**(3), 279 (1993).

85JM. X. Zhang and A. Atrens, Thermokinetic model for rapid solidification, *Int. J. Rapid Solidif.* **7**(2), 83 (1993).

86JM. Y. W. Zhang, Y. Y. Jin, Z. Q. Chen, Z. F. Dong and M. A. Ebadian, An analytical solution to melting in a finite slab with a boundary condition of the second kind, *J. Heat Transfer Trans. ASME* **115**(2), 463 (1993).

Freezing and melting applications

87JM. Jyh-Chen Chen and Wu-Fu Ueng, Effect of energy conservation on a heat transfer study of float-zone growth, *Chung-Kuo Chi Hsueh Kung Ch'eng Hsueh Pao* **14**(5), 522 (1993).

88JM. J. Choi and R. Viskanta, Freezing of aqueous sodium chloride solution saturated packed bed from a vertical wall of a rectangular cavity, *Int. J. Heat Mass Transfer* **36**(11), 2805 (1993).

89JM. S. Fukusako and M. Yamada, Recent advances in research on water—freezing and ice-melting problems, *Exp. Therm. Fluid Sci.* **6**(1), 90 (1993).

90JM. S. Fukusako, M. Yamada, H. Morizane and Myoung-Hwan Kim, Melting heat transfer along a horizontal heated tube immersed in a fluidized liquid ice bed, *Exp. Therm. Fluid Sci.* **6**(4), 353 (1993).

91JM. S. Fukusako, M. Yamada and Myoung-Hwan Kim, Melting heat transfer of liquid ice in a rectangular cavity with a heated vertical wall, *Heat Transfer Jpn Res.* **22**(3), 250 (1993).

92JM. I. Kececioglu and Yi Lin, Melting of a porous medium saturated with water near its density maximum, *Energy* **18**(9), 913 (1993).

93JM. M. Kochs, Ch. Körber, I. Heschel and B. Nunner, The influence of the freezing process on vapour transport during sublimation in vacuum-freeze-drying of macroscopic samples, *Int. J. Heat Mass Transfer* **36**(7), 1727 (1993).

94JM. M. W. McDonough and A. Faghri, Ultrasonic measurement of solid–liquid interface for the solidification of water in a rectangular enclosure, *J. Heat Transfer Trans. ASME* **115**(4), 1075 (1993).

95JM. D. G. Neilson and F. P. Incropera, Experimental study of unidirectional solidification of aqueous ammonium chloride in a cylindrical mold with and without rotation, *Exp. Heat Transfer* **6**(2), 131 (1993).

96JM. A. V. Reddy and C. Beckermann, Measurements of metal–mold interfacial heat transfer coefficients during solidification of Sn and Sn–Pb alloys, *Exp. Heat Transfer* **6**(2), 111 (1993).

97JM. J. Rix, D. Nevrala, L. Chauvet and S. D. Probert, Gas-powered liquid desiccant dehumidifier, *Appl. Energy* **45**(2), 167 (1993).

98JM. R. N. Smith and E. Meeks, Experimental investigation of freezing inside a thick-walled cylinder, *Exp. Therm. Fluid Sci.* **7**(1), 22 (1993).

99JM. C. D. Sulfredge, L. C. Chow and K. A. Tagavi, Void formation in unidirectional freezing from above, *Exp. Heat Transfer* **6**(1), 1 (1993).

100JM. G. E. Val'yano, A. Yu. Vorob'ev, V. A. Petrov, V. E. Titov and A. P. Chernyshev, Investigation of the melting and solidification temperatures of magnesia during radiant heating with a CO_2 laser, *High Temp.* **30**(5), 761 (1993).

101JM. M. Yamada, S. Fukusako, M. Tago and A. Horibe, Freezing characteristics along a horizontal cooled tube immersed in aqueous binary solution with main flow, *J. Engng Mater. Technol. Trans. ASME* **115**(1), 54 (1993).

102JM. C.-H. Yang, S. K. Rastogi and D. Poulikakos, Solidification of a binary mixture saturating and inclined bed of packed spheres, *Int. J. Heat Fluid Flow* **14**(3), 268 (1993).

Miscellaneous applications

103JM. Calculation of metal melting by concentrated flux of energy, *Izvestiya AN SSSR Metally* (1), 82 (1993).

104JM. G. Backmann, A. Koethe, W. Loeser, J. Richter, T. Schubert, S. Thiem and L. Hering, Investigations of the solidification behavior and mechanical properties of thin slabs, *Stahl Eisen* **113**(2), 63 (1993).

105JM. A. Celli, A. Fichera, C. Marega, A. Marigo, G. Pagnetto and R. Zannetti, Relationship between crystallization regimes and melting phenomena in isotactic polypropylene, *Eur. Polym. J.* **29**(8), 1037 (1993).

106JM. S. Chellaiah, R. A. Waters and M. A. Zampino, Solidification of an aqueous salt solution in the presence of thermosolutal convection, *Wärme Stoffübertrag.* **28**(4), 205 (1993).

107JM. M. Goel, S. Sengupta and S. K. Roy, Performance of liquid heat sinks with phase change material suspensions, *Int. Commun. Heat Mass Transfer* **20**(1), 69 (1993).

108JM. P. Kazmierowicz, Consistent thermal profiling, *Surf. Mount Technol.* **7**(2), 23 (1993).

109JM. V. N. Kukharenko, A. P. Fedosova, A. G. Kolgatin and V. G. Dosov, Studying the processes in the xenon heat exchanger–freezer, *Khimicheskoe Neftekhimicheskoe Mashinostroenie* (5), 19 (1993).

110JM. T. Lewin, V. Hildebrand and K.-H. Reichert, Heat transfer during polymerisation in a stirred tank reactor, *Chem. Ing. Tech.* **65**(6), 739 (1993).

111JM. J. S. Lim, A. J. Fowler and A. Bejan, Spaces filled with fluid and fibers coated with a phase-change material, *J. Heat Transfer Trans. ASME* **115**(4), 1044 (1993).

112JM. C. S. Magirl and F. P. Incropera, Flow and morphological conditions associated with unidirectional solidification of aqueous ammonium chloride, *J. Heat Transfer Trans. ASME* **115**(4), 1036 (1993).

113JM. K. Medjani and R. G. Watts, Freezing of the NaCl–H_2O binary compound from above in a partially open cylindrical geometry, *J. Heat Transfer* **115**(3), 777 (1993).

114JM. E. Specht and R. Jeschar, Kinetics of steel melting in carbon–steel alloys, *Steel Res.* **64**(1), 28 (1993).

115JM. S. Temkin, Particle force and heat transfer in a dusty gas sustaining an acoustic wave, *Phys. Fluids A* **5**(6), 1296 (1993).

116JM. Yu. S. Teplitskij and G. I. Zhuravskij, Heat release in the forced flow of a two-phase mixture in a tube, *Inzhenerno-Fizicheskii Zhurnal* **64**(5), 554 (1993).

117JM. V. T. Vitusevich, Enthalpy of Cr–B–C melts formation, *Izvestiya AN SSSR Metally* (3), 35 (1993).

118JM. B. Weigand and H. Beer, Freezing in turbulent flow inside tubes and channels, *Wärme Stoffübertrag.* **28**(12), 57 (1993).

119JM. S. E. Chidiac, J. K. Brimacombe and I. V. Samarasekera, A new transient method for analysis of solidification in the continuous casting of metals, *Appl. Sci. Res.* **51**(3), 573 (1993).

RADIATIVE HEAT TRANSFER

Radiative transfer to/from/within complex geometries

1K. B. R. Adams and P. J. Smith, Three-dimensional discrete-ordinates modeling of radiative transfer in a geometrically complex furnace, *Combust. Sci. Technol.* **88**(56), 293 (1993).

2K. A. Ambirajan and S. P. Venkateshan, Accurate determination of diffuse view factors between planar surfaces, *Int. J. Heat Mass Transfer* **36**(8), 2203 (1993).

3K. M. D'Amico and G. C. Pomraning, The treatment of nonlinearities in flux-limited diffusion calculations, *J. Quant. Spectroscopy Radiative Transfer* **49**(5), 457 (1993).

4K. J. R. Ehlert and T. F. Smith, View factors for perpendicular and parallel rectangular plates, *J. Thermophys. Heat Transfer* **7**(1), 173 (1993).

5K. S. Göktun, S. Özkaynak and H. Yavuz, Design parameters of a radiative heat engine, *Energy* **18**(6), 651 (1993).

6K. A. Guelzim, J. M. Souil and J. P. Vantelon, Suitable configuration factors for radiation calculation concerning tilted flames, *J. Heat Transfer Trans. ASME* **115**(2), 489 (1993).

7K. B. G. Hager, W. S. Chang and A. R. Field, Effects of payload heat flux on space radiator area, *J. Spacecr. Rockets* **30**(2), 255 (1993).

8K. L. C. Hartung and H. A. Hassan, Radiation transport around axisymmetric blunt body vehicles using a modified differential approximation, *J. Thermophys. Heat Transfer* **7**(2), 220 (1993).

9K. S. Hava and M. Auslender, Thermal radiation law for a small semiconductor body, *J. Quant. Spectroscopy Radiative Transfer* **49**(3), 259 (1993).

10K. S. S. Kumar, V. Nayak and S. P. Venkateshan, Optimum finned space radiators, *Int. J. Heat Fluid Flow* **14**(2), 191 (1993).

11K. S. Kuppurao and J. J. Derby, Finite-element formulations for accurate calculation of radiant heat transfer in diffuse-gray enclosures, *Numer. Heat Transfer Part B Fundam.* **24**(4), 431 (1993).

12K. J. P. Lagouarde and Y. Brunet, Simple model for estimating daily upward longwave surface radiation flux from NOAA-AVHRR data, *Int. J. Remote Sens.* **14**(5), 907 (1993).

13K. C. G. Malone, B. I. Choi, M. I. Flik and E. G. Cravalho, Spectral emissivity of optically anisotropic solid media, *J. Heat Transfer Trans. ASME* **115**(4), 1021 (1993).

14K. S. Maruyama, Uniform isotropic emission from an involute reflector, *J. Heat Transfer Trans. ASME* **115**(2), 492 (1993).

15K. S. Maruyama and T. Aihara, Radiation heat transfer of arbitrary axisymmetric bodies with specular and diffuse surfaces, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(566), 3202 (1993).

16K. S. Maruyama, Radiation heat transfer between arbitrary three-dimensional bodies with specular and diffuse surfaces, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **24**(2), 181 (1993).

17K. H. Masuda, H. Kou and I. Mizuta, Control of radiation heat transfer from solid surface by a grating of parallel circular cylinders, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1330 (1993).

18K. C. V. S. Murty, Evaluation of radiation reception factors in a rotary kiln using a modified Monte-Carlo scheme, *Int. J. Heat Mass Transfer* **36**(1), 119 (1993).

19K. R. B. Myneni and G. Asrar, Radiative transfer in three-dimensional atmosphere-vegetation media, *J. Quant. Spectrosc. Radiat. Transfer* **49**(6), 585 (1993).

20K. H. L. Noboa, D. O'Neal and W. D. Turner, Calculation of the shape factor from a small rectangular plane to a triangular surface perpendicular to the rectangular plane without a common edge, *J. Sol. Energy Engng Trans. ASME* **115**(2), 117 (1993).

21K. C. J. Saltiel and J. Kolibal, Adaptive grid generation for the calculation of radiative configuration factors, *J. Thermophys. Heat Transfer* **7**(1), 175 (1993).

22K. A. Steinfeld, Radiative transfer in a diffusively–specularly reflecting spherical cavity containing a gray medium, *Wärme Stoffübertrag.* **28**(12), 65 (1993).

23K. M. G. Vasil'ev, L. A. Stefanova and V. S. Yuferev, Radiation heat exchange in the gap between parallel coaxial plane rings. Derivation of approximate semi-empirical formulas, *High Temp.* **31**(2), 308 (1993).

Radiative transfer in scattering media

24K. E. M. Abulwafa, Radiative-transfer in a linearly-anisotropic spherical medium, *J. Quant. Spectrosc. Radiat. Transfer* **49**(2), 165 (1993).

25K. S. Audic and H. Frisch, Monte-Carlo simulation of a radiative transfer problem in a random medium: application to a binary mixture, *J. Quant. Spectrosc. Radiat. Transfer* **50**(2), 127 (1993).

26K. M. Box, T. Trautmann and P. E. Loughlin, Quadrature effects on the accuracy of flux calculations in realistic atmospheres, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 647 (1993).

27K. J. C. Chai, Hae Ok S. Lee and S. V. Patankar, Ray effect and false scattering in the discrete ordinates method, *Numer. Heat Transfer Part B Fundam* **24**(4), 373 (1993).

28K. A. L. Crosbie and L. C. Lee, Two-dimensional anisotropic scattering in a semi-infinite cylindrical medium exposed to a laser beam, *J. Quant. Spectrosc. Radiat. Transfer* **49**(2), 185 (1993).

29K. A. L. Crosbie and S. M. Shieh, Two-dimensional isotropic scattering in a semi-infinite cylindrical medium with refractive index greater than unity, *J. Quant. Spectrosc. Radiat. Transfer* **49**(5), 535 (1993).

30K. M. da Graca Carvalho, T. Farias and P. Fontes, Multidimensional modeling of radiative heat transfer in scattering media, *J. Heat Transfer Trans. ASME* **115**(2), 486 (1993).

31K. K. G. Degen, S. Rossetto and J. Fricke, Heat transfer in evacuated crinkled or embossed multilayer foil insulations, *J. Therm. Insul. Build. Envelopes* **16**, 340 (1993).

32K. I. V. Degtyarev, Method for solving the radiation transfer equation in nonuniform scattering and selectively absorbing media, *High Temp.* **30**(5), 810 (1993).

33K. A. A. Fatani and I. E. Megahed, Radiative heat transfer in fluidized beds, *Energy* **18**(7), 727 (1993).

34K. G. Flamant, J. D. Lu and B. Variot, Towards a generalized model for vertical walls to gas–solid fluidized beds heat transfer—II. Radiative transfer and temperature data, *Chem. Engng Sci.* **48**(13), 2493 (1993).

35K. A. V. Galaktionov, Operator method in analyzing nonsteady radiant energy transfer, *High Temp.* **30**(4), 661 (1993).

36K. H. Görmar and U. Renz, On the radiative heat transfer in bubbling fluidized beds, *Wärme Stoffübertrag.* **28**(7), 397 (1993).

37K. S. L. Hayes and K. L. Peddicord, Radiative heat transfer in porous uranium dioxide, *J. Nucl. Mater.* **202**(12), 87 (1993).

38K. J. J. Honrubia, A synthetically accelerated scheme for radiative transfer calculations, *J. Quant. Spectrosc. Radiat. Transfer* **49**(5), 491 (1993).

39K. P.-F. Hsu, Z. Tan and J. R. Howell, Radiative transfer by the YIX method in nonhomogeneous, scattering and nongray media, *J. Thermophys. Heat Transfer* **7**(3), 487 (1993).

40K. G. Jeandel, P. Boulet and G. Morlot, Radiative transfer through a medium of silica fibres oriented in parallel planes, *Int. J. Heat Mass Transfer* **36**(2), 531 (1993).

41K. S. Jendoubi, H. S. Lee and T.-K. Kim, Discrete ordinates solutions for radiatively participating media in a cylindrical enclosure, *J. Thermophys. Heat Transfer* **7**(2), 213 (1993).

42K. K. Kamiuto, S. Saito and K. Ito, Numerical model for combined conductive and radiative heat transfer in annular packed beds, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(4), 433 (1993).

43K. K. Kamiuto, An iterative method for inverse scattering problems, *J. Quant. Spectrosc. Radiat. Transfer* **49**(1), 1 (1993).

44K. K. Kudo, H. Taniguchi, A. Kuroda, M. Sumarsono and T. Fukuchi, Radiative characteristics of nongray gas containing anisotropic scattering particles, *Nippon Kikai Gakkai Ronbunshu B Hen* **56**(565), 2640 (1993).

45K. P. L. C. Lage and R. H. Rangel, Total thermal radiation absorption by a single spherical droplet, *J. Thermophys. Heat Transfer* 7(1), 101 (1993).

46K. S.-C. Lee, Propagation of radiation in high-density fibrous composite containing coated fibers, *J. Thermophys. Heat Transfer* 7(4), 637 (1993).

47K. H. Y. Li and M. N. Ozisik, Inverse radiation problem for simultaneous estimation of temperature profile and surface reflectivity, *J. Thermophys. Heat Transfer* 7(1), 88 (1993).

48K. D. C. Look, Jr. and Y. R. Chen, Study of polarization of laser radiation scattered 90 deg, *J. Thermophys. Heat Transfer* 7(4), 31 (1993).

49K. K. O. Lund, Radiation and phase change of lithium fluoride in an annulus, *J. Thermophys. Heat Transfer* 7(4), 600 (1993).

50K. M. P. Menguc and S. Manickavasagam, Inverse radiation problem in axisymmetric cylindrical scattering media, *J. Thermophys. Heat Transfer* 7(3), 479 (1993).

51K. H. M. Park, R. K. Ahluwalia and K. H. Im, Three-dimensional radiation in absorbing–emitting–scattering media using the modified differential approximation, *Int. J. Heat Mass Transfer* **36**(5), 1181 (1993).

52K. S. H. Park and S. S. Kim, Thermophoretic deposition of absorbing, emitting and isotropically scattering particles in laminar tube flow with high particle mass loading, *Int. J. Heat Mass Transfer* **36**(14), 3477 (1993).

53K. J. I. Peltoniemi, Radiative transfer in stochastically inhomogeneous media, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 655 (1993).

54K. C. Prabhakara, D. P. Kratz, J.-M. Yoo, G. Dalu and A. Vernekar, Optically thin cirrus clouds: radiative impact on the warm pool, *J. Quant. Spectrosc. Radiative Transfer* **49**(5), 467 (1993).

55K. H. M. Shafey, A. M. A. El-Ghany and A. M. Nassib, An analysis of the combined conductive–radiative heat transfer between a surface and a gas–fluidized bed at high temperature, *Int. J. Heat Mass Transfer* **36**(9), 2281 (1993).

56K. M. Shibahara and S. Kotake, Molecular dynamics study of radiative heating and cooling of solids, *Heat Transfer Jpn Res.* **22**(5), 518 (1993).

57K. R. Siegal and C. M. Spuckler Refractive index effects on radiation in an absorbing, emitting and scattering laminated layer, *J. Heat Transfer Trans. ASME* **115**(1), 194 (1993).

58K. R. Siegel and C. M. Spuckler, Variable refractive index effects on radiation in semitransparent scattering multilayered regions, *J. Thermophys. Heat Transfer* 7(4), 624 (1993).

59K. C. E. Siewert, A spherical-harmonics method for multi-group or non-gray radiation transport, *J. Quant. Spectrosc. Radiat. Transfer* **49**(2), 95 (1993).

60K. C. E. Siewert and N. J. McCormick, A particular solution for polarization calculations in radiative transfer, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 531 (1993).

61K. C. E. Siewert, On intensity calculations in radiative transfer, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 555 (1993).

62K. C. E. Siewert, An inverse source problem in radiative transfer, *J. Quant. Spectrosc. Radiat. Transfer* **50**(6), 603 (1993).

63K. C. M. Spuckler and R. Siegel, Refractive index and scattering effects on radiative behavior of a semitransparent layer, *J. Thermophys. Heat Transfer* 7(2), 302 (1993).

64K. J. Stasiek and M. W. Collins, Experimental and theoretical study on the radiation of gases containing dust particles, *Wärme Stoffübertrag.* **28**(4), 185 (1993).

65K. S. V. Stepanov, Temperatures and radiation waves in a plane layer of scattering medium, *High Temp.* **31**(2), 314 (1993).

66K. H. Sucher and M. Elsner, Heat transfer through absorbing, emitting and scattering porous insulations, *Wärme Stoffübertrag.* **28**(5), 251 (1993).

67K. C. Tezcan and C. Yildiz, The transformation of PL solutions for extremely anisotropic scattering to solutions with isotropic scattering and application to the critical slab problem, *J. Quant. Spectrosc. Radiat. Transfer* **49**(4), 411 (1993).

68K. R. Thatipamala, G. A. Hill nad S. Rohani, Absorption of radiation by substances at "high" concentrations: a new equation and process monitoring applications, *Can. J. Chem. Engng* **71**(6), 977 (1993).

69K. R. K. Thulasiram and N. M. Reddy, Vibrational relaxation in gas–particle nozzle flows: a study of the effect of particles, *J. Thermophys. Heat Transfer* 7(4), 747 (1993).

70K. Jen-Hui Tsai, Inverse scattering problem with two flux methods, *Int. Commun. Heat Mass Transfer* **20**(4), 585 (1993).

71K. I. A. Vasil'eva, Effect on spectral measurements of wall radiation scattered by macroscopic particles, *High Temp.* **31**(20, 360 (1993).

72K. O. S. Vaulina, A. N. Nefedov and O. F. Petrov, Calculation of the scattering and absorbing characteristics of spherical particles in high-temperature flows, *High Temp.* **30**(5), 817 (1993).

73K. C.-Y. Wu and S.-C. Wu, Radiative transfer in a two-layer medium on a cylinder, *Int. J. Heat Mass Transfer* **36**(5), 1147 (1993).

Radiative transfer in hot gases

74K. G. V. Candler, D. A. Levin, R. J. Collins, P. W. Erdman, E. Zipf and C. Howlett, Theory of plume radiance from the bow shock ultraviolet 2 rocket flight, *J. Thermophys. Heat Transfer* 7(4), 709 (1993).

75K. M. K. Denison and B. W. Webb, A spectral line-based weighted-sum-of-gray-gases model for arbitrary RTE solvers, *J. Heat Transfer Trans. ASME* **115**(4), 1004 (1993).

76K. M. K. Denison and B. W. Webb, An absorption-line blackbody distribution function for efficient calculation of total gas radiative transfer, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 499 (1993).

77K. P. W. Erdman, E. C. Zipf, P. Espy, C. Howlett, C. Christou, D. A. Levin, R. J. Collins and G. V. Candler, In-situ plume radiance measurements from the bow shock ultraviolet 2 rocket flight, *J. Thermophys. Heat Transfer* 7(4), 704 (1993).

78K. P. W. Erdman, E. C. Zipf, P. Espy, C. Howlett, D. A. Levin, R. Loda, R. J. Collins and G. V. Candler, Flight measurements of low-velocity bow shock ultraviolet radiation, *J. Thermophys. Heat Transfer* 7(1), 37 (1993).

79K. D. N. Gordge and R. H. Page, Infrared imagery of an air–CO_2 axisymmetric jet, *Exp. Fluids* **14**(6), 409 (1993).

80K. R. B. Greendyke, Parametric analysis of radiative structure in aerobrake shock layers, *J. Spacecr. Rockets* **30**(1), 51 (1993).

81K. J. T. Howe and L. Yang, Earth atmosphere entry thermal protection by radiation backscattering ablating materials, *J. Thermophys. Heat Transfer* 7(1), 74 (1993).

82K. F. Kritzstein and A. Soufiani, Infrared gas radiation from a homogeneously turbulent medium, *Int. J. Heat Mass Transfer* **36**(7), 1749 (1993).

83K. V. I. Kruglov, L. V. Kattovskiy and V. G. Redikultsev, Radiative transfer in a flat non-equilibrium mixture layer of CO_2–N_2 gases: numerical experiment, *Int. J. Heat Mass Transfer* **36**(13), 3375 (1993).

84K. K. Kudo, H. Taniguchi and A. Kuroda, Improvement of analytical method on radiative heat transfer in nongray media by Monte Carlo method, *Nippon Kikai Gakkai Ronbundhu B Hen* **59**(560), 1265 (1993).

85K. A. B. Kukushkin, An equation for resonance-radiation transfer in a heavy-atom gas injected into a rarefied atmosphere, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 541 (1993).

86K. D. A. Levin, G. V. Candler, R. J. Collins, P. W. Erdman, E. Zipf, P. Espy and C. Howlett, Comparison of theory with experiment for the bow shock ultraviolet 2 radiation, *J. Thermophys. Heat Transfer* **7**(1), 30 (1993).

87K. D. A. Levin, R. T. Loda, G. V. Candler and C. Park, Theory of radiation from low velocity shock heated air, *J. Thermophys. Heat Transfer* **7**(2), 269 (1993).

88K. W. K. McGregor, J. A. Drakes, K. S. Beale and F. G. Sherrell, AlCl absorption feature in solid rocket plume radiation, *J. Thermophys. Heat Transfer* **7**(4), 736 (1993).

89K. J. A. Menart and HaeOk Skarda Lee, Nongray gas analyses for reflecting walls utilizing a flux technique, *J. Heat Transfer* **115**(3), 645 (1993).

90K. J. A. Menart, HaeOk Skarda Lee and Tae-Kuk Kim, Discrete ordinates solutions of nongray radiative transfer with diffusely reflecting walls, *J. Heat Transfer Trans. ASME* **115**(1), 184 (1993).

91K. R. Siegal, Relations for local radiative heat transfer between rectangular boundaries of an absorbing–emitting medium, *J. Heat Transfer Trans. ASME* **115**(1), 272 (1993).

92K. A. D. Streater, Light-induced drift in a gas mixture with spectral structure formed by radiative transfer, *J. Quant. Spectrosc. Radiat. Transfer* **49**(4), 401 (1993).

93K. R. L. Sundberg, J. W. Duff and L. S. Bernstein, Nonequilibrium infrared emission model for the wake flow of re-entry vehicles, *J. Spacecr. Rockets* **30**(6), 731 (1993).

94K. S. T. Surzhikov, Calculation of radiant heat exchange in volumes of arbitrary geometry, *High Temp.* **31**(3), 521 (1993).

Flames, fires and combustion systems

95K. S. Agrawal, Determination of surface heat flux in the burning zone during wind-aided flame spread using burned PMMA samples, *Combust. Sci. Technol.* **91**(103), 187 (1993).

96K. M. V. Brykin and I. G. Zal'tsman, Radiation–convective heat transfer in a film of scale on the channel wall of an MHD generator operating on pulverized coal, *High Temp.* **30**(6), 969 (1993).

97K. C. Cahen and M. Sassi, Temperatures in a turbulent diffusion flame with and without exposure to an electric arc, *J. Quant. Spectrosc. Radiat. Transfer* **49**(3), 281 (1993).

98K. B. M. Cetegen and D. S. Pines, Combustion of a stretched carbon monoxide ligament with radiative heat losses, *Combust. Flame* **91**(2), 143 (1993).

99K. S. I. Chen, H. K. Ma and D. Y. Chen, Radiation blockage by the interaction of thermal radiation with conduction and convection in the combustion of condensed fuels, *Int. Commun. Heat Mass Transfer* **20**(1), 145 (1993).

100K. E. H. Chui, P. M. J. Hughes and G. D. Raithby, Implementation of the finite volume method for calculating radiative transfer in a pulverized fuel flame, *Combust. Sci. Technol.* **92**(46), 225 (1993).

101K. K. Görner and U. Dietz, Calculations of radiative exchange by the Monte-Carlo method. Theory and applications to industrial combustion systems, *Int. J. Chem. Engng* **33**(2), 165 (1993).

102K. Robert J. Hall, The radiative source term for plane-parallel layers of reacting combustion gases, *J. Quant. Spectrosc. Radiat. Transfer* **49**(5), 517 (1993).

103K. K. H. Im and R. K. Ahluwalia, Radiation properties of coal combustion products, *Int. J. Heat Mass Transfer* **36**(2), 293 (1993).

104K. Ching-China Ji and Ruben D. Cohen, Investigation of the combustion of pulverized coal–air mixture in different combustor geometries, *Combust. Flame* **90**(34), 307 (1993).

105K. A. A. Kopotev and A. D. Rekin, Two-dimensional calculations on mixing and radiation transport in wall cooling films in hydrocarbon combustion chambers, *High Temp.* **30**(5), 835 (1993).

106K. Ü. Ö. Köylü and G. M. Faeth, Radiative properties of flame-generated soot, *J. Heat Transfer Trans. ASME* **115**(2), 409 (1993).

107K. D. Laredo and D. W. Netzer, The dominant effect of alumina on nearfield plume radiation, *J. Quant. Spectrosc. Radiat. Transfer* **50**(5), 511 (1993).

108K. F. Liu and J. Swithenbank, The effects of particle size distribution and refractive index on fly-ash radiative properties using a simplified approach, *Int. J. Heat Mass Transfer* **36**(7), 1905 (1993).

109K. Huilin Lu, Yiling Bao, Zidong Zhang, Lidan Yang and Yukan Qin, Imaginary plane method for radiation heat transfer in the freeboard of atmospheric bubbling fluidized bed boiler, *J. Therm. Sci.* **2**(1), 18 (1993).

110K. T. E. Peard, J. E. Peters, M. Q. Brewster and R. O. Buckius, Radiative heat transfer augmentation in gas-fired radiant tube burners by porous inserts: effect of insert geometry, *Exp. Heat Transfer* **6**(3), 273 (1993).

111K. T. Saitoh, K. Yamazaki and R. Viskanta, Effect of thermal radiation on transient combustion of a fuel droplet, *J. Thermophys. Heat Transfer* **7**(1), 94 (1993).

112K. Y. R. Sivathanu, J. P. Gore, J. M. Janssen and D. W. Senser, A study of in-situ specific absorption coefficients of soot particles in laminar flat flames, *J. Heat Transfer* **115**(3), 653 (1993).

113K. Y. R. Sivathanu and J. P. Gore, A discrete probability function method for the equation of radiative transfer, *J. Quant. Spectrosc. Radiat. Transfer* **49**(3), 269 (1993).

114K. T.-H. Song, Comparison of engineering models of nongray behavior of combustion products, *Int. J. Heat Mass Transfer* **36**(16), 3975 (1993).

115K. S. Umezono, M. Aoki and N. Imanishi, Simulation of reformer for fuel cell system, *R&D Res. Dev.* **43**(2), 131 (1993).

Radiation with convection or conduction

116K. L. Allançon, B. Porterie et J.-C. Loraud, Etude des transferts radiatifs et convectifs induits par une source de chaleur et de masse dans une cavité a deux zones, *Int. J. Heat Mass Transfer* **36**(13), 3211 (1993).

117K. V. N. Anan'ev and A. P. Kuryachii, Comparative tests of model passive and combined heat shields, *High Temp.* **30**(6), 990 (1993).

118K. J. S. Chiou, Combined radiation–convection heat transfer in a pipe, *J. Thermophys. Heat Transfer* **7**(1), 178 (1993).

119K. U. O. Farrukh and P. Brockman, Temperature distribution in side- and end-pumped laser crystal rods: temporal and spatial variations, *Appl. Opt.* **32**(12), 2075 (1993).

120K. R. S. R. Gorla and I. Pop, Conjugate heat transfer with radiation from a vertical circular pin in a non-Newtonian ambient medium, *Wärme Stoffübertrag.* **28**(12), 11 (1993).

121K. T. J. Hendricks, Quantifying thermal radiation and convection effects during constant-heat-flux irradiation, *J. Thermophys. Heat Transfer* **7**(3), 526 (1993).

122K. S. Hirasawa, S. Kieda, T. Watanabe, T. Torii, T. Takagaki and T. Uchino, Temperature distribution in semiconductor wafers heated in a vertical diffusion furnace, *IEEE Trans. Semicond. Manuf.* **6**(3), 226 (1993).
123K. K. H. Kang, K.-J. Lutz, N. A. Tahir and J. A. Maruhn, Two-dimensional study of symmetrization of thermal radiation in a Hohlraum including hydrodynamics, *Nucl. Fusion* **33**(1), 17 (1993).
124K. M. Kassemi and M. H. N. Naraghi, Analysis of radiation–natural convection interactions in 1-g and low-g environments using the discrete exchange factor method, *Int. J. Heat Mass Transfer* **36**(17), 4141 (1993).
125K. V. G. Lisienko, "E–I"-characteristics and effectiveness autogeneration in heat transfer by radiation, *High Temp.* **31**(2), 323 (1993).
126K. V. Parfenov, V. Shashkin and E. Stepanov, Numerical investigation of thermally induced birefringence in optical elements of solid-state lasers, *Appl. Opt.* **32**(27), 5243 (1993).
127K. V. A. Petrov, Optical and thermophysical properties of semitransparent materials in the calculation of combined radiation–conduction heat transfer, *Sov. Technol. Rev.* **4**(5), 1 (1993).
128K. H. Rawson, Radiative heat transfer in glass manufacture—One- and two-dimensional problems, *Glastech. Ber.* **66**(4), 77 (1993).
129K. S. V. Rusakov, O. L. Rusakova and E. L. Tarunin, Effect of thermal radiation exchange between boundaries on convection in a gas heated from below, *Fluid Dyn.* **27**(5), 639 (1993).
130K. J. Stasiek and M. W. Collins, Radiant and convective heat transfer for flow of a radiation gas in a heated/cooled tube with a grey wall, *Int. J. Heat Mass Transfer* **36**(14), 3633 (1993).
131K. H. Yamashita, H. R. Baum, G. Kushida, K. Nakabe and T. Kashiwagi, Heat transfer from radiatively heated material in a low Reynolds number microgravity environment, *J. Heat Transfer Trans. ASME* **115**(2), 418 (1993).
132K. W.-M. Yang and M.-C. Leu, Instability of radiation-induced flow in an inclined slot, *Int. J. Heat Mass Transfer* **36**(12), 3089 (1993).

Radiative transfer to/from surfaces

133K. A. Helebbrant, C. Buerhop and R. Weissmann, Mathematical modelling of temperature distribution during CO_2 laser irradiation of glass, *Glass Technol.* **34**(4), 154 (1993).
134K. H. H. Legner, A. W. Bailey and M. F. Hinds, Three-dimensional thermal analysis for laser–structural interactions, *J. Thermophys. Heat Transfer* **7**(4), 545 (1993).
135K. M. Lobo and A. F. Emery, The discrete maximum principle in finite-element thermal radiation analysis, *Numer. Heat Transfer Part B Fundam.* **24**(2), 209 (1993).
136K. K. Mente, Non-steady heat transfer in plastics films by infrared radiation, *Kunstoffe German Plastics* **83**(1), 7 (1993).
137K. H. K. Park, X. Xu, C. P. Grigoropoulos, N. Do, L. Klees, P. T. Leung and A. C. Tam, Transient optical transmission measurement in excimer-laser irradiation of amorphous silicon films, *J. Heat Transfer Trans. ASME* **115**(1), 178 (1993).
138K. V. K. Pustovalov, Thermal processes under the action of laser radiation pulse on absorbing granules in heterogeneous bio-tissues, *Int. J. Heat Mass Transfer* **36**(2), 391 (1993).
139K. H. Wakabayashi, Y. Shimazu, T. Furuta and T. Makino, Numerical simulation on melting behavior of an atomic layer irradiated by thermal radiation, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(563), 171 (1993).

Experimental methods/radiative properties

140K. C. T. Christou, R. T. Loda and D. A. Levin, Simulation of range-resolved DIAL measurements on in-flight condition of 4100 K, *J. Thermophys. Heat Transfer* 7(2), 233 (1993).
141K. M. A. Havstad, W. McLean II and S. A. Self, Measurements of the thermal radiative properties of liquid uranium, *J. Heat Transfer Trans. ASME* **115**(4), 1013 (1993).
142K. E. Hummer, X. Lu, Th. Rettelbach and J. Fricke, Heat transfer in opacified aerogel powders, *J. Non Cryst. Solids* **145**(13), 211 (1993).
143K. J. Lohrengel, R. Todtenhaupt and M. Ragab, Determination of the directional spectral emissivity of solids in the spectral range from 2.5 μm to 45 μm at temperatures between 80°C and 350°C, *Wärme Stoffübertrag.* **28**(6), 321 (1993).
144K. X. Lu, P. Wang, M. C. Arduini-Schuster, J. Kuhn, D. Buttner, O. Nilsson and U. Heinemann, Thermal transport in organic and opacified silica monolithic aerogels, *J. Non Cryst. Solids* **145**(13), 207 (1993).
145K. T. Makino, T. Yoshida and S. Tanaka, New reflectometer for measuring a spectrum of hemispherical reflectance for perfect-diffuse hemispherical irradiation, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(565), 2875 (1993).
146K. B. Orel, M. Klanjsek Gunde and A. Krainer, Radiative cooling efficiency of white pigmented paints, *Sol. Energy* **50**(6), 477 (1993).
147K. Subhransu Roy, Se Yoon Bang, M. F. Modest and V. S. Stubican, Measurement of spectral, directional reflectivities of solids at high temperatures between 9 and 11 μm, *Appl. Opt.* **32**(19), 3550 (1993).
148K. V. Witter, Development of aerogel windows, *J. Non Cryst. Solids* **145**(13), 233 (1993).
149K. X. Xu and C. P. Grigoropoulos, High temperature radiative properties of thin polysilicon films at the $1 = 0.6328$ μm wavelength, *Int. J. Heat Mass Transfer* **36**(17), 4163 (1993).
150K. T. Yoshida, S. Tanaka and T. Makino, New ellipsoidal mirror-type reflectometer for measuring normal-incident hemispherical reflectance spectrum, *JSME Int. J. Ser. B* **36**(1), 166 (1993).

NUMERICAL METHODS

Heat conduction (direct problems)

1N. J. D. Austin and S. H. Pulko, The use of general curvilinear orthogonal meshes in TLM heat conduction models, *Numer. Heat Transfer Part B Fundam.* **24**(1), 107 (1993).
2N. M. C. Bhattacharya, Improved finite-difference solutions of the diffusion equation for heat conduction, *Commun. Numer. Methods Engng* **9**(9), 713 (1993).
3N. X. Chen, K. K. Tamma and D. Sha, A new virtual-pulse time integral methodology for linear transient heat transfer problems, *Numer. Heat Transfer Part B Fundam.* **24**(3), 301 (1993).
4N. R. I. Fernendes and G. Fairweather, Analysis of alternating direction collocation methods for parabolic and hyperbolic problems in two space variables, *Numer. Methods Partial Differential Equations* **9**(2), 191 (1993).
5N. P. Newnham and S. Abrate, Finite element analysis of heat transfer in anisotropic solids: application to manufacturing problems, *J. Reinf. Plast. Compos.* **12**(8), 854 (1993).
6N. G. E. Schneider and K. Wittich, Explicit vs implicit

schemes for the spectral method for the heat equation, *J. Thermophys. Heat Transfer* **7**(3), 454 (1993).
7N. Mingyu Wang and S. P. Vanka, A parallel ADI algorithm for high-order finite-difference solution of the unsteady heat conduction equation, and its implementation on the CM-5, *Numer. Heat Transfer Part B Fundam.* **24**(2), 143 (1993).

Heat conduction (inverse problems)
8N. O. M. Alifanov and I. V. Repin, Study of heat transfer in heterogeneous flows by the method of inverse heat-conduction, *High Temp.* **31**(1), 94 (1993).
9N. O. M. Alifanov, E. A. Artyukhin, A. V. Nenarokomov and I. V. Repin, Determination of characteristics of the thermal interaction of materials with two-phase flows by the inverse problem method, *High Temp.* **31**(3), 543 (1993).
10N. D. B. Ingham and Y. Yuan, Solution of a nonlinear inverse problem in heat transfer, *IMA J. Appl. Math.* **50**(2), 113 (1993).

Phase change
11N. S. Ghosh and S. Moorthy, An arbitrary Lagrangian–Eulerian finite element model for heat transfer analysis of solidification processes, *Numer. Heat Transfer Part B Fundam.* **23**(3), 327 (1993).
12N. R. Viswanath and Y. Jaluria, A comparison of different solution methodologies for melting and solidification problems in enclosures, *Numer. Heat Transfer Part B Fundam.* **24**(1), 77 (1993).

Convection and diffusion
13N. Guoqian Chen and Zhifeng Yang, Perturbational fourth-order upwind finite difference scheme for the convection–diffusion equation, *J. Hydrodynamics* **5**(1), 82 (1993).
14N. R. Codina, A Discontinuity-capturing crosswind-dissipation for the finite element solution of the convection–diffusion equation, *Comput. Methods Appl. Mech. Engng* **110**(34), 325 (1993).
15N. G. Comini, O. Saro and M. Manzan, A physical approach to finite-element modeling of coupled conduction and convection, *Numer. Heat Transfer Part B Fundam.* **24**(3), 243 (1993).
16N. C. Farhat, L. Fezoui and S. Lanteri, Two-dimensional viscous flow computations on the connection machine: unstructured meshes, upwind schemes and massively parallel computations, *Comput. Methods Appl. Mech. Engng* **102**(1), 61 (1993).
17N. D. L. Hill and E. A. Baskharone, A monotone streamline upwind method for quadratic finite elements, *Int. J. Numer. Methods Fluids* **17**(6), 463 (1993).
18N. Hyun Dae Kim and Nan-Suey Liu, A time-accurate high-resolution TVD scheme for solving the Navier–Stokes equation, *Computers Fluids* **22**(45), 517 (1993).
19N. A. J. K. Leiroz and R. M. Cotta, On the solution of nonlinear elliptic convection–diffusion problems through the integral transform method, *Numer. Heat Transfer Part B Fundam.* **23**(4), 401 (1993).
20N. B. Q. Li, A Newton-based boundary element method for nonlinear convective diffusion problems, *Numer. Heat Transfer Part B Fundam.* **23**(3), 369 (1993).
21N. H. Lin and C.-C. Chieng, Comparisons of TVD schemes for turbulent transonic projectile aerodynamics computations with a two-equation model of turbulence, *Int. J. Numer. Methods Fluids* **16**(5), 365 (1993).
22N. A. Mahallati, J. Militzer, Yuping Sun and Ningsheng Yang, The three-dimensional piecewise parabolic finite analytic method for unsteady three-dimensional convection–diffusion equations, *Numer. Heat Transfer Part B Fundam.* **24**(3), 315 (1993).
23N. A. Mahallati and J. Militzer, Application of the piecewise parabolic finite analytic method to the three-dimensional cavity flow, *Numer. Heat Transfer Part B Fundam.* **24**(3), 337 (1993).
24N. K. Muralidhar, M. Verghese and K. M. Pillai, Application of an operator-splitting algorithm for advection–diffusion problems, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 99 (1993).
25N. B. Semper, Computation of outflow flux for convection–dominated transport equations, *Commun. Numer. Methods Engng* **9**(8), 639 (1993).
26N. M. A. R. Sharif, An evaluation of the bounded directional transportive upwind differencing scheme for convection–diffusion problems, *Numer. Heat Transfer Part B Fundam.* **23**(2), 201 (1993).
27N. C. R. Swaminathan, V. R. Voller and S. V. Patankar, Streamline upwind control volume finite element method for modeling fluid flow and heat transfer problems, *Finite Elem. Anal. Des.* **13**(23), 169 (1993).
28N. P. Tamamidis and D. N. Assanis, Evaluation of various high-order-accuracy schemes with and without flux limiters, *Int. J. Numer. Methods Fluids* **16**(10), 931 (1993).
29N. P. Tamamidis and D. N. Assanis, Three-dimensional incompressible flow calculations with alternative discretization schemes, *Numer. Heat Transfer Part B Fundam.* **24**(1), 57 (1993).
30N. Y. Tamura and K. Fujii, A multi-dimensional upwind scheme for the Euler equations on structured grids, *Computers Fluids* **22**(23), 125 (1993).
31N. S. Thakur and Wei Shyy, Some implementational issues of convection schemes for finite-volume formulations, *Numer. Heat Transfer Part B Fundam.* **24**(1), 31 (1993).
32N. S. Thakur and Wei Shyy, Development of high-accuracy convection schemes for sequential solvers, *Numer. Heat Transfer Part B Fundam.* **23**(2), 175 (1993).
33N. J. B. Yapo and S. K. Aggarwal, Comparison of FCT with other numerical schemes for the Burgers equation, *Int. Commun. Heat Mass Transfer* **20**(3), 393 (1993).

Multigrid techniques
34N. G. de Felice, F. M. Denaro and C. Meola, Multidimensional single-step vector upwind schemes for highly convective transport problems, *Numer. Heat Transfer Part B Fundam.* **23**(4), 425 (1993).
35N. B. L. Lapworth, Three-dimensional mesh embedding for the Navier–Stokes equations using upwind control volumes, *Int. J. Numer. Methods Fluids* **17**(3), 195 (1993).
36N. A. Rizzi, P. Eliasson, I. Lindblad, C. Hirsch, C. Lacor and J. Haeuser, The engineering of multiblock/multigrid software for Navier–Stokes flows on structured meshes, *Computers Fluids* **22**(23), 341 (1993).
37N. Wei Shyy, Chia-Sheng Sun, Ming-Hsiung Chen and K. C. Chang, Multigrid computation for turbulent recirculating flows in complex geometries, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 79 (1993).
38N. K. M. Smith, W. K. Cope and S. P. Vanka, A multigrid procedure for three-dimensional flows on non-orthogonal collocated grids, *Int. J. Numer. Methods Fluids* **17**(10), 887 (1993).
39N. P. M. Sockol, Multigrid solution of the Navier–Stokes equations on highly stretched grids, *Int. J. Numer. Methods Fluids* **17**(7), 543 (1993).

Radiation
40N. E. H. Chui and G. D. Raithby, Computation of radiant heat transfer on a nonorthogonal mesh using the finite-volume method, *Numer. Heat Transfer Part B Fundam.* **23**(3), 269 (1993).
41N. J. Everson and H. F. Nelson, Rocket plume radiation

base heating by reverse Monte Carlo simulation, *J. Thermophys. Heat Transfer* 7(4), 717 (1993).

42N. R. G. Minnich and D. V. Pryor, Radiative heat transfer simulation on a SPARCStation farm, *Concurrency Practice Experience* **5**(4), 345 (1993).

43N. C. Saltiel and M. H. N. Naraghi, Parallel processing approach for radiative heat transfer prediction in participating media, *J. Thermophys. Heat Transfer* **7**(4), 739 (1993).

44N. Y. Zhang and M. H. N. Naraghi, Analysis of spectral radiative heat transfer using discrete exchange factor method, *J. Thermophys. Heat Transfer* **7**(3), 542 (1993).

Solution of flow equations

45N. E. Blosch, Wei Shyy and R. Smith, The role of mass conservation in pressure-based algorithms, *Numer. Heat Transfer Part B Fundam.* **24**(4), 415 (1993).

46N. S. K. Choi, H. Y. Nam, Y. B. Lee and M. Cho, An efficient three-dimensional calculation procedure for incompressible flows in complex geometries, *Numer. Heat Transfer Part B Fundam.* **23**(4), 387 (1993).

47N. Seok Ki Choi, Ho Yun Nam and Mann Cho, Use of the momentum interpolation method for numerical solution of incompressible flows in complex geometries: choosing cell face velocities, *Numer. Heat Transfer Part B Fundam.* **23**(1), 21 (1993).

48N. H. W. Dandekar, V. Hlavacek and J. Degreve, An explicit 3D finite-volume method for simulation of reactive flows using a hybrid moving adaptive grid, *Numer. Heat Transfer Part B Fundam.* **24**(1), 1 (1993).

49N. D. Elkaim, M. Reggio and R. Camarero, Control volume finite-element solution of a confined turbulent diffusion flame, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(3), 259 (1993).

50N. Yao-Hsin Hwang, Solution of the steady Navier–Stokes equations by the pressure correction method in the ALE grid, *Numer. Heat Transfer Part B Fundam.* **23**(2), 237 (1993).

51N. A. J. Kassab and S. Chesla, Iterative CVBEM solution of nonlinear heat transfer problems, *Engng Anal. Boundary Elements* **11**(1), 67 (1993).

52N. K. M. Kelkar and D. Chouhury, Numerical method for the computation of flow and scalar transport using nonorthogonal boundary-fitted coordinates, *Numer. Heat Transfer Part B Fundam.* **24**(4), 391 (1993).

53N. C.-J. Kim, S. T. Ro and J. S. Lee, An efficient computational technique to solve the moving boundary problems in the axisymmetric geometries, *Int. J. Heat Mass Transfer* **36**(15), 3759 (1993).

54N. Z. Lilek and M. Peric, A collocated finite volume method for predicting flows at all speeds, *Int. J. Numer. Methods Fluids* **16**(12), 1029 (1993).

55N. D. Pan and J.-C. Cheng, A second-order upwind finite-volume method for the Euler solution on unstructured triangular meshes, *Int. J. Numer. Methods Fluids* **16**(12), 1079 (1993).

56N. S. Parameswaran and I. Kiris, A steady, shock-capturing pressure-based computational procedure for inviscid, two-dimensional transonic flows, *Numer. Heat Transfer Part B Fundam.* **23**(2), 221 (1993).

57N. T. Rhodes and S. Acharya, An adaptive differencing scheme for flow and heat transfer problems, *Numer. Heat Transfer Part B Fundam.* **23**(2), 153 (1993).

58N. V. Selmin, The node-centred finite volume approach: bridge between finite differences and finite elements, *Comput. Methods Appl. Mech. Engng* **102**(1), 107 (1993).

59N. G. D. Thiart and T. W. von Backstrom, Extension of the Simplen algorithm differencing scheme to cylindrical polar coordinates, *Numer. Heat Transfer Part B Fundam.* **23**(1), 1 (1993).

60N. K. Vafai and C. P. Desai, Comparative analysis of the finite-element and finite-difference methods for simulation of buoyancy-induced flow and heat transfer in closed and open ended annular cavities, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 35 (1993).

61N. M. Williams, The solution of the two-dimensional incompressible flow equations on unstructured triangular meshes, *Numer. Heat Transfer Part B Fundam.* **23**(3), 309 (1993).

62N. M. A. Wood, C. J. Ciejka and T. V. Hromadka, II, CVBEM error reduction using the approximate boundary method, *Engng Anal. Boundary Elements* **11**(3), 233 (1993).

63N. Ruey-Hor Yen and Chen-Hua Liu, Enhancement of the simple algorithm by an additional explicit corrector step, *Numer. Heat Transfer Part B Fundam.* **24**(1), 127 (1993).

Other studies

64N. I.-S. Chang, Adaptive, unstructured, finite-element, multimaterial, thermal analysis, *J. Spacecr. Rockets* **30**(1), 43 (1993).

65N. N. Dombrowski, E. A. Foumeny and A. Riza, Know the CFD codes, *Chem. Engng Prog.* **89**(9), 46 (1993).

66N. A. F. Emery, R. J. Cochran and D. W. Pepper, Current trends in heat transfer computations, *J. Thermophys. Heat Transfer* 7(2), 193 (1993).

67N. E. A. Foumeny and F. Benyahia, Can CFD improve the handling of air, gas and gas–liquid mixtures, *Chem. Engng Prog.* **899**(2), 21 (1993).

68N. S. Gavali, K. Karki, S. Patankar and K. Miura, Numerical study of flow and heat transfer for circular jet impingement on the bottom of a cylindrical cavity, *J. Electron. Packag.* **115**(3), 292 (1993).

69N. R. C. Mehta and V. M. K. Sastri, Numerical analysis of wall pressure and heat flux fluctuations in shock-turbulent-boundary layer interaction, *Int. J. Numer. Methods Fluids* **16**(8), 739 (1993).

70N. Tien-Mo Shih and M. M. Ohadi, Literature survey on numerical heat transfer (1990–1991), *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 129 (1993).

71N. G. G. Stefani, N. S. Goel and D. B. Jenks, An efficient numerical technique for thermal characterization of printed wiring boards, *J. Electron. Packag.* **115**(4), 366 (1993).

72N. Guannan Xi, S. Futagami, Y. Hagiwara and K. Suzuki, Flow and heat transfer characteristics of fin arrays in the middle range of Reynolds number (2nd Report, mechanism of heat transfer promotion), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1324 (1993).

73N. Guannan Xi, S. Futagami, Y. Hagiwara and K. Suzuki, Flow and heat transfer characteristics of fin arrays in the middle range of Reynolds number (1st Report, statistical characteristics of unsteady flow and temperature fields), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1318 (1993).

TRANSPORT PROPERTIES

Thermal conductivity

1P. R. S. Agarwal and A. F. Waleed, Transport properties of R22–DMF mixtures, *Energy Convers. Manage.* **34**(3), 223 (1993).

2P. M. Alagar and P. Manohar, Studies on heat transfer characteristics of different series of alkoxysilanes, *Hung. J. Ind. Chem.* **21**(2), 121 (1993).

3P. S. Yu. Belov, V. V. Vasil'ev, I. A. Kovalevich and T. M. Teterina, The thermal conductivity of ash deposits on tubes of boilers burning Kansk-Achinsk coals, *Therm. Engng* **40**(9), 692 (1993).

4P. V. Calzona, M. R. Cimberle, C. Ferdeghini, M. Putti and A. S. Siri, Fully automated apparatus for thermal diffusivity measurements on HTSC in high magnetic field, *Rev. Scient. Instrum.* **64**(3), 766 (1993).

5P. G. Chen and C. L. Tien, Thermal conductivities of quantum well structures, *J. Thermophys. Heat Transfer* **7**(2), 311 (1993).

6P. Bih-Cherng Chern, T. J. Moon and J. R. Howell, Measurement of the temperature and cure dependence of the thermal conductivity of epoxy resin, *Exp. Heat Transfer* **6**(2), 157 (1993).

7P. K. Y. Donaldson, H. D. Bhatt, D. P. H. Hasselman, K. Chyung and M. P. Taylor, Role of interfacial gaseous heat transfer in the transverse thermal conductivity of a uniaxial carbon fiber-reinforced aluminoborosilicate glass, *J. Am. Ceram. Soc.* **76**(7), 1888 (1993).

8P. D. D. Edie, C. C. Fain, K. E. Robinson, A. M. Harper and D. K. Rogers, Ribbon-shape Carbon Fibers for Thermal Management, *Carbon* **31**(6), 941 (1993).

9P. R. Frank, V. Drach and J. Fincke, Determination of thermal conductivity and specific heat by a combined 3w/decay technique, *Rev. Scient. Instrum.* **64**(3), 760 (1993).

10P. H. Fujishiro, M. Ikebe, K. Noto, T. Sasaoka and K. Nomura, Thermal and electrical properties of Ag–Au and Ag–Cu alloy tapes for metal stabilizers of oxide superconductors, *Cryogenics* **33**(11), 1086 (1993).

11P. G. G. Gadzhiev, Sh. M. Ismailov and A. I. Dadashev, Thermal properties of ceramics based on AIIBVI compounds, *High Temp.* **31**(3), 468 (1993).

12P. Tie Gao, T. Nishikawa, M. Hibi and M. Takatsu, Temperature dependence of so-called heat transfer coefficient under thermal shock test, *J. Ceram. Soc. Jpn Int. Ed.* **101**(7), 768 (1993).

13P. F. Geotti-Bianchini and J. Lohrengel, Thermal conductivity of float glass at room temperature, *Glastechnische Berichte* **66**(2), 25 (1993).

14P. Yuqin Gu, Xiaowei Tang, Yuan Xu and Ichiro Hatta, Ingenious method for eliminating effects of heat loss in measurements of thermal diffusivity by AC calorimetric method, *Jpn J. Appl. Phys. Part* 2 **32**(9), 1365 (1993).

15P. G. V. Jackson and A. G. Leach, Thermal conductivity of foams—II. The thermal conductivity of a layer mineral foam, *J. Phys. D* **26**(5), 740 (1993).

16P. V. L. Kalitvyanskii, An analytical calculation of the nonstationary thermal conductivity of multilayered bodies, *High Temp.* **31**(3), 618 (1993).

17P. S. W. Kim and R. E. Taylor, Estimation of thermophysical properties of a film coated on a substrate using pulsed transient analysis, *Int. J. Thermophys.* **14**(1), 135 (1993).

18P. V. A. Konstantinov, V. G. Manzhelii and S. A. Smirnov, A correlation between the nature of the rotational motion of molecules and the behavior of the isochoric thermal conductivity of molecular crystals, *High Temp.* **31**(3), 607 (1993).

19P. P. G. Kosky, A method of measurement of thermal conductivity: application to free-standing diamond sheet, *Rev. Scient. Instrum.* **64**(4), 1071 (1993).

20P. B. Kruppa and J. Straub, Dynamic light scattering: an efficient method to determine thermal diffusivity of transparent fluids, *Exp. Therm. Fluid Sci.* **6**(1), 28 (1993).

21P. A. G. Leach, The thermal conductivity of foams—I. Models for heat conduction, *J. Phys. D* **26**(5), 733 (1993).

22P. Xianping Lu, O. Nilsson, J. Fricke and R. W. Pekala, Thermal and electrical conductivity of monolithic carbon aerogels, *J. Appl. Phys.* **73**(2), 581 (1993).

23P. C. V. Madhusudana, Thermal contact conductance and rectification at low joint pressures, *Int. Commun. Heat Mass Transfer* **20**(1), 123 (1993).

24P. U. B. Magomedov, Thermal conductivity of aqueous solutions of salts at high pressures, temperatures and concentrations, *High Temp.* **31**(3), 610 (1993).

25P. C. S. McMenamin, J. P. Bird, D. F. Brewer, N. E. Hussey, C. Moreno, A. L. Thomson and A. J. Young, Heat pulse measurement of thermal properties: an improved fitting technique, *Cryogenics* **33**(10), 941 (1993).

26P. C. Meis, A. K. Froment and D. Moulinier, Determination of gadolinium thermal conductivity using experimentally measured values of thermal diffusivity, *J. Phys. D* **26**(4), 560 (1993).

27P. S. V. Nagaev and G. A. Kirsanov, High-temperature thermal conductivity of "Karbotekstim-V" graphitized fiber, *High Temp.* **31**(1), 179 (1993).

28P. J. Nicolas, Ph. André, J. F. Rivez and V. Debbaut, Thermal conductivity measurements in soil using an instrument based on the cylindrical probe method, *Rev. Scient. Instrum.* **64**(3), 774 (1993).

29P. J. R. Olson, Thermal conductivity of some common cryostat materials between 0.05 and 2 K, *Cryogenics* **33**(7), 729 (1993).

30P. V. E. Peletskii, A. P. Grishchuk and Z. A. Musaeva, Transport properties of a and b zirconium, *High Temp.* **30**(6), 900 (1993).

31P. V. A. Petrov and S. Al. Ulybin, Measurement of the high-temperature diffusivity of thermal insulation materials by the method of temperature waves, *High Temp.* **30**(6), 910 (1993).

32P. T. Poulin, L. Nguyen, G. Larson, M. Michael and N. Jeeves, Thermal conductance of green tape via arrays, *Int. J. Microcircuits Electron. Packag.* **16**(3), 199 (1993).

33P. G. Shabbir, M. Maqsood, A. Maqsood, Izhar-Ul-Haq, N. Amin and S. E. Gustafsson, Thermophysical properties of rock marbles as a function of temperature, *J. Phys. D* **26**(10), 1576 (1993).

34P. M. Susa, F. Li and K. Nagata, Thermal conductivity, thermal diffusivity and specific heat of slags containing iron oxides, *Ironmaking Steelmaking* **20**(3), 201 (1993).

35P. A. Vásquez and J. G. Briano, Thermal conductivity of hydrocarbon mixtures: a perturbation approach, *Ind. Engng Chem. Res.* **32**(1), 194 (1993).

36P. V. Vesovic and W. A. Wakeham, Practical, accurate expressions for the thermal conductivity of atom–diatom gas mixtures, *Phys. A* **201**(4), 501 (1993).

Diffusion coefficients

37P. E. Pemha, B. Gay and A. Tailland, Measurement of the diffusion coefficient in a heated plane airstream, *Phys. Fluids A* **5**(6), 1289 (1993).

38P. H. L. Toor, Effect of chemical reactions on turbulent diffusivities, *A. I. Ch. E. Jl* **39**, 1603 (1993).

Viscosity

39P. M. Felli, F. Cotana and F. Rossi, Experimental determination of the thermophysical properties of water–xylitol mixtures, *Exp. Therm. Fluid Sci.* **7**(1), 80 (1993).

40P. R. Linden, M. Gebauer and R.-P. Pfitzner, Experimental determination of pressure- and temperature-dependence of the viscosity of lubricating oils, *Chem. Ing. Tech.* **65**(12), 1495 (1993).

41P. E. S. Mukhtarov and A. M. Semenov, Transport coefficients of barium, zinc and cadmium vapor, *High Temp.* **31**(2), 220 (1993).

42P. V. P. Romanov and S. V. Ul'yanov, Bulk viscosity in relaxing media, *Phys. A* **201**(4), 527 (1993).

43P. A. V. Shenoy, SFI: a simple rheological parameter for estimating viscosity, *Exp. Therm. Fluid Sci.* **6**(3), 324 (1993).

44P. Sehyun Shin and Young I. Cho, Temperature effect on the non-Newtonian viscosity of an aqueous poly-

acrylamide solution, *Int. Commun. Heat Mass Transfer* **20**(6), 831 (1993).

Thermodynamic data

45P. K. Abu-Abdou and M. F. Zedan, Comparative study of some equations of state for computing properties of refrigerant-12, *Appl. Energy* **45**(4), 355 (1993).
46P. A. Aguilar and E. Braun, The specific heat at reentrancies. Is there a break in its universal behavior?, *Physica A* **193**(1), 169 (1993).
47P. F. Bärmann, G.-R. Greye and A. Lieberam, Application of neuronal networks for the prediction of thermophysical material constants of pure substances from structural information, *Chem. Ing. Tech.* **65**(3), 310 (1993).
48P. J. E. Bishop and V. K. Kinra, Thermoelastic damping of a laminated beam in flexure and extension, *J. Reinf. Plast. Compos.* **12**(2), 210 (1993).
49P. L. A. Blagonravov, Isobaric specific heat of low-boiling point metals by high temperatures and pressures, *High Temp.* **31**(3), 575 (1993).
50P. R. Budin and A. Mihelic-Bogdanic, Generalized thermodynamic calculations for CHP generation, *Energy* **18**(7), 791 (1993).
51P. M. Cassettari, F. Papucci, G. Salvetti, E. Tombari, S. Veronesi and G. P. Johari, Simultaneous measurements of enthalpy and heat capacity of a thermosetting polymer during the curing process, *Rev. Scient. Instrum.* **64**(4), 1076 (1993).
52P. Yu. G. Degtev and V. P. Panchenko, Properties of the combustion products of powder fuels and pulsed MHD generators, *High Temp.* **31**(2), 263 (1993).
53P. S. Göktun and S. Özkaynak, Selection of ozone-safe refrigerants for heat pumps, *Energy* **18**(8), 867 (1993).
54P. N. Hammouda, S. C. Cheng and D. C. Groeneveld, Evaluation of thermophysical properties of freon-22, *Wärme Stoffübertrag.* **28**(7), 387 (1993).
55P. K. Humer, E. K. Tschegg and H. W. Weber, Tensile, fracture and thermal properties of polyarylates at room and cryogenic temperatures, *Cryogenics* **33**(7), 686 (1993).
56P. Ya. M. Naziev, M. M. Bashirov, M. A. Talybov and Yu. A. Badalov, Experimental study of the isobaric heat capacity of methyl and isopropyl alcohols, *High Temp.* **31**(2), 244 (1993).
57P. L. G. Nikiforov, Relationship between thermal expansion and heat capacity, melting point, and parameters of interatomic interaction and crystal structure, *High Temp.* **31**(1), 171 (1993).
58P. I. I. Petrova and V. Ya. Chekovskoi, Experimental investigation of the thermophysical properties of a tungsten–copper pseudoalloy by a pulsed blowing method, *High Temp.* **30**(6), 906 (1993).

HEAT TRANSFER APPLICATIONS—HEAT PIPES AND HEAT EXCHANGERS

Heat pipes

1Q. T. Y. Bong, K. C. Ng and H. Bao, Thermal performance of a flat-plate heat-pipe collector array, *Sol. Energy* **50**(6), 491 (1993).
2Q. Y. Cao and A. Faghri, Conjugate modeling of high-temperature nosecap and wing leading edge heat pipes, *J. Heat Transfer* **115**(3), 819 (1993).
3Q. Y. Cao and A. Faghri, Simulation of the early startup period of high-temperature heat pipes from the frozen state by a rarefied vapor self-diffusion model, *J. Heat Transfer Trans. ASME* **115**(1), 239 (1993).
4Q. Y. Cao and A. Faghri, A numerical analysis of high-temperature heat pipe startup from the frozen state, *J. Heat Transfer Trans. ASME* **115**(1), 247 (1993).
5Q. M. S. El-Genk and L. Huang, An experimental investigation of the transient response of a water heat pipe, *Int. J. Heat Mass Transfer* **36**(15), 3823 (1993).
6Q. A. Faghri, S. Gogineni and S. Thomas, Vapor flow analysis of an axially rotating heat pipe, *Int. J. Heat Mass Transfer* **36**(9), 2293 (1993).
7Q. B. J. Huang, Performance rating method of thermosyphon solar water heaters, *Sol. Energy* **50**(5), 435 (1993).
8Q. M. Kuramae and M. Suzuki, Two-component heat pipes utilizing the Marangoni effect, *J. Chem. Engng. Jpn* **26**(2), 230 (1993).
9Q. M. Levy, R. Levitan, H. Rosin and R. Rubin, Solar energy storage via a closed-loop chemical heat pipe, *Sol. Energy* **50**(2), 179 (1993).
10Q. A. L. Luks, L. S. Shmeleva, N. V. Gorbunova and V. N. Kalabukhov, Study of hydraulic characteristics of antigravitational heat pipe taking into account phase interactions, *Izvestiya VUZ Aviatsionnaya Tekhnika* (2), 112 (1993).
11Q. Kurt O. Lund and Karl W. Baker, Minimum-weight analysis of anisotropic plane-fin heat-pipe space radiators, *J. Sol. Energy Engng Trans. ASME* **115**(1), 37 (1993).
12Q. M. T. North and C. T. Avedisian, Heat pipes for cooling high flux–high power semiconductor chips, *J. Electron. Packag.* **115**(1), 112 (1993).
13Q. J. Schmalhofer and A. Faghri, A study of circumferentially-heated and block-heated heat pipes—I. Experimental analysis and generalized analytical prediction of capillary limits, *Int. J. Heat Mass Transfer* **36**(1), 20 (1993).
14Q. J. Schmalhofer and A. Faghri, A study of circumferentially-heated and block-heated heat pipes—II. Three-dimensional numerical modeling as a conjugate problem, *Int. J. Heat Mass Transfer* **36**(1), 213 (1993).
15Q. A. Segal and M. Levy, Solar chemical heat pipe in closed loop operation: mathematical model and experiments, *Sol. Energy* **51**(5), 367 (1993).
16Q. A. Segal and M. Levy, Modular solar chemical heat pipe for a parabolic dish: conceptual design and model calculations, *Sol. Energy* **51**(5), 419 (1993).
17Q. G. F. Smirnov, O. K. Biryukov and B. V. Kosoi, Thermal design of heat exchangers with heat pipes and thermosiphons, *Therm. Engng* **40**(1), 71 (1993).
18Q. G. F. Smirnov, O. K. Biryukov and B. V. Kosoi, Optimizing heat-exchange apparatuses with heat pipes and thermosiphons, *Therm. Engng* **40**(10), 802 (1993).

Heat exchangers

19Q. A. Ya Blagoveshchenskii, V. L. Leont'eva, A. G. Mitryukhin and I. L. Paramonova, The use of natural circulation of coolant in systems for heat removal from reactor cores, *Therm. Engng* **40**(3), 169 (1993).
20Q. H. Brauer and T.-H. Kim, Fluid flow and heat transfer for tube rows and bundles at low values of the Reynolds number—I. One row of tubes with in-line arrangement of the tubes, *Forsch. Ingenieurwes.* **59**(7), 129 (1993).
21Q. G. P. Celata, Recent achievements in the thermal hydraulics of high heat flux components in fusion reactors, *Exp. Therm. Fluid Sci.* **7**(4), 263 (1993).
22Q. R. de Goede and E. J. de Jong, Heat transfer properties of a scraped-surface heat exchanger in the turbulent flow regime, *Chem. Engng Sci.* **48**(8), 1393 (1993).
23Q. R. Dezek and D. Klompmaker, Mechanically bonded radiators for heavy-duty off-highway diesel engines, *Automot. Engng* (Warrendale PA) **100**(8), 19 (1993).
24Q. M. S. El-Genk, B. Su and Z. Guo, Experimental studies of forced, combined and natural convection

of water in vertical nine-rod bundles with a square lattice, *Int. J. Heat Mass Transfer* **36**(9), 2359 (1993).

25Q. S. A. Idem and V. W. Goldschmidt, Sensible and latent heat transfer to a baffled finned-tube heat exchanger, *Heat Transfer Engng* **14**(3), 26 (1993).

26Q. A. M. Jacobi, S. A. Idem and V. W. Goldschmidt, Predicting the performance of multistage heat exchangers, *Heat Transfer Engng* **14**(1), 62 (1993).

27Q. J. Jilek, Exergy efficiency of a counterflow air–air heat exchanger with vapour condensation, *Wärme Stoffübertrag.* **28**(3), 123 (1993).

28Q. A. Y. Khan and H. D. Ball, Experimental performance verification of a coil-type liquid desiccant system at part-load operation, *Sol. Energy* **51**(5), 401 (1993).

29Q. Nae-Hyun Kim, Sang-Keun Lee and Si-Hwan Kim, Development of an algebraic model to predict the heat transfer for turbulent flow in a rod bundle, *J. Heat Transfer Trans. ASME* **115**(1), 266 (1993).

30Q. G. S. H. Lock and M. Wu, Heat transfer characteristics of a bayonet tube using air under laminar conditions, *Int. J. Heat Mass Transfer* **36**(2), 287 (1993).

31Q. A. T. Lukyanov, P. G. Itskova and A. S. Bukharbayeva, Modelling of resonance effects during burning in a continuous-flow reactor, *Int. J. Heat Mass Transfer* **36**(6), 1687 (1993).

32Q. F. S. Neto and R. M. Cotta, Dynamic analysis of double-pipe heat exchangers subjected to periodic inlet temperature disturbances, *Wärme Stoffübertrag.* **28**(8), 497 (1993).

33Q. F. Scofano Neto and R. M. Cotta, Improved hybrid lumped-differential formulation for double-pipe heat exchanger analysis, *J. Heat Transfer Trans. ASME* **115**(4), 921 (1993).

34Q. C. B. Panchal and T. J. Rabas, Thermal performance of advanced heat exchangers for ammonia refrigeration systems, *Heat Transfer Engng* **14**(4), 42 (1993).

35Q. G. Polley, Heat exchangers for the future, *Chem. Engng (London)* **544,** 14 (1993).

36Q. I. Quesada and I. E. Grossmann, Global optimization algorithm for heat exchanger networks, *Ind. Engng Chem. Res.* **32**(3), 487 (1993).

37Q. M. Reppich and J. Kohoutek, An approach to computer-aided design and optimisation of tubular heat exchangers, *Chem. Ing. Tech.* **65**(1), 303 (1993).

38Q. R. K. Shah and A. Pignotti, Thermal analysis of complex crossflow exchangers in terms of standard configurations, *J. Heat Transfer Trans. ASME* **115**(2), 353 (1993).

39Q. O. S. Sobolev, Automatic control of the heating of parallel flows in heat exchangers, *Therm. Engng* **40**(10), 769 (1993).

40Q. R. Steinhagen, H. Müller-Steinhagen and K. Maani, A survey of heat exchanger applications, *Heat Transfer Engng* **14**(2), 13 (1993).

41Q. K. Suaysompol and R. M. Wood, Estimation of the installed cost of heat exchanger networks, *Int. J. Prod. Econ.* **29**(3), 303 (1993).

42Q. D. J. Van Aarde and D. G. Kröger, Flow losses through an array of A-frame heat exchangers, *Heat Transfer Engng* **14**(1), 43 (1993).

43Q. C. Zhang and Y. Zhang, Quasi-three-dimensional approach to predict the performance of steam surface condensers, *J. Energy Resour. Technol. Trans. ASME* **115**(3), 213 (1993).

Design

44Q. M. Affan Badar, S. M. Zubair and A. K. Sheikh, Uncertainty analysis of heat-exchanger thermal designs using the Monte Carlo simulation technique, *Energy* **18**(8), 859 (1993).

45Q. M. Bojic, Mathematical model of heat recovery in a space-heating and ventilation system, *Energy* **18**(1), 49 (1993).

46Q. J. Boyer and G. Trumpfheller, Specification tips to maximize transfer heat, *Chem. Engng* (New York) **100**(5), 90 (1993).

47Q. O. N. Ignatenko, I. L. Strulya and V. V. Kharitonov, Calculated optimization of a microchannel cooling system for mirrors for high-power lasers, *High Temp.* **31**(1), 82 (1993).

48Q. L. Neel, Failure analysis helps improve heat exchanger designs, *Power Engng* **97**(8), 33 (1993).

49Q. E. Nieuwlaar and D. Dijk, Exergy evaluation of space-heating options, *Energy* **18**(7), 779 (1993).

50Q. T. Nishimura, H. Itoh and H. Miyashita, The influence of tube layout on flow and mass transfer characteristics in tube banks in the transitional flow regime, *Int. J. Heat Mass Transfer* **36**(3), 553 (1993).

51Q. S. Papastratos, A. Isambert and D. Depeyre, Computerized optimum design and dynamic simulation of heat exchanger networks, *Comput. Chem. Engng* **17,** 329 (1993).

52Q. H. Peerhossaini, C. Castelain and Y. Le Guer, Heat exchanger design based on chaotic advection, *Exp. Therm. Fluid Sci.* **7**(4), 333 (1993).

53Q. G. Polley, Integration means inserts, *Chem. Engng* (London) **541,** 18 (1993).

54Q. T. A. Reddy and D. E. Claridge, Effect of air-conditioner oversizing and control on electric-peak loads in a residence, *Energy* **18**(11), 1139 (1993).

55Q. L. Wilson and B. Nugent, Primary cooling systems. A comparative analysis, *ASHRAE J.* **35**(1), 19 (1993).

56Q. M. Zaheer-uddin, Energy start–stop and fluid flow regulated control of multizone HVAC systems, *Energy* **18**(3), 289 (1993).

Enhancement

57Q. N. Ashgriz, J. P. Seet and J. D. Felske, Flow behavior in thin-gapped diamond-shaped channels with pins, *J. Fluids Engng Trans. ASME* **115**(1), 175 (1993).

58Q. A. Aziz, The effects of internal heat generation, anisotropy and base temperature nonuniformity on heat transfer from a two-dimensional rectangular fin, *Heat Transfer Engng* **14**(2), 63 (1993).

59Q. R. F. Babus'haq, S. D. Probert and C. R. Taylor, Heat-transfer effectiveness of shrouded, rectangular-fin arrays, *Appl. Energy* **46**(2), 99 (1993).

60Q. A. Bejan and A. M. Morega, Optimal arrays of pin fins and plate fins in laminar forced convection, *J. Heat Transfer Trans. ASME* **115**(1), 75 (1993).

61Q. Th. Bes and W. Roetzel, Thermal theory of the spiral heat exchanger, *Int. J. Heat Mass Transfer* **36**(3), 765 (1993).

62Q. L. P. Chauvet, D. J. Nevrala and S. D. Probert, Heat-transfer correlations for an immersed finned heat-exchanger coil transferring heat from a hot-water store, *Appl. Energy* **44**(4), 283 (1993).

63Q. L. P. Chauvet, D. J. Nevrala and S. D. Probert, Influences of baffles on the rate of heat recovery via a finned-tube heat-exchanger immersed in a hot-water store, *Appl. Energy* **45**(3), 191 (1993).

64Q. B. T. F. Chung and J. R. Lyer, Optimum design of longitudinal rectangular fins and cylindrical spines with variable heat transfer coefficient, *Heat Transfer Engng* **14**(1), 31 (1993).

65Q. M. K. Chyu and V. Natarajan, Effects of a slit in a rib on the heat transfer from a rib-mounted wall, *J. Heat Transfer* **115**(3), 792 (1993).

66Q. M. Fiebig, A. Valencia and N. K. Mitra, Wing-type vortex generators for fin-and-tube heat exchangers, *Exp. Therm. Fluid Sci.* **7**(4), 287 (1993).

67Q. W. Forsch, Temperature distribution and efficiency of the dry square fin, *Forsch. Ingenieurwes.* **59**(6), 105 (1993).

68Q. X. Hu and A. M. Jacobi, Local heat transfer behavior and its impact on a single-row, annularly finned tube heat exchanger, *J. Heat Transfer Trans. ASME* **115**(1), 66 (1993).

69Q. B. A. Jubran, M. A. Hamdan and R. M. Abdualh, Enhanced heat transfer, missing pin and optimization for cylindrical pin fin arrays, *J. Heat Transfer* **115**(3), 576 (1993).

70Q. P. C. S. Jucá and A. T. Prata, Two-dimensional fins attached to a thick wall-effect of non-uniform root temperature, *Int. J. Heat Mass Transfer* **36**(1), 233 (1993).

71Q. N. Kayansayan, Heat transfer characterization of flat plain fins and round tube heat exchangers, *Exp. Therm. Fluid Sci.* **6**(3), 263 (1993).

72Q. N. Kayansayan, Thermal characteristics of fin-and-tube heat exchanger cooled by natural convection, *Exp. Therm. Fluid Sci.* **7**(3), 177 (1993).

73Q. M. Noguchi, A. Ishibashi and T. Higo, Technical trends toward higher performance of inner grooved tube, *R&D Res. Dev. Kobe Steel Ltd* **43**(1), 117 (1993).

74Q. J. Orozco and To-Nga Nguyen, An analysis of the heat transfer characteristics of the fin–refractory system in a cyclone furnace, *Heat Transfer Engng* **14**(3), 19 (1993).

75Q. X. F. Peng, G. P. Peterson and X. J. Lu, Analysis of capillary-induced rewetting in circular channels with internal grooves, *J. Thermophys. Heat Transfer* **7**(2), 334 (1993).

76Q. P. Razelos and B. R. Satyaprakash, Analysis and optimization of convective trapezoidal profile longitudinal fins, *J. Heat Transfer Trans. ASME* **115**(2), 461 (1993).

77Q. Oscar R. San Roman Gutierrez, Effect of wetted floating fins on water–atmosphere heat exchange, *J. Energy Engng* **119**(1), 32 (1993).

78Q. M. Sano, Enhancement of heat transfer in turbulent rectangular channel flow using thin inclined plates, *Heat Transfer Jpn Res.* **22**(3), 238 (1993).

79Q. P. R. Thimmapuram, N. S. Rao and S. C. Saxena, Heat transfer from immersed tubes in a baffled slurry bubble column, *Chem. Engng Commun.* **120,** 27 (1993).

80Q. Jung-Kuei Tseng, Chia-Lin Shih and Wen-Jyi Wu, Analysis of transient heat transfer in straight fins of various shapes with its base subjected to a decayed exponential function of time in heat flux, *Computers Structures* **47**(2), 289 (1993).

Fouling/deposits/surface effects

81Q. V. E. Abaltusov and T. N. Nemova, Interaction of high-temperature one- and two-phase flows with active thermoprotective elements, *High Temp.* **30**(4), 657 (1993).

82Q. B. Bansal and H. Müller-Steinhagen, Crystallization fouling in plate heat exchangers, *J. Heat Transfer* **115**(3), 584 (1993).

83Q. V. A. Burakov, S. F. Saidu and S. I. Kraskova, Thermal erosion of coking thermal protection materials in supersonic two-phase flow, *High Temp.* **30**(4), 650 (1993).

84Q. S. H. Chan, Z. J. Chen and P. He, Effects of sodium and potassium chlorides on silica fouling, *J. Heat Transfer Trans. ASME* **115**(1), 82 (1993).

85Q. H. Müller-Steinhagen, Methods for reducing deposits in heat exchangers, *Chem. Ing. Tech.* **65**(5), 523 (1993).

86Q. T. J. Rabas, C. B. Panchal, D. S. Sasscer and R. Schaefer, Comparison of river-water fouling rates for spirally indented and plain tubes, *Heat Transfer Engng* **14**(4), 58 (1993).

87Q. A. A. Skryabin, M. I. Nekrasov and A. I. Dushkin, Fouling of double-walled tube banks, *Therm. Engng* **40**(9), 695 (1993).

88Q. R. Steinhagen, Hans Müller-Steinhagen and Kambiz Maani, Problems and costs due to heat exchanger fouling in New Zealand industries, *Heat Transfer Engng* **14**(1), 19 (1993).

Packed beds/storage

89Q. M. Affan Badar, S. M. Zubair and A. A. Al-Farayedhi, Second-law-based thermoeconomic optimization of a sensible heat thermal energy storage system, *Energy* **18**(6), 641 (1993).

90Q. J. G. Holmes, Surface mount solution for power devices, *Surf. Mount Technol.* **7**(9), 18 (1993).

91Q. B. Ivanov, K. Peneva and N. Bancheva, Heat integration in batch reactors operating in different time intervals—III. Synthesis and reconstruction of integrated systems with heat tanks, *Hung. J. Ind. Chem.* **21**(3), 217 (1993).

92Q. B. Ivanov, K. Peneva and N. Bancheva, Heat integration in batch reactors operating in different time intervals—II. A hot–cold reactor system with a common storage tank, *Hung. J. Ind. Chem.* **21**(3), 209 (1993).

93Q. S. C. Kranc, Performance of counterflow cooling towers with structured packings and maldistributed water flow, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(1), 115 (1993).

94Q. M. Lacroix, Study of the heat transfer behavior of a latent heat thermal energy storage unit with a finned tube, *Int. J. Heat Mass Transfer* **36**(8), 2083 (1993).

95Q. D. F. Marr, A. M. Gola-Galimidi and W. E. Stewart, Transport modelling of packed-tube reactors—III. Initial data-based functions and application, *Chem. Engng Sci.* **48**(23), 3945 (1993).

96Q. G. R. Mirsky and J. Bauthier, Evolution of cooling tower fill, *J. Cool. Tower Inst.* **14**(1), 12 (1993).

97Q. J. J. Wang, Mathematical modeling of the drying process in a fixed-bed dryer, *Numer. Heat Transfer Part B Fundam.* **24**(2), 229 (1993).

98Q. Dongsheng Zhu and Yingke Tan, Heat and mass transfer characteristics in the 'Zeolite–water' closed adsorption cycle, *J. Chem. Engng Chin. Univ. Technol.* **7**(1), 62 (1993).

Regenerators/rotary devices

99Q. F. E. Romie, Calculation of temperatures in a single-blow regenerative heat exchanger having arbitrary initial solid and entering gas temperatures, *J. Heat Transfer Trans. ASME* **115**(4), 1064 (1993).

100Q. I. Sakai and Y. Kawaguchi, Transient temperature distribution in rotary regenerator heat exchanger, *Int. J. Numer. Methods Heat Fluid Flow* **3**(2), 173 (1993).

101Q. J.-Y. San, Heat and mass transfer in a two-dimensional cross-flow regenerator with a solid conduction effect, *Int. J. Heat Mass Transfer* **36**(3), 633 (1993).

102Q. J. Y. San and S. C. Hsiau, Effect of axial solid heat conduction and mass diffusion in a rotary heat and mass regenerator, *Int. J. Heat Mass Transfer* **36**(8), 2051 (1993).

103Q. C. M. Shen and W. M. Worek, Second-law optimization of regenerative heat exchangers, including the effect of matrix heat conduction, *Energy* **18**(4), 355 (1993).

104Q. A. J. Wilmott and D. P. Knight, Improved collocation methods for thermal regenerator simulations, *Int. J. Heat Mass Transfer* **36**(6), 1663 (1993).

105Q. L. Zhang and D. M. Scott, A unified approach to discretizations of the linear analysis of thermal regenerators, *Int. J. Heat Mass Transfer* **36**(4), 1035 (1993).

106Q. W. Zheng and W. M. Worek, Numerical simulation of combined heat and mass transfer processes in a rotary dehumidifier, *Numer. Heat Transfer Int. J. Comput. Methodol. Part A Appl.* **23**(2), 211 (1993).

Shell and tube exchangers

107Q. G. N. Danilova, V. A. Dyundin and A. G. Solov'ev, Experimental investigation of heat transfer in boiling R-22 and R-717 on different surfaces in horizontal shell-and-tube evaporators, *High Temp.* **30**(4), 645 (1993).

108Q. M. Lacroix, Numerical simulation of a shell-and-tube latent heat thermal energy storage unit, *Sol. Energy* **50**(4), 357 (1993).

109Q. T. Pekdemir, T. W. Davies, L. E. Haseler and A. D. Diaper, Flow distribution on the shellside of a cylindrical shell and tube heat exchanger, *Int. J. Heat Fluid Flow* **14**(1), 76 (1993).

110Q. W. Roetzel and Y. Xuan, The effect of core longitudinal heat conduction on the transient behavior of multipass shell-and-tube heat exchangers, *Heat Transfer Engng* **14**(1), 52 (1993).

111Q. W. Roetzel and D. Lee, Experimental investigation of leakage in shell-and-tube heat exchangers with segmental baffles, *Int. J. Heat Mass Transfer* **36**(15), 3765 (1993).

112Q. W. Roetzel and Y. Xuan, The effect of heat conduction resistances of tubes and shells on transient behaviour of heat exchangers, *Int. J. Heat Mass Transfer* **36**(16), 3967 (1993).

113Q. W. Roetzel and Yimin Zuan, Transient behaviour of shell-and-tube heat exchangers, *Chem. Engng Technol.* **16**(5), 296 (1993).

114Q. Si-Ying Sun, Ya-Dong Lu and Cai-Qiu Yan, Optimization in calculation of shell–tube heat exchanger, *Int. Commun. Heat Mass Transfer* **20**(5), 675 (1993).

115Q. A. V. Tatarinov and A. M. Tsirlin, The dynamic characteristics and selection of settings on regulators for shell-and-tube heat exchangers at the design stage, *Therm. Engng* **40**(2), 122 (1993).

116Q. Y. Xuan and W. Roetzel, Stationary and dynamic simulation of multipass shell and tube heat exchangers with the dispersion model for both fluids, *Int. J. Heat Mass Transfer* **36**(17), 4221 (1993).

Transient

117Q. E. Assis and H. Kalman, Transient temperature response of different fins to step initial conditions, *Int. J. Heat Mass Transfer* **36**(17), 4107 (1993).

118Q. D. D. Gvozdenac, Analytical solution for transient response of counter flow heat exchanger with finite wall capacitance, *Wärme Stoffübertrag.* **28**(6), 351 (1993).

119Q. I. M. Lagun, Rate of heat transfer under nonsteady conditions, *High Temp.* **31**(1), 108 (1993).

120Q. A. Negiz, M. A. Hastaoglu and R. A. Heidemann, Three-dimensional transient heat transfer from a buried pipe—I. Laminar flow, *Chem. Engng Sci.* **48**(20), 3507 (1993).

121Q. B. I. Nigmatulin, V. E. Kroshilin and Ya. D. Khodzhaev, Study of the heat-transfer crisis in a rod bundle with allowance for the distribution of the liquid film over the perimeter of the fuel elements for steady and nonsteady conditions, *High Temp.* **31**(1), 101 (1993).

122Q. A. Rogowski, R. Heinisch and E. Schütt, Transient energy and mass transfer in a honeycomb tube reactor, *Chem. Ing. Tech.* **65**(10), 1251 (1993).

Miscellaneous

123Q. G. Cacciola, A. Hajji, G. Maggio and G. Restuccia, Dynamic simulation of a recuperative adsorption heat pump, *Energy* **18**(11), 1125 (1993).

124Q. C. Cecchini, B. Cellarosi, V. Cancellier and G. P. Pirotta, Alternative blowing agents for CFC free rigid PU foams, *J. Cell. Plast.* **29**(2), 159 (1993).

125Q. P. M. Dieguez and J. M. Sala, Heat transfer in a cylindrical geometry and application to reciprocating internal combustion engines, *Energy* **18**(9), 987 (1993).

126Q. I. Dincer, Heat-transfer coefficients in hydrocooling of spherical and cylindrical food products, *Energy* **18**(4), 335 (1993).

127Q. W. Erdmann, H. Koehler and P. Schwarzmann, Heating semi-finished products with ceramic or quartz radiators?, *Kunststoffe German Plastics* **82**(11), 3 (1993).

128Q. A. Fuchs, D. R. Lewin and S. J. Wajc, Modelling, simulation and control of a crude oil preheating furnace, *Chem. Engng Sci.* **48**(4), 661 (1993).

129Q. S. L. Garrett, J. A. Adeff and T. J. Hofler, Thermoacoustic refrigerator for space applications, *J. Thermophys. Heat Transfer* **7**(4), 595 (1993).

130Q. A. Jadrijevic, Determination of cement content in a concrete mix by heat flow measurement, *ACI Mater. J.* **90**(2), 111 (1993).

131Q. K. Kaygusuz and T. Ayhan, Exergy analysis of solar-assisted heat-pump systems for domestic heating, *Energy* **18**(10), 1077 (1993).

132Q. S. Hoda Khan and S. M. Zubair, Thermodynamic analyses of the CFC-12 and HFC-123a refrigeration cycles, *Energy* **18**(7), 717 (1993).

133Q. A. R. King, M. Kronfalt and R. F. Clements, Stratified air conditioning of large spaces with high heat loads, *Aust. Refrig. Air Cond. Heat* **47**(2), 24 (1993).

134Q. A. A. Kornhauser and J. L. Smith, Jr, Effects of heat transfer on gas spring performance, *J. Energy Resour. Technol. Trans. ASME* **60**(3), 721 (1993).

135Q. J. P. Meyer and G. P. Greyvenstein, The influence of height above sea level on the COP of air-source heat pumps used for water heating, *Heat Transfer Engng* **14**(2), 44 (1993).

136Q. G. Philippou and D. Luss, Temperatures patterns on a catalytic ribbon heated by a constant voltage, *Chem. Engng Sci.* **48**(12), 2313 (1993).

137Q. G. Philippou, M. Somani and D. Luss, Traveling temperature fronts on catalytic ribbons, *Chem. Engng Sci.* **48**(12), 2325 (1993).

138Q. F. Sarvar, P. A. Wittig and N. J. Poole, Convection heat transfer from a hybrid circuit, *J. Electron. Mater.* **22**(7), 751 (1993).

139Q. F. Trenc and R. Pavletic, Combined air–oil cooling on a supercharged TC&IC TAM diesel engine, *J. Engng Gas Turbines Power Trans. ASME* **115**(4), 742 (1993).

HEAT TRANSFER APPLICATIONS—GENERAL

Aerospace

1S. K. M. Al-Khalil, T. G. Keith and K. J. DeWitt, New concept in runback water modeling for anti-iced aircraft surfaces, *J. Aircr.* **30**(1), 41 (1993).

2S. C. P. Desai and K. Vafai, Investigation of the temporal thermal performance of the wheel outboard of an aircraft, *J. Thermophys. Heat Transfer* **7**(2), 377 (1993).

3S. S. V. Garimella, K. A. Shollenberger, P. A. Eibeck and S. White, Flow and heat transfer in simulated re-entry vehicle tile gaps, *J. Thermophys. Heat Transfer* **7**(4), 644 (1993).

4S. V. N. Golubkin, Hypersonic gas flow around a wing with heat input, *High Temp.* **31**(2), 294 (1993).

5S. R. K. Jain and D. J. Flood, Monolithic and mechanical multijunction space solar cells, *J. Sol. Energy Eng. Trans. ASME* **115**(2), 106 (1993).

6S. A. Karl and C. Weiland, Interaction of rocket plumes with the outer hypersonic flowfield during the re-entry maneuver, *J. Spacecr. Rockets* **30**(6), 769 (1993).

7S. T. M. Liou, L. Chen and Y. Y. Wu, Effects of momentum ratio on turbulent nonreacting and reacting flows in a ducted rocket combustor, *Int. J. Heat Mass Transfer* **36**(10), 2589 (1993).
8S. M. Tauber, M. Chargin, W. Henline, A. Chiu, L. Yang, K. R. Hamm Jr and H. Miura, Aerobrake design studies for manned mars missions, *J. Spacecr. Rockets* **30**(6), 656 (1993).
9S. Jinqi Yin, Xinping Wu, Guangshou Su, Baoqing Zhang and Kexiu Wang, Experimental study on liquid quench of solid rocket motor, *J. Propul. Power* **9**(5), 719 (1993).

Bioengineering
10S. J. M. Mwangi, S. S. H. Rizvi and A. K. Datta, Heat transfer to particles in shear flow: application in aseptic processing, *J. Food Engng* **19**(1), 55 (1993).
11S. H. S. Tharp and W. Zhang, Analytical study of temperature oscillations in living tissues, *IEEE Trans. Biomed. Engng* **40**(1), 108 (1993).
12S. Y. L. Wu, S. Weinbaum and L. M. Jiji, A new analytic technique for 3D heat transfer from a cylinder with two or more axially interacting eccentrically embedded vessels with application to countercurrent blood flow, *Int. J. Heat Mass Transfer* **36**(4), 1073 (1993).
13S. S. Erbay, H. A. Erbay, N. Djilali and S. Dost, Investigation of solutal convection during the dissolution of silicon in a sandwich system, *Int. J. Heat Mass Transfer* **36**(12), 3017 (1993).

Digital data processing, electronics
14S. C. P. Grigoropoulos, H. K. Park and X. Xu, Modeling of pulsed laser irradiation of thin silicon layers, *Int. J. Heat Mass Transfer* **36**(4), 919 (1993).
15S. C. P. Grigoropoulos, A. A. Rostami, X. Xu, S. L. Taylor and H. K. Park, Transient reflectivity measurements and heat transfer modeling in laser annealing of semiconductor films, *Int. J. Heat Mass Transfer* **36**(5), 1219 (1993).
16S. S. H. Kang and R. Greif, Thermophoretic transport in the outside vapor deposition process, *Int. J. Heat Mass Transfer* **36**(4), 1007 (1993).
17S. S. Mereu, E. Sciubba and A. Bejan, The optimal cooling of a stack of heat generating boards with fixed pressure drop, flowrate or pumping power, *Int. J. Heat Mass Transfer* **36**(15), 3677 (1993).
18S. G. P. Peterson, A. B. Duncan and M. H. Weichold, Experimental investigation of micro heat pipes fabricated in silicon wafers, *J. Heat Transfer* **115**(3), 751 (1993).
19S. P. E. Phelan, O. Nakabeppu, K. Ito, K. Hijikata, T. Ohmori and K. Torikoshi, Heat transfer and thermoelectric voltage at metallic point contacts, *J. Heat Transfer* **115**(3), 757 (1993).
20S. M. S. Polentini, S. Ramadyani and F. P. Incropera, Single-phase thermosyphon cooling of an array of discrete heat sources in a rectangular cavity, *Int. J. Heat Mass Transfer* **36**(16), 3983 (1993).
21S. W. C. Tam, C. W. Leung and S. D. Probert, Forced convective air-cooling of simulated printed-circuit boards, *Appl. Energy* **46**(3), 197 (1993).
22S. H. Y. Wang and J. B. Saulnier, A sensitivity study of material properties for coupled convective–conductive heat transfer generated in an electronic equipment, *Int. J. Heat Mass Transfer* **36**(15), 3831 (1993).
23S. D. E. Wroblewski and Y. Joshi, Computations of liquid immersion cooling for a protruding heat source in a cubical enclosure, *Int. J. Heat Mass Transfer* **36**(5), 1201 (1993).

Energy
24S. A. Bejan, How to distribute a finite amount of insulation on a wall with nonuniform temperature, *Int. J. Heat Mass Transfer* **36**(1), 49 (1993).
25S. C. Bellecci and M. Conti, Transient behaviour analysis of a latent heat thermal storage module, *Int. J. Heat Mass Transfer* **36**(15), 3851 (1993).
26S. M. A. Bernier and B. R. Baliga, Effects of heat losses (or gain) from insulated portions of closed-loop thermosyphons with vertical heat transfer sections, *J. Heat Transfer Trans. ASME* **115**(2), 480 (1993).
27S. A. Brown, B. A. Jubran and B. W. Martin, Coolant optimization of a gas turbine engine, *Proc. Inst. Mech. Engrs Part A* **207**(1), 31 (1993).
28S. Yufei Chen and J. W. Evans, Heat transfer phenomena in lithium–polymer-electrolyte batteries for electric vehicle application, *J. Electrochem. Soc.* **140**(7), 1833 (1993).
29S. R. E. Collins, C. A. Davis, C. J. Dey, S. J. Robinson, J.-Z. Tang and G. M. Turner, Measurement of local heat flow in flat evacuated glazing, *Int. J. Heat Mass Transfer* **36**(10), 2553 (1993).
30S. M. A. Cotter and M. E. Charles, Transient cooling of petroleum by natural convection in cylindrical storage tanks—II. Effect of heat transfer coefficient, aspect ratio and temperature-dependent viscosity, *Int. J. Heat Mass Transfer* **36**(8), 2175 (1993).
31S. M. A. Daughterty, R. Maekawa and S. W. Van Sciver, Characterization of flow in sub-scale cable-in-conduit conductors, *IEEE Trans. Appl. Supercond.* **3**(1), 500 (1993).
32S. J. D. Denton, The 1993 IGTI Scholar Lecture: loss mechanisms in turbomachines, *J. Turbomach.* **115**(4), 621 (1993).
33S. T. Doi and T. Tanaka, Transient heat loss and temperature response in thermal insulation pipe—Numerical analysis and simplified analysis, *Heat Transfer Jpn Res.* **22**(3), 305 (1993).
34S. G. Evans and R. Greif, Thermally unstable convection with applications to chemical vapor deposition channel reactors, *Int. J. Heat Mass Transfer* **36**(11), 2769 (1993).
35S. M. R. Gopal and S. S. Murthy, Influence of heat and mass transfer effectiveness on metal hydride heat pump performance, *Int. J. Hydrogen Energy* **18**(1), 31 (1993).
36S. S. C. Hill and D. L. Smoot, Comprehensive three-dimensional model for simulation of combustion systems: PCGC-3, *Energy Fuels* **7**(6), 874 (1993).
37S. G. F. Jones and J. Cai, Analysis of a transient asymmetrically heated/cooled open thermosyphon, *J. Heat Transfer* **115**(3), 621 (1993).
38S. I. Kotaka, T. Shigenaka and S. Hoizumi, Improvement of the bottoming cycle and heat recovery steam generator for combined plants, *Hitachi Rev.* **42**(1), 11 (1993).
39S. G. S. H. Lock and J. Fu, Natural convection in the inclined, cranked thermosyphon, *J. Heat Transfer Trans. ASME* **115**(1), 166 (1993).
40S. G. S. H. Lock and D. Ladoon, Heat transfer characteristics on the single-phase, elbow thermosyphon, *J. Heat Transfer Trans. ASME* **115**(1), 173 (1993).
41S. G. S. H. Lock and D. Ladoon, Natural convection in the cranked thermosyphon, *Int. J. Heat Mass Transfer* **36**(1), 177 (1993).
42S. G. S. H. Lock and D. Ladoon, The influence of tilt on natural convection in the elbow thermosyphon, *Int. J. Heat Mass Transfer* **36**(1), 183 (1993).
43S. G. S. H. Lock and J. Fu, Heat transfer characteristics of a cranked, evaporative thermosyphon, *Int. J. Heat Mass Transfer* **36**(7), 1827 (1993).
44S. M. Louge, J. M. Yusof and J. T. Jenkins, Heat transfer in the pneumatic transport of massive particles, *Int. J. Heat Mass Transfer* **36**(2), 265 (1993).
45S. H. K. Ma, F. H. Lee and M. W. Wang, Numerical study on heat and mass transfer in a liquid-fueled gas turbine combustor, *Int. J. Heat Mass Transfer* **36**(13), 3271 (1993).

46S. P. W. O'Callaghan, Energy resources, CO_2 production and energy conservation, *Appl. Energy* **44**(2), 65 (1993).

47S. Se H. Oh, E. J. Bissett and P. A. Battiston, Mathematical modeling of electrically heated monolith converters: model formulation, numerical methods, and experimental verification, *Ind. Engng Chem. Res.* **32**(8), 1560 (1993).

48S. R. J. Roback and R. P. Dring, Hot streaks and phantom cooling in a turbine rotor passage—I. Separate effects, *J. Turbomach.* **115**(4), 657 (1993).

49S. R. J. Roback and R. P. Dring, Hot streaks and phantom cooling in a turbine rotor passage—II. Combined effects and analytical modeling, *J. Turbomach.* **115**(4), 667 (1993).

50S. J. A. Sabbagh, A. M. A. Khalifa and I. A. Olwi, Development of passive dry cooling system for power plants in arid land, *Sol. Energy* **51**(6), 431 (1993).

51S. H. Seko, E. Murata and T. Fujinaga, A new application of fluidized beds at the cooling medium for exothermic catalytic oxidation occurring inside a multitubular reactor, *J. Chem. Engng Jpn* **26**(4), 451 (1993).

52S. M. Shimizu, Heat transfer performance in boiler furnace by dimensionless numbers, *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1344 (1993).

53S. K. Sikorski, Kwan-Liu Ma, P. J. Smith and B. R. Adams, Distributed combustion simulations, *Energy Fuels* **7**(6), 902 (1993).

54S. R. J. Simoneau and F. F. Simon, Progress towards understanding and predicting heat transfer in the turbine gas path, *Int. J. Heat Fluid Flow* **14**(2), 106 (1993).

55S. A. K. Stubos and J.-M. Buchlin, Analysis and numerical simulation of the thermo-hydraulic behaviour of a heat dissipating debris bed during power transients, *Int. J. Heat Mass Transfer* **36**(5), 1391 (1993).

56S. S. Sun and W. K. Lu, Mathematical modelling of reactions in iron ore–coal composites, *ISIJ Int.* **33**(10), 1062 (1993).

57S. K. D. Vertin, R. Keribar and G. Venkatesh, Accelerated piston tests in natural gas engines, *Automot. Engng* (Warrendale PA) **101**(7), 33 (1993).

58S. P. B. West, Empirical evaluation of diving wet suit material heat transfer and thermal conductivity, *Heat Transfer Engng* **14**(4), 74 (1993).

59S. Chih Wu, Heat transfer effect on the specific power availability of heat engines, *Energy Convers. Manage.* **34**(12), 1239 (1993).

60S. J. Zhao and C. P. Tso, Heat transfer by water flow in rock fractures and the application to hot dry rock geothermal systems, *Int. J. Rock Mech. Min. Sci. Geomech. Abstr.* **30**(5), 633 (1993).

Environment

61S. H. Al-Hinai, W. J. Batty and S. D. Probert, Vernacular architecture of Oman: features that enhance thermal comfort achieved within buildings, *Appl. Energy* **44**(3), 233 (1993).

62S. B. R. Anderson, Effect of edge insulation on the steady-state heat loss through a slab-on-ground floor, *Build. Envir.* **28**(3), 361 (1993).

63S. O. Badr and S. D. Probert, Environmental impacts of atmospheric nitrous oxide, *Appl. Energy* **44**(3), 197 (1993).

64S. A. Bhattacharya, Simulating minerals pyroprocessing by thermal analysis. Clinkerisation of cement raw mixes, *J. Therm. Anal.* **40**(1), 141 (1993).

65S. Y. Candau and G. Piar, An application of spectral decomposition to model validation in the thermal analysis of buildings, *Int. J. Heat Mass Transfer* **36**(3), 645 (1993).

66S. R. Caps, M. C. Arduini-Schuster, H.-P. Ebert and J. Fricke, Improved thermal radiation extinction in metal coated polypropylen microfibers, *Int. J. Heat Mass Transfer* **36**(11), 2789 (1993).

67S. J. A. Clarke, Assessing building performances by simulation, *Build. Envir.* **28**(4), 419 (1993).

68S. N. Almao de Herrera and J. Rincon, Alternative designs for passive cooling of homes for Venezuela, *J. Sol. Energy Engng Trans. ASME* **115**(3), 161 (1993).

69S. A. E. Delsante, Effect of water table depth on steady-state heat transfer through a slab-on-ground floor, *Build. Envir.* **28**(3), 369 (1993).

70S. D. E. Farrow and J. C. Patterson, On the stability of the near shore waters of a lake when subject to solar heating, *Int. J. Heat Mass Transfer* **36**(1), 89 (1993).

71S. F. E. Fendell and E. Y. Kung, Pyrolysis of vegetation by brief intense irradiation, *J. Thermophys. Heat Transfer* **7**(3), 510 (1993).

72S. D. W. Hawes, D. Feldman and D. Banu, Latent heat storage in building materials, *Energy Build.* **20**(1), 77 (1993).

73S. N. A. Hoffmann and E. R. Galea, An Extension of the fire-field modelling technique to include fire-sprinkler interaction—I. The mathematical basis, *Int. J. Heat Mass Transfer* **36**(6), 1435 (1993).

74S. N. A. Hoffmann and E. R. Galea, An extension of the fire-field modelling technique to include fire-sprinkler interaction—II. The simulations, *Int. J. Heat Mass Transfer* **36**(6), 1445 (1993).

75S. S.-S. Hou, C.-C. Liu and T.-H. Lin, The influence of external heat transfer on flame extinction of dilute sprays, *Int. J. Heat Mass Transfer* **36**(7), 1867 (1993).

76S. M. Krarti, Steady-state heat transfer from partially insulated basements, *Energy Build.* **20**(1), 1 (1993).

77S. F. C. Lai, Improving effectiveness of pipe insulation by using radial baffles to suppress natural convection, *Int. J. Heat Mass Transfer* **36**(4), 899 (1993).

78S. E. Malek, Rapid changes of the surface soil heat flux and its effects on the estimation of evapotranspiration, *J. Hydrol.* **142**(14), 89 (1993).

79S. E. H. Mathews and P. G. Richards, Efficient tool for future building design, *Build. Envir.* **28**(4), 409 (1993).

80S. K. Muralidhar, Near-field solution for heat and mass transfer from buried nuclear waste canisters, *Int. J. Heat Mass Transfer* **36**(10), 2665 (1993).

81S. D. Parker, P. Fairney and Lixing Gu, Simulation of the effects of duct leakage and heat transfer on residential space-cooling energy use, *Energy Build.* **20**(2), 97 (1993).

82S. M. S. Phanikumar and A. N. Bhaskarwar, On the enhancement in heat transfer through the use of slurries, *Int. J. Heat Mass Transfer* **36**(3), 735 (1993).

83S. I. K. Puri, Prediction of the pulsation frequency of flames formed over a semi-infinite horizontal surface, *Int. J. Heat Mass Transfer* **36**(10), 2657 (1993).

84S. K. R. Shah and A. Ghani Razaqpur, Two-dimensional frost-heave model for buried pipelines, *Int. J. Numer. Methods Engng* **36**(15), 2545 (1993).

85S. D. V. Tomecek and J. A. Milke, Study of the effect of partial loss of protection on the fire resistance of steel columns, *Fire Technol.* **29**(1), 3 (1993).

86S. H. Xue, E. Hihara and T. Saito, Turbulence model of fire-induced air flow in a ventilated tunnel, *Int. J. Heat Mass Transfer* **36**(7), 1739 (1993).

87S. H. Yoshino, S. Matsumoto, M. Nagatomo and T. Sakanishi, Five-year measurements of thermal performance for a semi-underground test house, *Tunnelling Underground Space Technol.* **7**(4), 339 (1993).

88S. V. G. Zverev, G. N. Isakov, V. V. Nesmelov and V. A. Nazarenko, Heat transfer mechanism and fire insulation properties of some intumescent materials, *Int. J. Polym. Mater.* **20**(1), 91 (1993).

Manufacturing

89S. S. Y. Bang, S. Roy and M. F. Modest, CW laser machining of hard ceramics—II. Effects of multiple reflections, *Int. J. Heat Mass Transfer* **36**(14), 3529 (1993).

90S. M. R. Barone and E. Kock, Method for analysing the effect of flow on heat transfer in die casting, *Int. J. Numer. Methods Heat Fluid Flow* **3**(5), 457 (1993).

91S. Yiu Wing Chan, Computer simulation of heat flow in pulsed current arc welding, *J. Mater. Process. Technol.* **38**(12), 449 (1993).

92S. Y. Chen and I. C. Sheng, On the solid–fluid transition zone in welding analysis, *J. Engng Mater. Technol. Trans. ASME* **115**(1), 17 (1993).

93S. H. H. Chiang, K. Himasekhar, N. Santhanam and K. K. Wang, Integrated simulation of fluid flow and heat transfer in injection molding for the prediction of shrinkage and warpage, *J. Eng. Mater. Techol. Trans. ASME* **115**(1), 37 (1993).

94S. J. G. Conybear, High-pressure gas quenching, *Adv. Mater. Process.* **143**(2), 20 (1993).

95S. R. Ducharme, P. Kapadia, F. Scarfe and J. Dowden, A mathematical model of glass flow and heat transfer in a platinum downspout, *Int. J. Heat Mass Transfer* **36**(7), 1789 (1993).

96S. M. Gremaud, S. Katayama, A. Zryd and A. Matsunawa, Influence of crystallographic and heat flow orientations on growth of cellular dendrites, *ISIJ Int.* **33**(9), 941 (1993).

97S. H. Huang, V. K. Suri, J. L. Hill and J. T. Berry, Issues in thermal contact and phase change in porosity prediction, *J. Engng Mater. Technol. Trans. ASME* **115**(1), 2 (1993).

98S. M. Irie, M. Kato and T. Kitamura, Thermal transfer color printing using laser heating, *J. Imaging Sci. Technol.* **37**(3), 235 (1993).

99S. K. Kaino, Similarity curve in the solidification process of latent heat energy storage unit with straight fins (2nd Report, Effect of heat transfer tube on the formation of the similarity rule), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(558), 571 (1993).

100S. J. Kroos, U. Gratzke, M. Vicanek and G. Simon, Dynamic behaviour of the keyhole in laser welding, *J. Phys. D* **26**(3), 481 (1993).

101S. R. K. Mallik and S. P. Mehrotra, Mathematical modelling of single roll continuous steel strip caster based on fluid flow and heat transfer considerations, *ISIJ Int.* **33**(5), 595 (1993).

102S. A. Mo, Mathematical modelling of surface segregation in aluminum DC casting caused by exudation, *Int. J. Heat Mass Transfer* **36**(18), 4335 (1993).

103S. M. M. Ohadi and K. L. Cheng, Modeling of temperature distributions in the workplace during abrasive waterjet machining, *J. Heat Transfer Trans. ASME* **115**(2), 446 (1993).

104S. J. R. Popov and I. H. Katzarov, Formation of castings with complex geometry. thermo-mechanical effects, growth and influence of the air gap, *Int. J. Heat Mass Transfer* **36**(11), 2861 (1993).

105S. V. K. Pustovalov and D. S. Bobuchenko, Thermal processes in gas–powder laser cladding of metal materials, *Int. J. Heat Mass Transfer* **36**(9), 2449 (1993).

106S. S. Roy and M. F. Modest, CW laser machining of hard ceramics—I. Effects of three-dimensional conduction, variable properties and various laser parameters, *Int. J. Heat Mass Transfer* **36**(14), 3515 (1993).

107S. S. Shamasundar, A. A. Tseng, W. Aung and S. K. Biswas, Numerical and experimental study of the thermal behavior of coining and upsetting processes, *J. Mater. Process. Technol.* **36**(2), 199 (1993).

108S. W. Shyy, Y. Pang, G. B. Hunter, D. Y. Wei and M.-H. Chen, Effect of turbulent heat transfer on continuous ingot solidification, *J. Engng Mater. Technol. Trans. ASME* **115**(1), 8 (1993).

109S. A. Sluzalec and A. Sluzalec, Solutions of thermal problems in friction welding—Comparative study, *Int. J. Heat Mass Transfer* **36**(6), 1583 (1993).

110S. S. Sundarraj and V. R. Voller, The binary alloy problem in an expanding domain: the microsegregation problem, *Int. J. Heat Mass Transfer* **36**(3), 713 (1993).

111S. A. Unal and M.-C. Chyu, Study of quenching and recovery for superconductor wires and cylinders, *IEEE Trans. Appl. Supercond.* 3(1), 305 (1993).

112S. A. S. Usamani, J. T. Cross and R. W. Lewis, Analysis of mould filling in castings using the finite element method, *J. Mater. Process. Technol.* **38**(12), 291 (1993).

113S. P. S. Wei and M. D. Shian, Three-dimensional analytical temperature field around the welding cavity produced by moving distributed high-intensity beam, *J. Heat Transfer Trans. ASME* **115**(4), 848 (1993).

114S. M. A. Wilkinson and J. W. Tester, Computational modeling of the gas-phase transport phenomena during flame-jet thermal spallation drilling, *Int. J. Heat Mass Transfer* **36**(14), 3459 (1993).

115S. A. Yamauchi, K. Sorimachi, T. Sakuraya and T. Fujii, Heat transfer between mold and strand through mold flux film in continuous casting of steel, *ISIJ Int.* **33**(1), 140 (1993).

Processing

116S. Simultaneous microwave heat and mass transfer characteristics of porous hygroscopic solids, *J. Microwave Power Electromagn. Energy* **28**(1), 41 (1993).

117S. S. Ait. Amer, S. Magnaudeix and P. Duverneiul, On the behavior of rapid thermal CVD reactors, *J. Phys.* (Paris) **3**(3), 35 (1993).

118S. P. M. Armenante and Yuan Shen Li, Complete design analysis of a continuous sterilizer for fermentation media containing suspended solids, *Biotechnol. Bioengng* **41**(9), 900 (1993).

119S. G. B. Awuah, H. S. Ramaswamy and B. K. Simpson, Surface heat transfer coefficients associated with heating of food particles in CMC solutions, *J. Food Process Engng* **16**(1), 39 (1993).

120S. C. Butcher, All steamed up, *Chem. Engng* (London) **539**, 16 (1993).

121S. S. Cenkowski, D. S. Jayas and S. Pabis, Deep-bed grain drying. A review of particular theories, *Drying Technol.* **11**(7), 1553 (1993).

122S. F. Chen and A. J. Pearlstein, Hot spot locations and temperature distributions in a forced convection photochemical reactor, *Int. J. Heat Mass Transfer* **36**(8), 2105 (1993).

123S. B. Cousin, J. C. Bénet and R. Auria, Experimental study of the drying of a thick-layer of natural crumb rubber, *Drying Technol.* **11**(6), 1401 (1993).

124S. D. A. Cummings, J. B. Litchfield and M. R. Okos, Stress and failure prediction for the drying, tempering and cooling of extruded durum semolina, *Drying Technol.* **11**(7), 1809 (1993).

125S. I. Dincer, C. Varlik and H. Gun, Heat transfer rate variations in a canned food during sterilization, *Int. Commun. Heat Mass Transfer* **20**(2), 301 (1993).

126S. D. C. Elliot, E. G. Baker, R. S. Butner and L. J. Sealock, Jr, Bench-scale reactor tests of low temperature, catalytic gasification of wet industrial wastes, *J. Sol. Energy Engng Trans. ASME* **115**(1), 52 (1993).

127S. M. Erhun and S. G. Advani, Heat transfer effects during solidification of semicrystalline polymers, *J. Engng Mater. Technol. Trans. ASME* **115**(1), 30 (1993).

128S. K. Genthner, A. Gregorzewski and A. Seifert, Effects and limitations issued by non-condensible gases in sea water distillers, *Desalination* **93**(13), 207 (1993).

129S. G. S. Gouvalias and N. C. Markatos, Mathematical modeling of heat and mass transfer in packed-bed

adsorbers–regenerators, *A. I. Ch. E. Jl* **39,** 1799 (1993).
130S. T. R. Gupta, Thermal conductivity of Indian unleavened flat bread (chapati) at various stages of baking, *J. Food Process Engng* **16**(3), 227 (1993).
131S. S. Haam, R. S. Brodkey and J. B. Fasano, Local heat transfer in a mixing vessel using a high-efficiency impeller, *Ind. Engng Chem. Res.* **32**(3), 575 (1993).
132S. H. M. Hassan and C. J. Mumford, Mechanisms of drying of skin-forming materials—II. Droplets of heat sensitive materials, *Drying Technol.* **11**(7), 1751 (1993).
133S. H. M. Hassan and C. J. Mumford, Mechanisms of drying of skin-forming materials—III. Droplets of natural products, *Drying Technol.* **11**(7), 1765 (1993).
134S. R. H. Hurt, T. H. Fletcher and R. S. Sampaio, Heat transfer from a molten phase to an immersed coal particle during devolatilization, *J. Heat Transfer* **115**(3), 717 (1993).
135S. Y. Imoto, T. Kasakura and M. Hasatani, The state of the art of sludge drying in Japan, *Drying Technol.* **11**(7), 1495 (1993).
136S. X. Jia, S. Clements and P. Jolly, Study of heat pump assisted microwave drying, *Drying Technol.* **11**(7), 1583 (1993).
137S. M. Kassemi, S. A. Gokoglu, C. H. Panzarella and L. C. Veitch, A combined heat-transfer analysis of a single-fiber CVD reactor, *A. I. Ch. E. Jl* **39,** 1687 (1993).
138S. A. Khalil, Dehumidification of atmospheric air as a potential source of fresh water in the UAE, *Desalination* **93**(13), 587 (1993).
139S. C. Kiparissides, G. Verros, G. Kalfas, M. Koutoudi and C. Kantzia, Comprehensive mathematical model for a multizone tubular high pressure LDPE reactor, *Chem. Engng Commun.* **121,** 193 (1993).
140S. W. I. Kordonsky, S. P. Gorodkin and S. A. Demchuk, Magnetorheological control of heat transfer, *Int. J. Heat Mass Transfer* **36**(11), 2783 (1993).
141S. A. F. Mikkelsen and S. C. Conen, New heat transfer fluid improves performance in anode paste plant, *CIM Bull.* **86**(966), 98 (1993).
142S. O. J. Morin, Design and operating comparison of MSF and MED systems, *Desalination* **93**(13), 69 (1993).
143S. K. V. Narasimha Rao, G. S. V. L. Narasimham and M. V. Krishna Murthy, Parametric study on the bulk hydraircooling of spherical food products, *A. I. Ch. E. Jl* **39,** 1870 (1993).
144S. N. K. Sharma and C. P. Arora, Prediction of transient temperature distribution during freeze drying of yoghurt, *Drying Technol.* **11**(7), 1863 (1993).
145S. C. H. Tong and D. B. Lund, Microwave heating of baked dough products with simulatneous heat and moisture transfer, *J. Food Engng* **19**(4), 319 (1993).
146S. G. Trystram, D. Fahloul, A. Duquenoy and M. Allache, Dynamic modelling and simulation of the biscuit baking oven process, *Comput. Chem. Engng* **17,** 203 (1993).
147S. F. Y. Wang, I. T. Cameron, J. D. Litster and P. L. Douglas, A distributed parameter approach to the dynamics of rotary drying processes, *Drying Technol.* **11**(7), 1641 (1993).
148S. B. Wilhelmsson, L. Nilsson, S. Stenström and R. Wimmerstedt, Simulation models of multi-cylinder paper drying, *Drying Technol.* **11**(6), 1177 (1993).
149S. B. Zanoni, C. Peri and S. Pierucci, Study of the bread-baking process—I. A phenomenological model, *J. Food Engng* **19**(4), 389 (1993).
150S. C. A. Zaror, D. L. Pyle and G. Molnar, Mathematical modelling of an ohmic heating steriliser, *J. Food Engng* **19**(1), 33 (1993).
151S. Hui Zhang, M. Karim Moallemi and S. Kumar, Thermal analysis of the hot dip-coating process, *J. Heat Transfer Trans. ASME* **115**(2), 453 (1993).

SOLAR ENERGY

Buildings and enclosed spaces

1T. K. A. Antonopoulos and S. P. Valsamakis, Effects of indoor and outdoor heat-transfer coefficients and solar absorptance on heat flow through walls, *Energy* **18**(3), 259 (1993).
2T. N. K. Bansal, R. Mathur and M. S. Bhandari, Solar chimney for enhanced stack ventilation, *Build. Envir.* **28**(3), 373 (1993).
3T. M. Bomberg and W. Brown, Building envelope: heat, air and moisture interactions, *J. Therm. Insul. Build. Envelopes* **16,** 306 (1993).
4T. M. Bomberg and W. Brown, Building envelope and environmental control: issues of systems integration, *J. Therm. Insul. Build. Envelopes* **17,** 5 (1993).
5T. Wongee Chun, Myung Seok Jeon and Hyung Taek Kim, Energy monitoring of a thermally massive passive solar residence by the PSTAR approach, *J. Sol. Energy Engng Trans. ASME* **115**(3), 155 (1993).
6T. C. A. Estrada-Gasca, G. Alvarez-Garcia and P. K. Nair, Theoretical analysis of the thermal performance of chemically deposited solar control, *J. Phys. D* **26**(8), 1304 (1993).
7T. C. A. Estrada-Gasca, G. Alvarez-Garcia and P. K. Nair, Thermal performance of an architectural window with chemically deposited SnS–Cu–xS solar control coating, *Renewable Energy* 3(67), 683 (1993).
8T. Xiande Fang, Improvement of numerical simulation of lattice wall passive solar heating buildings, *Taiyangneng Xuebao* **14**(2), 143 (1993).
9T. B. Givoni, Semiempirical model of a building with a passive evaporative cool tower, *Sol. Energy* **50**(5), 425 (1993).
10T. K. I. Jensen, Passive solar component based on evacuated monolithic silica aerogel, *J. Non Cryst. Solids* **145**(13), 237 (1993).
11T. R. Kraus, E. R. F. Winter and W. Ibele, Investigation of the energy flows for transparent and non-transparent building facade, *Sol. Energy* **51**(6), 481 (1993).
12T. B. M. Nebeker and T. W. Tong, Evaluation of various methods used to predict heat transfer across rectangular reflective insulation systems, *J. Therm. Insul. Build. Envelopes* **17,** 34 (1993).
13T. W. Smolec and A. Thomas, Theoretical and experimental investigations of heat transfer in a trombe wall, *Energy Convers. Manage.* **34**(5), 385 (1993).
14T. G. N. Tiwari, M. Upadhyay and S. N. Rai, Thermal control of a passive solar apartment under active mode of operation, *Energy Convers. Manage.* **34**(1), 51 (1993).
15T. A. B. Vardiyashvili, V. D. Kim and T. A. Fajziev, Heat conditions of a tray with a substrate and a heat-accumulating channel in a solar greenhouse, *Geliotekhnika* (1), 35 (1993).
16T. N. E. Wijeyusundera, S. K. Chou and S. E. G. Jayamaha, Heat flow through walls under transient rain conditions, *J. Therm. Insul. Build. Envelopes* **17,** 118 (1993).
17T. M. F. Zedan and A. M. Mujahid, Efficient solution for heat transfer in composite walls with periodic ambient temperature and solar radiation, *Int. J. Ambient Energy* **14**(2), 83 (1993).

Collectors

18T. A. A. Badran and Y. S. H. Najjar, Inverted trickle flat plate solar collector, *Int. J. Solar Energy* **14**(1), 33 (1993).

19T. V. Balasubramanian and G. Sankarasubramanian, Stretched tape design of fixed mirror solar concentrator with curved mirror elements, *Sol. Energy* **51**(2), 109 (1993).

20T. A. Carotenuto, F. Reale, G. Ruocco, U. Nocera and F. Bonomo, Thermal behaviour of a multi-cavity volumetric solar receiver: design and tests results, *Sol. Energy* **50**(2), 113 (1993).

21T. P. A. Davies, Sun-tracking mechanism using equatorial and ecliptic axes, *Sol. Energy* **50**(6), 487 (1993).

22T. P. C. Eames and B. Norton, Validated, unified model for optics and heat transfer in line-axis concentrating solar energy collectors, *Sol. Energy* **50**(4), 339 (1993).

23T. M. A. El-Nasr and S. M. El-Haggar, Performance of a wickless heat pipe solar collector, *Energy Sources* **15**(3), 513 (1993).

24T. R. P. Friedman, J. M. Gordon and H. Ries, New high-flux two-stage optical designs for parabolic solar concentrators, *Sol. Energy* **51**(5), 317 (1993).

25T. J. D. Garrison, Effect of pressure-induced stress on the design of shaped-glass evacuated solar collectors, *Sol. Energy* **50**(6), 527 (1993).

26T. R. E. Hogan, Jr, Numerical modeling of reflux solar receivers, *J. Sol. Energy Engng Trans. ASME* **115**(2), 93 (1993).

27T. B. A. Jubran and M. A. Al-Saad, Prediction of solar irradiance on concentrating collectors under Jordanian climatic conditions, *Energy Convers. Manage.* **34**(2), 111 (1993).

28T. T. W. Kerslake and R. D. Quinn, Solar dynamic modules for space station freedom: the relationship between fine-pointing control and thermal loading of the aperture plate—II. Results, *J. Sol. Energy Engng Trans. ASME* **115**(4), 195 (1993).

29T. C. F. Kutscher, C. B. Christensen and G. M. Barker, Unglazed transpired solar collectors: heat loss theory, *J. Sol. Energy Engng Trans. ASME* **115**(3), 182 (1993).

30T. M. Mbaye and E. Bilgen, Conduction and convection heat transfer in composite solar collector systems with porous absorber, *Wärme Stoffübertrag.* **28**(5), 267 (1993).

31T. A. Meaburn and F. M. Hughes, Resonance characteristics of distributed solar collector fields, *Sol. Energy* **51**(3), 215 (1993).

32T. S. O. Onyegegbu and J. Morhenne, Transient multidimensional second-law analysis of solar collectors subjected to time-varying insolation with diffuse components, *Sol. Energy* **50**(1), 85 (1993).

33T. B. Perers, Dynamic method for solar collector array testing and evaluation with standard database and simulation programs, *Sol. Energy* **50**(6), 517 (1993).

34T. B. Perers and B. Karlsson, External reflectors for large solar collector arrays, simulation model and experimental results, *Sol. Energy* **51**(5), 327 (1993).

35T. R. D. Quinn and T. W. Kerslake, Solar dynamic modules for space station freedom: the relationship between fine-pointing control and thermal loading of the aperture plate—I. Analysis, *J. Sol. Energy Engng Trans. ASME* **115**(4), 189 (1993).

36T. S. A. M. Said and S. M. Zubair, On second-law efficiency of solar collectors, *J. Sol. Energy Engng Trans. ASME* **115**(1), 2 (1993).

37T. F. Sakkal, N. Ghaddar and J. Diab, Solar collectors for the Beirut climate, *Appl. Energy* **45**(4), 313 (1993).

38T. P. Singh and J. A. Liburdy, A solar concentrator design for uniform flux on a flat receiver, *Energy Convers. Manage.* **34**(7), 533 (1993).

39T. S. Svendsen, Solar collector with monolithic silica aerogel, *J. Non Cryst. Solids* **145**(13), 240 (1993).

40T. A. Thomas and H. M. Guven, Parabolic trough concentrators—Design, construction and evaluation, *Energy Convers. Manage.* **34**(5), 401 (1993).

41T. W. M. K. van Niekerk and T. B. Scheffler, Measured performance of a solar water heater with a parallel tube polymer absorber, *Sol. Energy* **51**(5), 339 (1993).

42T. N. Yehezkel, J. Appelbaum, A. Yogev and M. Oron, Losses in a three-dimensional compound parabolic concentrator as a second stage of a solar concentrator, *Sol. Energy* **51**(1), 45 (1993).

Radiation characteristics and related effects

43T. F. O. Akuffo and A. Brew-Hammond, The frequency distribution of daily global irradiation at kumasi, *Sol. Energy* **50**(2), 145 (1993).

44T. S. D. Alaruri and M. F. Amer, Empirical regression models for weather data measured in Kuwait during the years 1985, 1986 and 1987, *Sol. Energy* **50**(3), 229 (1993).

45T. J. Appelbaum, G. A. Landis and I. Sherman, Solar radiation on Mars—Update 1991, *Sol. Energy* **50,** 35 (1993).

46T. B. S. Attili and Y. A. G. Abdalla, Numerical models for the correlation of global solar radiation with meteorological data for Bahrain, *Energy Convers. Manage.* **34**(1), 1 (1993).

47T. C. Balaras, I. Tselepidaki, M. Santamouris and D. Asimakopoulos, Calculations and statistical analysis of the environmental cooling power for Athens, Greece, *Energy Convers. Manage.* **34**(2), 139 (1993).

48T. J. A. Ballinger, T. L. di Franco and D. K. Prasad, Bonnyrigg solar village: an analysis of annual energy use and comfort, *Sol. Energy* **50**(6), 499 (1993).

49T. A. P. Brunger and F. C. Hooper, Anisotropic sky radiance model based on narrow field of view measurements of shortwave radiance, *Sol. Energy* **51**(1), 53 (1993).

50T. A. de La Casiniere, J. C. Grenier, T. Cabot and M. Werneck-Faga, Altitude effect on the clearness index in the French Alps, *Sol. Energy* **51**(2), 93 (1993).

51T. D. Goossens, Z. Y. Offer and A. Zangvil, Wind tunnel experiments and field investigations of Eolian dust deposition on photovoltaic solar collectors, *Sol. Energy* **50**(1), 75 (1993).

52T. K. K. Gopinathan and A. Soler, Sky irradiation mapping, *Energy Convers. Manage.* **34**(3), 159 (1993).

53T. C. Gueymard, Mathematically integrable parameterization of clear-sky beam and global irradiances and its use in daily irradiation applications, *Sol. Energy* **50**(5), 385 (1993).

54T. C. Gueymard, Critical analysis and performance assessment of clear sky solar irradiance models using theoretical and measured data, *Sol. Energy* **51**(2), 121 (1993).

55T. C. Gueymard, Analysis of monthly average solar radiation and bright sunshine for different thresholds at Cape Canaveral, Florida, *Sol. Energy* **51**(2), 139 (1993).

56T. N. Halouani, C. T. Nguyen and D. Vo-Ngoc, Calculation of monthly average global solar radiation on horizontal surfaces using daily hours of bright sunshine, *Sol. Energy* **50**(3), 247 (1993).

57T. M. A. Hamdan and N. Gazzawi, The effect of clouds on solar radiation, *Energy Convers. Manage.* **34**(1), 29 (1993).

58T. H. D. Kambezidis and A. E. Tsangrassoulis, Solar position and right ascension, *Sol. Energy* **50**(5), 415 (1993).

59T. M. A. Kamel, S. A. Shalaby and S. S. Mostafa, Solar radiation over Egypt: comparison of predicted and measured meteorological data, *Sol. Energy* **50**(6), 463 (1993).

60T. R. Kittler and P. Valko, Radiance distribution on densely overcast skies: comparison with CIE luminance standard, *Sol. Energy* **51**(5), 349 (1993).

61T. A. I. Kudish and A. Ianetz, Analysis of diffuse radiation data for Beer Sheva: measured (shadow ring) vs calculated (global-horizontal beam) values, *Sol. Energy* **51**(6), 495 (1993).

62T. S. M. Nasir and S. M. Raza, Wind and solar energy in Pakistan, *Energy* **18**(4), 397 (1993).

63T. M. Noia, C. F. Ratto and R. Festa, Solar irradiance estimation from geostationary satellite data—I. Statistical models, *Sol. Energy* **51**(6), 449 (1993).

64T. M. Noia, C. F. Ratto and R. Festa, Solar irradiance estimation from geostationary satellite data—II. Physical models, *Sol. Energy* **51**(6), 457 (1993).

65T. J. A. Olseth and A. Skartveit, Characteristics of hourly global irradiance modelled from cloud data, *Sol. Energy* **51**(3), 197 (1993).

66T. J. E. Parrott, Choice of an equivalent black body solar temperature, *Sol. Energy* **51**(3), 195 (1993).

67T. R. Perez, R. Seals and J. Michalsky, All-weather model for sky luminance distribution—Preliminary configuration and validation, *Sol. Energy* **50**(3), 235 (1993).

68T. R. Perez, R. Seals, J. Michalsky and P. Ineichen, Geostatistical properties and modeling of random cloud patters for real skies, *Sol. Energy* **51**(1), 7 (1993).

69T. S. K. Srivastava, O. P. Singh and G. N. Pandey, Estimation of global solar radiation in Uttar Pradesh (India) and comparison of some existing correlations, *Sol. Energy* **51**(1), 27 (1993).

70T. R. J. Stone, Improved statistical procedure for the evaluation of solar radiation estimation models, *Sol. Energy* **51**(4), 289 (1993).

71T. P. T. Tsilingiris, Low-cost, non-selective, solar-radiation detectors, *Appl. Energy* **45**(4), 283 (1993).

72T. M. Abdel Wahab, New approach to estimate Angström coefficients, *Sol. Energy* **51**(4), 241 (1993).

73T. M. A. Al-Nimr, Temperature distribution inside a solar collector storage tank of finite wall thickness, *J. Sol. Energy Engng Trans. ASME* **115**(2), 112 (1993).

Solar heating and cooling

74T. V. Belessiotis and D. Haralambopoulos, Testing solar water heating systems in Athens, Greece, *Sol. Energy* **50**(2), 167 (1993).

75T. J. C. V. Chinnappa, M. R. Crees, S. Srinivasa Murthy and K. Srinivasan, Solar-assisted vapor compression–Absorption cascaded air-conditioning systems, *Sol. Energy* **50**(5), 453 (1993).

76T. C. Choudhary, H. P. Garg and J. Prakash, Design studies of packed-bed solar air heaters, *Energy Convers. Manage.* **34**(2), 125 (1993).

77T. C. Choudhury and H. P. Garg, Performance calculations for closed-loop air-to-water solar hybrid heating systems with and without a rock bed in the solar air heater, *Renewable Energy* **3**(8), 897 (1993).

78T. J. H. Davidson, W. T. Carlson, W. S. Duff, P. J. Schaefer, W. A. Beckman and S. A. Klein, Comparison of experimental and simulated thermal ratings of drain-back solar water heaters, *J. Sol. Energy Engng Trans. ASME* **115**(2), 101 (1993).

79T. M. A. Hamdan, B. A. Jubran and S. Rimawii, Water conservation in solar domestic hot water systems, *Energy Convers. Manage.* **34**(4), 287 (1993).

80T. M. N. A. Hawlader, K. S. Novak and B. D. Wood, Unglazed collector–regenerator performance for a solar assisted open cycle absorption cooling system, *Sol. Energy* **50**(1), 59 (1993).

81T. E. M. Kleinbach, W. A. Beckman and S. A. Klein, Performance study of one-dimensional models for stratified thermal storage tanks, *Sol. Energy* **50**(2), 155 (1993).

82T. S. Kumar, G. N. Tiwari and S. Sinha, Techno-economic feasibility analysis of solar thermal systems, *Energy Convers. Manage.* **34**(12), 1267 (1993).

83T. R. S. Misra, Evaluation of thermal stratification in thermosyphonic solar water heating systems, *Energy Convers. Manage.* **34**(5), 347 (1993).

84T. R. S. Misra, Evaluation of economic and thermal performance of closed loop solar hybrid air and water heating systems for Indian climates, *Energy Convers. Manage.* **34**(5), 363 (1993).

85T. B. F. Parker, M. R. Lindley, D. G. Colliver and W. E. Murphy, Thermal performance of three solid–air heaters, *Sol. Energy* **51**(6), 467 (1993).

86T. P. V. Pedersen, Experience with a large solar DHW system in Denmark—The Nordic solar heating demonstration project, *Sol. Energy* **50**(3), 259 (1993).

87T. P. V. Pedersen, System design optimization for large building integrated solar heating systems for domestic hot water, *Sol. Energy* **50**(3), 267 (1993).

88T. D. E. Prapas, S. G. Tsiamouris, V. D. Giannaros and B. A. Sotiropoulos, Storage tanks interconnection and operation modes in large DHW solar systems, *Sol. Energy* **51**(2), 83 (1993).

89T. M. Sokolov and D. Hershgal, Optimal coupling and feasibility of a solar-powered year-round ejector air conditioner, *Sol. Energy* **50**(6), 507 (1993).

90T. M. Sokolov and D. Hershgal, Solar-powered compression-enhanced ejector air conditioner, *Sol. Energy* **51**(3), 183 (1993).

91T. G. N. Tiwari and A. K. Singh, Thermal efficiency of collection-cum-storage solar water heater, *Energy Convers. Manage.* **34**(2), 147 (1993).

92T. P. T. Tsinlingiris, Theoretical modelling of a solar air conditioning system for domestic applications, *Energy Convers. Manage.* **34**(7), 523 (1993).

Stills/desalination

93T. N. S. Al Baharna, N. Al Mahdi and F. Zaky, Performance analysis of a triple-basin still integrated with a natural circulation solar heater, *Energy Convers. Manage.* **34**(7), 545 (1993).

94T. H. M. Ali, Effect of forced convection inside the solar still on heat and mass transfer coefficients, *Energy Convers. Manage.* **34**(1), 73 (1993).

95T. D. K. Dutt, A. Kumar, J. D. Anand and G. N. Tiwari, Improved design of a double effect solar still, *Energy Convers. Manage.* **34**(6), 507 (1993).

96T. H. E. S. Fath and S. M. Elsherbiny, Effect of adding a passive condenser on solar still performance, *Energy Convers. Manage.* **34**(1), 63 (1993).

97T. A. Palacio and J. L. Fernandez, Numerical analysis of greenhouse-type solar stills with high inclination, *Sol. Energy* **50**(6), 469 (1993).

98T. V. B. Sharma and S. C. Mullick, Calculation of hourly output of a solar still, *J. Sol. Energy Engng Trans. ASME* **115**(4), 231 (1993).

99T. A. K. Singh and G. N. Tiwari, Thermal evaluation of regenerative active solar distillation under thermosyphon mode, *Energy Convers. Manage.* **34**(8), 697 (1993).

100T. G. N. Tiwari and S. Sinha, Parametric studies of active regenerative solar still, *Energy Convers. Manage.* **34**(3), 209 (1993).

101T. G. N. Tiwari, S. K. Singh and V. P. Bhatnagar, Analytical thermal modelling of multi-basin solar still, *Energy Convers. Manage.* **34**(12), 1261 (1993).

102T. Y. P. Yadav, Performance analysis of a solar still coupled to a heat exchanger, *Desalination* **91**(2), 135 (1993).

103T. Y. P. Yadav, Transient performance of a high temperature solar distillation system, *Desalination* **91**(2), 145 (1993).

104T. Ho-Ming Yeh, Experimental studies on upward-type double-effect solar distillers with air flow through the second effect, *Energy* **18**(11), 1107 (1993).

105T. G. M. Zaki, A. M. Radhwan and A. O. Balbeid, Analysis of assisted coupled solar stills, *Sol. Energy* **51**(4), 277 (1993).

Storage

106T. C. Bellecci and M. Conti, Latent heat thermal storage for solar dynamic power generation, *Sol. Energy* **51**(3), 169 (1993).

107T. C. Bellecci and M. Conti, Phase change thermal storage: transient behaviour analysis of a solar receiver–storage module using the enthalpy method, *Int. J. Heat Mass Transfer* **36**(8), 2157 (1993).

108T. Ch. Charach, Second-law efficiency of an energy storage-removal cycle in a phase-change material shell-and-tube heat exchanger, *J. Sol. Energy Engng Trans. ASME* **115**(4), 240 (1993).

109T. S. Das and T. K. Dutta, Mathematical modeling and experimental studies on solar energy storage in a phase change material, *Sol. Energy* **51**(5), 305 (1993).

110T. E. Fountoukidis, S. Yanniotis and N. Leontaridis, Theoretical model for direct solar regeneration of hygroscopic solutions, *Sol. Energy* **51**(4), 247 (1993).

111T. L. C. C. Goncalves and S. D. Probert, Thermal energy storage: dynamic performance characteristics of cans each containing a phase-change material, assembled as a packed-bed, *Appl. Energy* **45**(2), 117 (1993).

112T. L. H. Gunnewiek, S. Nguyen and M. A. Rosen, Evaluation of the optimum discharge period for closed thermal energy storages using energy and exergy analyses, *Sol. Energy* **51**(1), 39 (1993).

113T. K. Kaino, Similarity curve in the solidification process of latent heat energy storage unit with straight fins (1st Report, Effect of Stefan number on the formation of the similarity rule), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(557), 236 (1993).

114T. K. Kaino, Similarity curve in the solidification process of latent heat energy storage unit with straight fins (3rd Report, Effect of fin on the formation of the similarity rule), *Nippon Kikai Gakkai Ronbunshu B Hen* **59**(560), 1228 (1993).

115T. T. W. Kerslake and M. B. Ibrahim, Analysis of thermal energy storage material with change-of-phase volumetric effects, *J. Sol. Energy Engng Trans. ASME* **115**(1), 22 (1993).

116T. A. E. Moschatos, Combined thermal storage, *Sol. Energy* **51**(5), 391 (1993).

117T. M. Riahi, Efficiency of heat storage in solar energy systems, *Energy Convers. Manage.* **34**(8), 677 (1993).

118T. H. Yoo and E.-T. Pak, A theoretical model of the charging process for stratified thermal storage tanks, *Sol. Energy* **51**(6), 513 (1993).

Solar ponds

119T. K. A. Antonopoulos and E. D. Rogdakis, Correlations for the yearly or seasonally optimum salt-gradient solar pond in Greece, *Sol. Energy* **50**(5), 417 (1993).

120T. Z. Harel, J. Tanny and A. Tsinober, The equilibrium solar pond: a laboratory model for the gradient layer, *J. Sol. Energy Engng Trans. ASME* **115**(1), 32 (1993).

121T. Y. Keren, H. Rubin, J. Atkinson, M. Priven and G. A. Bemporad, Theoretical and experimental comparison of conventional and advanced solar pond performance, *Sol. Energy* **51**(4), 255 (1993).

122T. R. Prasad and D. P. Rao, Feasibility studies on the enhancement of energy storage in the ground beneath solar ponds, *Sol. Energy* **50**(2), 135 (1993).

123T. D. Subhakar and S. Srinivasa Murthy, Saturated solar ponds—1. Simulation procedure, *Sol. Energy* **50**(3), 275 (1993).

124T. D. Subhakar and S. Srinivasa Murthy, Saturated solar ponds—2. Parametric studies, *Sol. Energy* **50**(4), 307 (1993).

Power generation/industrial applications

125T. N. G. Anderson, Proposal for a new superlattice-based solar cell structure, *Sol. Energy* **50**(2), 191 (1993).

126T. H. Arashi and Y. Kaneda, Solar-pumped laser and its second harmonic generation, *Sol. Energy* **50**(5), 447 (1993).

127T. L. Barra and D. Coiante, Annual energy production and room temperature effect in siting flat plate photovoltaic systems, *Sol. Energy* **51**(5), 383 (1993).

128T. S. M. Eldighidy, Optimum outlet temperature of solar collector for maximum work output for an Otto air-standard cycle with ideal regeneration, *Sol. Energy* **51**(3), 175 (1993).

129T. P. Gandhidasan, Thermodynamic analysis of a closed-cycle, solar gas-turbine plant, *Energy Convers. Manage.* **34**(8), 657 (1993).

130T. A. K. Gupta, R. Z. Parker, C. E. Keefer and R. J. Hanrahan, Factors affecting quantum yields for chlorine formation in the solar photolysis of acidic chloride solutions containing hexachloroiridate (IV), *Sol. Energy* **51**(5), 409 (1993).

131T. S. Kumar and R. Varadarajan, Urban market response for solar photovoltaic systems: an economic appraisal—South Indian case study, *Sol. Energy* **51**(3), 229 (1993).

132T. G. C. Nihous and L. A. Vega, Design of a 100 MW OTEC-hydrogen plantship, *Mar. Structures* **6**(23), 207 (1993).

133T. J. E. Pacheco, M. R. Prairie and L. Yellowhorse, Photocatalytic destruction of chlorinated solvents in water with solar energy, *J. Sol. Energy Engng Trans. ASME* **115**(3), 123 (1993).

134T. V. M. Pathak and R. Srivastava, Series resistance in n-MoSe2 (TMDC)-based PEC solar cells, *Sol. Energy* **50**(2), 123 (1993).

135T. A. Steinfeld, P. Kuhn and J. Karni, High-temperature solar thermochemistry: production of iron and synthesis gas by Fe_3O_4-reduction with methane, *Energy* **18**(3), 239 (1993).

136T. A. Tosun and Ö. Saygin, Construction of a solar boiler–dryer for processing restaurant food wastes for their use as ingredients in animal feed, *Sol. Energy* **51**(1), 1 (1993).

137T. V. S. Trukhov and I. A. Tursunbaev, Stirling's engine as an energy converter in solar power systems, *Geliotekhnika* (2), 27 (1993).

138T. H. Yalcin and T. Koc, Solar power for cathodic protection of steel pipeline, *Sol. Energy* **51**(5), 415 (1993).

Cookers and dryers

139T. A. Arata, V. K. Sharma and G. Spagna, Performance evaluation of solar assisted dryers for low temperature drying application—II. Experimental results, *Energy Convers. Manage.* **34**(5), 417 (1993).

140T. E. A. Arinze, G. J. Schoenau, S. Sokhansanj, S. S. Adefila and S. M. Mumah, A dynamic performance simulation model of flat-plate solar collectors for a heat pump system, *Energy Convers. Manage.* **34**(1), 33 (1993).

141T. Boyi Chen, Xianzhi Du, Xiande Fang and Zuyi Zheng, Study on influence of solar radiation on performance of outdoor air heat exchanger, *Taiyangneng Xuebao* **14**(3), 239 (1993).

142T. O. Comakli, K. Kaygusuz, T. Ayhan and F. Arslan, Experimental investigation and a dynamic simulation of the solar-assisted energy-storaged heat pump system, *Sol. Energy* **51**(2), 147 (1993).

143T. Ö. Comakli, K. Kaygusuz and T. Ayhan, Solar-assisted heat pump and energy storage for residential heating, *Sol. Energy* **51**(5), 357 (1993).

144T. A. De Vos, P. T. Landsberg, P. Baruch and J. E.

Parrott, Entropy fluxes, endoreversibility, and solar energy conversion, *J. Appl. Phys.* **74**(6), 3631 (1993).
145T. L. M. Diamante and P. A. Munro, Mathematical modelling of the thin layer solar drying of sweet potato slices, *Sol. Energy* **51**(4), 271 (1993).
146T. H. P. Garg, Jai Prakash and D. S. Hrishikesan, Performance prediction of a solar timber kiln, *Energy Convers. Manage.* **34**(7), 569 (1993).
147T. S. M. A. Ibrahim and M. K. El-Reidy, Performance of a solar cooker in Egypt, *Energy Sources* **15**(3), 415 (1993).
148T. K. Kaygusuz, N. Gültekin and T. Ayhan, Solar-assisted heat pump and energy storage for domestic heating in Turkey, *Energy Convers. Manage.* **34**(5), 335 (1993).
149T. Guiping Lin and Xiugan Yuan, Modelling of the absorption and desorption process of chemical heat pumps, *J. Therm. Sci.* **2**(1), 57 (1993).
150T. Zude Liu and Yongling Sha, Theory and method for determining the specific properties of thermal efficiency of the condensing solar cookers, *Taiyangneng Xuebao* **14**(2), 154 (1993).
151T. A. Mulet, A. Berna, C. Rosselló and J. Cañellas, Analysis of open sun drying experiments, *Drying Technol.* **11**(6), 1385 (1993).
152T. N. M. Nahar, J. P. Gupta and P. Sharma, Performance and testing of an improved community size solar cooker, *Energy Convers. Manage.* **34**(4), 327 (1993).
153T. I. Olwi and A. Khalifa, Numerical modeling and experimental testing of a solar grill, *J. Sol. Energy Engng Trans. ASME* **115**(1), 5 (1993).
154T. A. V. Narasimha Rao, R. V. Chalam, S. Subramanyam and T. L. Sitharama Rao, Energy contribution by booster mirrors, *Energy Convers. Manage.* **34**(4), 309 (1993).
155T. V. K. Sharma, A. Colangelo and G. Spagna, Experimental performance of an indirect type solar fruit and vegetable dryer, *Energy Convers. Manage.* **34**(4), 293 (1993).

PLASMA HEAT TRANSFER AND MAGNETOHYDRODYNAMICS

Plasma heat transfer modeling

1U. N. E. Andreev, S. L. Leshkevich, V. T. Tikhonchuk and V. E. Fortov, Numerical modeling of the effect of powerful laser radiation on plasma, *High Temp.* **30**(5), 724 (1993).
2U. D. A. Benoy, J. A. M. van der Mullen and D. C. Schram, Radiation energy loss in a non-equilibrium argon plasma, *J. Phys. D* **26**(9), 1408 (1993).
3U. D. A. Benoy, J. A. M. van der Mullen, M. C. M. van de Sanden, B. van der Sijde and D. C. Schram, Application of a hybrid collisional radiative model to recombining argon plasmas, *J. Quant. Spectrosc. Radiat. Transfer* **49**(2), 129 (1993).
4U. A. J. Chamkha, Temperature and heat transfer solutions for aeromagnetic dusty-gas flow, *J. Thermophys. Heat Transfer* **7**(3), 529 (1993).
5U. C. H. Chang and J. D. Ramshaw, Numerical simulations of argon plasma jets flowing into cold air, *Plasma Chem. Plasma Proc.* **13**(2), 189 (1993).
6U. J. M. Cormier and J. Chapelle, Simple simulation of a decaying argon arc submitted to a recovery voltage, *J. Phys. D* **26**(6), 945 (1993).
7U. J. F. Coudert, C. Delalondre, P. Roumilhac, O. Simonin and P. Fauchais, Modeling and experimental study of a transferred arc stabilized with argon and flowing in a controlled-atmosphere chamber filled with argon at atmospheric pressure, *Plasma Chem. Plasma Proc.* **13**(3), 399 (1993).
8U. L. G. D'yachkov, The calculation of continuous radiative spectra of a plasma, *High Temp.* **30**(5), 709 (1993).
9U. T. A. Gally, L. A. Carlson and D. Green, Flowfield coupled excitation and radiation model for nonequilibrium reacting flows, *J. Thermophys. Heat Transfer* **7**(2), 285 (1993).
10U. J. J. Gonzalez, A. Gleizes, P. Proulx and M. Boulos, Mathematical modeling of a free-burning arc in the presence of metal vapor, *J. Appl. Phys.* **74**(5), 3065 (1993).
11U. P. H. Hauschildt, Multi-level non-LTE radiative transfer in expanding shells, *J. Quant. Spectros. Radiat. Transfer* **50**(3), 301 (1993).
12U. Z. Njah, J. Mostaghimi, M. Faghri and M. Boulos, Study of 3D mixing of a cold jet with a transverse plasma stream, *Int. J. Heat Mass Transfer* **36**(16), 3897 (1993).
13U. Z. Njah, J. Mostaghimi and M. Boulos, Mathematical modelling of the 3D mixing in an induction plasma reactor, *Int. J. Heat Mass Transfer* **36**(16), 3909 (1993).
14U. Seungho Paik, P. C. Huang, J. Heberlein and E. Pfender, Determination of the arc-root position in a DC plasma torch, *Plasma Chem. Plasma Proc.* **13**(3), 379 (1993).
15U. J. D. Ramshaw and C. H. Chang, Ambipolar diffusion in two-temperature multicomponent plasmas, *Plasma Chem. Plasma Proc.* **13**(3), 489 (1993).
16U. B. M. Smirnov, Condensation processes in decaying plasmas, *High Temp.* **31**(2), 197 (1993).
17U. D. R. Topham and H. D. Pite, On axisymmetric deformations of the electric arc column in an accelerating flow, *J. Phys. D* **26**(12), 2159 (1993).

Plasma wall and plasma particle interactions

18U. M. A. Capelli, The nonequilibrium region of an electrode in contact with a flowing thermal plasma, *IEEE Trans. Plasma Sci.* **21**(1), 194 (1993).
19U. J. P. Chabrerie, J. Devautour and Ph. Teste, A numerical model for thermal processes in an electrode submitted to an arc in air and its experimental verification, *IEEE Trans. Compon. Hybrids Mfg Technol.* **16**(4), 449 (1993).
20U. Xi Chen and Xin Tao, An improved analysis of the thermophoretic force on a small particle suspended in a rarefied plasma, *J. Phys. D* **26**(4), 590 (1993).
21U. P. Durgapal, Current distribution in the cathode areas of an arcjet, *J. Thermophys. Heat Transfer* **7**(2), 241 (1993).
22U. P. Durgapal, Electrode phenomena in high-current, high-pressure arc heaters, *J. Thermophys. Heat Transfer* **7**(3), 412 (1993).
23U. A. G. Gnedovets, A. V. Gusarov and A. A. Uglov, Effect of Debye screening on heat transfer to a spherical particle from rarefied plasma, *Plasma Chem. Plasma Proc.* **13**(4), 633 (1993).
24U. J. J. Gonzalez, A. Gleizes, S. Vacquié and P. Brunelot, Modeling of the cathode jet of a high-power transferred arc, *Plasma Chem. Plasma Process.* **13**(2), 237 (1993).
25U. A. Lefort, M. J. Parizet, S. Jellouli and R. Bessege, Heat transfer from an electric arc to insulating wall, *IEEE Trans. Plasma Sci.* **21**(5), 593 (1993).
26U. E. Meeks and M. A. Cappelli, Two-temperature fluid model for high-pressure plasmas in contact with cooled electrodes, *J. Appl. Phys.* **73**(7), 3172 (1993).
27U. R. Morrow and J. J. Lowke, A one-dimensional theory for the electrode sheaths of electric arcs, *J. Phys. D* **26**(4), 634 (1993).
28U. L. Müller, Modelling of an ablation-controlled arc, *J. Phys. D* **26**(8), 1253 (1993).
29U. Seong-Won Nam, M. Okubo, H. Nishiyama and S. Kamiyama, Numerical analysis of heat transfer and

fluid flow of a high-temperature jet including particles in a plasma spraying, *Heat Transfer Jpn Res.* **22**(5), 493 (1993).

30U. J. Paulini, T. Klein and G. Simon, Thermo-field emission and the Nottingham effect, *J. Phys. D* **26**(8), 1310 (1993).

31U. B.-J. Wang and N. Saka, Thermal analysis of electrode heating and melting due to a spark, *IEEE Trans. Compon. Hybrids Mfg Technol.* **16**(4), 456 (1993).

32U. P. Zhu and J. J. Lowke, Theoretical study of the melting of the cathode tip of a free burning arc in argon for various conical angles, *J. Phys. D* **26**(7), 1073 (1993).

Plasma properties

33U. I. D. Boyd and T. Gokcen, Evaluation of thermochemical models for particle and continuum simulations of hypersonic flow, *J. Thermophys. Heat Transfer* **7**(3), 406 (1993).

34U. K. Chen and T. L. Eddy, Thermodynamic properties of molecular hydrogen plasma in thermal and chemical nonequilibrium, *J. Thermophys. Heat Transfer* **7**(2), 277 (1993).

35U. P. Chévrier and J. Maftoul, State law equation of a real gas and simulation of electrical arc–gas flow interaction, *J. Phys. D* **26**(6), 949 (1993).

36U. A. Gleizes, J. J. Gonzalez, B. Liani and G. Raynal, Calculation of net emission coefficient of thermal plasmas in mixtures of gas with metallic vapour, *J. Phys. D* **26**(11), 1921 (1993).

37U. A. A. Mihajlov, A. M. Ermolaev, Z. Djuric and Lj Ignjatovic, Static electrical conductivity in weak and moderately non-ideal plasmas, *J. Phys. D* **26**(7), 1041 (1993).

38U. M. Stobbe, R. Redmer and A. Könies, Nonlinear electrical conductivity in hydrogen plasma, *Phys. Fluids B* **5**(1), 55 (1993).

Diagnostics

39U. H. Akatsuka and M. Suzuki, Arc-heated magnetically trapped expanding plasma jet generator, *Rev. Scient. Instrum.* **64**(7), 1734 (1993).

40U. R. F. Avramenko, A. Yu. Gridin, A. I. Klimov and V. I. Nikolaeva, Experimental investigation of the interaction of a high-enthalpy plasma with a shock wave and with high-power laser radiation, *High Temp.* **31**(1), 42 (1993).

41U. D. S. Baer and R. K. Hanson, Semiconductor laser-based measurements of quench rates in an atmospheric pressure plasma by using saturated-fluorescence spectroscopy, *Appl. Opt.* **32**(6), 948 (1993).

42U. D. E. Buraczyk, G. G. Edelmon and K. W. Zieher, Time-of-flight analysis of a plasma jet from a spark plug in vacuum, *J. Appl. Phys.* **73**(7), 3169 (1993).

43U. J.-S. Chang and J. G. Laframboise, Theory of electrostatic probes in a flowing continuum plasma: numerical solutions for cylindrical probes in cross flow, *J. Phys. D* **26**(1), 42 (1993).

44U. Nai-Ho Cheung, Lun-Chiu Ng and Shu-Chi Chen, A moving-mirror Michelson interferometer for probing transient plasma plumes, *Rev. Scient. Instrum.* **64**(1), 49 (1993).

45U. R. M. Clements and P. R. Smy, The positively biased planar Langmuir probe in a high-pressure plasma, *J. Phys. D* **26**(11), 1916 (1993).

46U. F. Dahmani, Experimental scaling laws for mass-ablation rate, ablation pressure in planar laser-produced plasmas with laser intensity, laser wavelength and target atomic number, *J. Appl. Phys.* **74**(1), 622 (1993).

47U. J. Dawe, S. A. H. Rizvi and P. R. Smy, Electron current to a cylindrical probe in a moving high pressure plasma, *IEEE Trans. Plasma Sci.* **21**(1), 202 (1993).

48U. G. Fiksel, J. Frank and D. Holly, Fast pyrobolometers for measurements of plasma heat fluxes and radiation losses in the Madison symmetric torus reversed field pinch, *Rev. Scient. Instrum.* **64**(10), 2761 (1993).

49U. J. R. Fincke, W. D. Swank and D. C. Haggard, Plasma spraying of alumina: plasma and particle flow fields, *Plasma Chem. Plasma Proc.* **13**(4), 579 (1993).

50U. J. R. Fincke, W. D. Swank, S. C. Snyder and D. C. Haggard, Enthalpy probe performance in compressible thermal plasma jets, *Rev. Scient. Instrum.* **64**(12), 3585 (1993).

51U. J. R. Fincke, S. C. Snyder and W. D. Swank, Comparison of enthalpy probe and laser light scattering measurement of thermal plasma temperatures and velocities, *Rev. Scient. Instrum.* **64**(3), 711 (1993).

52U. J. Haidar and A. J. D. Farmer, Temperature measurements for high-current free-burning arcs in nitrogen, *J. Phys. D* **26**(8), 1224 (1993).

53U. J. Haidar and A. J. D. Farmer, A method for the measurement of the cathode surface temperature for a high-current free-burning arc, *Rev. Scient. Instrum.* **64**(2), 542 (1993).

54U. J. Hermann, C. Boulmer-Leborgne, B. Dubreuil and I. N. Mihailescu, Influence of irradiation conditions on plasma evolution in laser-surface interaction, *J. Appl. Phys.* **74**(5), 3071 (1993).

55U. N. Jelic, M. Cercek, T. Gyergyek and M. Stanojevic, Determination of plasma parameters from plane probe characteristics in a current-carrying plasma, *J. Phys. D* **26**(1), 49 (1993).

56U. S.-G. Lee, D. Diebold, N. Hershkowitz, T. Intrator, X. Wang and G.-H. Kim, Direct measurement of plasma flow velocity using a Langmuir probe, *Rev. Scient. Instrum.* **64**(2), 481 (1993).

57U. X. L. Mao, W. T. Chan, M. A. Shannon and R. E. Russo, Plasma shielding during picosecond laser sampling of solid materials by ablation in He vs Ar atmosphere, *J. Appl. Phys.* **74**(8), 4915 (1993).

58U. G. Neumann, U. Bänziger, M. Kammeyer and M. Lange, Plasma-density measurements by microwave interferometry and Langmuir probes in an RF discharge, *Rev. Scient. Instrum.* **64**(1), 19 (1993).

59U. G. A. Raiche and J. B. Jeffries, Laser-induced fluorescence temperature measurements in a d.c. arcjet used for diamond deposition, *Appl. Opt.* **32**(24), 4629 (1993).

Specific plasma heat transfer applications

60U. C. D. Scott, Survey of measurements of flow properties in arcjets, *J. Thermophys. Heat Transfer* **7**(1), 9 (1993).

61U. W. D. Swank, J. R. Fincke and D. C. Haggard, Modular enthalpy probe and gas analyzer for thermal plasma measurements, *Rev. Scient. Instrum.* **64**(1), 56 (1993).

62U. N. Vogel, The cathode spot plasma in low current air and vacuum break arcs, *J. Phys. D* **26**(10), 1655 (1993).

63U. E. S. Aydiland and J. Demetre, Modeling of plasma etching reactors including wafer heating effects, *J. Electrochem. Soc.* **140**(5), 1471 (1993).

64U. O. Barin, Mass transfer in the gas phase during top-blowing with plasma jets, *Plasma Chem. Plasma Proc.* **13**(2), 211 (1993).

65U. H. Brachold, C. Peukert and H. Regner, Electric arc plasma reactors for the production of acetylene from coal, *Chem. Ing. Tech.* **65**(3), 293 (1993).

66U. M. E. Coltrin and D. S. Dandy, Analysis of diamond growth in subatmospheric d.c. plasma-gun reactors, *J. Appl. Phys.* **74**(9), 5803 (1993).

67U. J.-F. Daviet, L. Peccoud and F. Mondon, Heat transfer in a microelectronics plasma reactor, *J. Appl. Phys.* **73**(3), 1471 (1993).

68U. J. Dowden, P. Kapadia and B. Fenn, Space charge in plasma arc welding and cutting, *J. Phys. D* **26**(8), 1215 (1993).

69U. P. T. Eubank, M. R. Patel, M. A. Barrufet and B.

Bozkurt, Theoretical models of the electrical discharge machining process—III. The variable mass, cylindrical plasma model, *J. Appl. Phys.* **73**(11), 7900 (1993).

70U. D. Evans, L. A. Rosocha, G. K. Anderson, J. J. Coogan and M. J. Kushner, Plasma remediation of trichloroethylene in silent discharge plasmas, *J. Appl. Phys.* **74**(9), 5378 (1993).

71U. S. L. Girshick, C. Li, B. W. Yu and H. Han, Fluid boundary layer effects in atmospheric-pressure plasma diamond film deposition, *Plasma Chem. Plasma Proc.* **13**(2), 169 (1993).

72U. P. G. Jönsson, R. C. Westhoff and J. Szekely, Arc characteristics in gas-metal arc welding of aluminum using argon as the shielding gas, *J. Appl. Phys.* **74**(10), 5997 (1993).

73U. R. G. Keanini and B. Rubinsky, Three-dimensional simulation of the plasma arc welding process, *Int. J. Heat Mass Transfer* **36**(13), 3283 (1993).

74U. H. Liu, E. J. Lavernia and R. H. Rangel, Numerical simulation of substrate impact and freezing of droplets in plasma spray, *J. Phys. D* **26**(11), 1900 (1993).

75U. M. A. S. Minucci and H. T. Nagamatsu, Hypersonic shock-tunnel testing at an equilibrium interface condition of 4100 K, *J. Thermophys. Heat Transfer* **7**(2), 251 (1993).

76U. T. G. Owano and C. H. Kruger, Parametric study of atmospheric-pressure diamond synthesis with an inductively coupled plasma torch, *Plasma Chem. Plasma Proc.* **13**(3), 433 (1993).

77U. H. Sekiguchi, T. Honda and A. Kanzawa, Thermal plasma decomposition of chlorofluorocarbons, *Plasma Chem. Plasma Proc.* **13**(3), 463 (1993).

78U. L. D. Thornhill and J. H. Batteh, Scaling laws for plasma armatures in railguns, *IEEE Trans. Plasma Sci.* **21**(3), 282 (1993).

79U. M. Aydin and H. Yavuz, Application of finite-time thermodynamics to MHD power cycles, *Energy* **18**(9), 907 (1993).

Magnetohydrodynamics

80U. G. Fabris and L. Back, Prediction of performance of two-phase flow nozzle and liquid metal magnetohydrodynamic (LMMHD) generator for no slip condition, *Energy Convers. Manage.* **34**(5), 373 (1993).

81U. R. C. Goforth and H. C. Kruger, Investigation of secondary flows in magnetohydrodynamic channels, *J. Propul. Power* **9**(6), 889 (1993).

82U. N. Harada, T. Suekane, K. Tsunoda, T. Okamura, K. Yoshikawa, H. Yamasaki, S. Kabashima and S. Shioda, Experimental studies of closed cycle MHD power generation with FUJI-1 blow-down facility, *Energy Convers. Manage.* **34**(6), 433 (1993).

83U. M. Ishikawa and J. Umoto, Environmentally attractive oxygen-coal-fired MHD-steam combined system with CO_2 recovery, *Energy Convers. Manage.* **34**(8), 597 (1993).

84U. M. Ishikawa, M. Fujita, Y. Fujita and J. Umoto, Performance of coal-fired MHD generators with large leakage current, *Energy Convers. Manage.* **34**(8), 607 (1993).

85U. A. Kageyama, K. Watanabe and T. Sato, Simulation study of a magnetohydrodynamic dynamo: convection in a rotating spherical shell, *Phys. Fluids B* **5**(8), 2793 (1993).

86U. P. J. Karditsas, One-dimensional theory of a thermal equilibrium MHD channel, *Energy Convers. Manage.* **34**(7), 557 (1993).

87U. Wenli Z. Liang and P. H. Diamond, A renormalization group analysis of two-dimensional magnetohydrodynamic turbulence, *Phys. Fluids B* **5**(1), 63 (1993).

88U. I. Maya, S. Anghaie, N. J. Diaz and E. T. Dugan, Ultrahigh temperature vapor-core reactor. Magnetohydrodynamic system for space nuclear electric power, *J. Propul. Power* **9**(1), 98 (1993).

89U. J. P. Moder, L. N. Myrabo and D. A. Kaminski, Analysis and design of an ultrahigh temperature hydrogen-fuelled MHD generator, *J. Propul. Power* **9**(5), 739 (1993).

90U. K. Tsunoda, N. Harada, S. Kabashima and S. Shioda, Numerical simulation studies on FUJI-1 experiments, *Energy Convers. Manage.* **34**(6), 447 (1993).

91U. T. Watanabe, Magnetohydrodynamic free convection flow over a wedge in the presence of a transverse magnetic field, *Int. Commun. Heat Mass Transfer* **20**(6), 871 (1993).

92U. Cheng-Ren Lin and Cha'o-Kuang Chen, Hydromagnetic flow and heat transfer about a fluid underlying the axisymmetric spreading surface, *Int. J. Engng Sci.* **31**(2), 257 (1993).