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# REPORT

## SYMPOSIUM ON HEAT TRANSFER AT THE INDIAN INSTITUTE OF SCIENCE, BANGALORE 12, INDIA

A SYMPOSIUM on Heat Transfer was inaugurated at the Indian Institute of Science, Bangalore, in November 1959. The Symposium was organized by the Mechanical Engineering Department, in connexion with the Golden Jubilee of the Institute, and was the first occasion on which a Symposium on Heat Transfer was held in India. Twenty papers were presented and discussed at sessions for presentation of papers on 27th and 28th November. The following is a brief review of the papers (a list of which is given at the end) presented.

Hoelscher [1] discussed the assumptions both explicit and implicit made in the derivation of the heat and mass diffusion and/or dispersion equation, using the classical model of a rectangular parallellopiped, and its limitations in physical situations. Two alternate models were presented by him which may be more nearly correct for certain classes of physical problems. Analytical solutions and experimental data are not available to check these.

Jain and Subramanian [2] presented a method of obtaining approximate solutions for many cases of unsteady state heat conduction in finite solids in terms of those applicable to semi-infinite solids. They applied this method to problems of heat conduction in finite rods (a) with radiation boundary condition (for instance thin films of non-conducting material at the end of the rod give rise to radiation boundary condition), and (b) when the end temperature is an arbitrarily plotted function of time. When thermal parameters are temperature dependent, it was indicated by them that a straightforward application of the simple method is not possible since the problem reduced to one with constant thermal parameters but with moving boundary.

The thermal conductivity of various mould materials [3] were determined using the line heat source method. In this method, the temperature rise of the line heat source embedded in the material was recorded against time and the thermal conductivity computed.

Two papers [4, 5] were presented on the use of electrical analogues. Maheshwari [4] indicated that the adverse influence of anisotropy and non-uniformity of commercially available conductive sheets can be considerably reduced by using the sheet in the transverse and longitudinal directions and then taking the arithmetic mean. For the different categories of problems investigated by him the error in temperature distribution was not greater than 2·5 per cent. In the second paper was described a short time analogue computer comprising 32 resistance and 16 capacitance units. Its use and accuracy in solving heat transfer and fluid flow problems was discussed with examples.

Bergelin [6] discussed heat transfer and pressure drop during flow at right angles to tube banks, during flow through a well-baffled tubular heat exchanger, and during flow through poorly baffled heat exchangers. The effect of fluid leakages around baffles and around tube bank was also indicated. The effect of high $D_P/D_T$ (diameter of packed particle to diameter of packed tube) ratio and the thermal conductivity of packing materials on heat transfer in packed tube exchangers was discussed by Raghavan and Laddha [7].

Spalding and Muralidharan [8] made a critical comparison of the methods available for calculating laminar heat transfer of arbitrary two dimensional or axisymmetrical bodies. Heat transfer from a turbine blade, calculated by three different methods, were compared with experimental data while heat transfer from a partially heated ellipse was determined by two methods. No general conclusions could be drawn about the relative validity of the methods. Further lines of work were indicated in their paper. Smith and Shah [9] extended the method of Smith and Spalding for calculation of heat transfer in a laminar boundary layer with constant fluid properties and constant wall temperature to cover a range of Prandtl numbers up to 10.

The effect of pulsations and vapour agitation on heat transfer was the subject matter of two papers. Singh *et al.* [10] indicated that heat transfer to pulsating medium is considerably modified by the frequency of pulsations imposed on the medium. The peak values of the rate of heat transfer obtained could be attributed to resonance phenomena occurring in the system. Srinivasan and Ramachandran [11] discussed the effect of vapour agitation on heat transfer from an electrically heated platinum wire submerged in water. With vapour agitation, the heat transfer coefficients increased by as much as five times the free convection value. The effect of the parameters viz. air hole diameter, distance between the platinum wire and the perforated tube, and air flow rate on heat transfer were found to be interdependent.

Two papers on Heat Transfer in circular and non-circular ducts were presented. Ede [12] reported experimental data on heat transfer for turbulent flow of air and water in pipes. The test data were compared with the familiar Dittus–Boelter equation. He recommended a different value of the coefficient for air and water, suggested figures being 0·018 and 0·026 respectively.

Eckert and Irvine [13] reported measurements of friction factors and heat transfer for flow of air through a duct with a triangular cross-section having a side ratio of 5 to 1. Friction factors for laminar flow were in good agreement with calculated values. For turbulent flow, they were 20 per cent lower than the Blasius expression. Average Nusselt numbers obtained in the triangular duct, when based on the hydraulic diameter, was found to be only one half as large as the Nusselt numbers for turbulent pipe flow. Duct length in excess of 100 diameters were required to obtain an established temperature field.

Two papers on combustion were presented at the Symposium. DeSa [14] dealt with an investigation of fuel droplet combustion. With larger droplets, vaporization was observed to begin at 300°C followed by a preflame reaction which erupted into a lifted flame burning at some distance in the vapour trail. After this, the boundary vapour also ignited and the two flames coalesced with growth of a carbon tube in the vapour. With small gas oil droplets, no carbon formation was observed and ignition took place in a single flame. Krishna Prasad *et al.* [15] reported that increased flame speeds could be obtained by imposing oscillations on a gas column in a tube open at one end, at all mixture strengths of an acetylene air mixture and at several frequencies and amplitudes of oscillations.

The influence of thermal properties of mould materials on the casting characteristics of aluminium and its alloys was presented by Seshadri and Ramachandran [16]. The freezing time of a given metal or alloy decreased with increase in heat diffusivity of mould material. Chilling power usually increased with increase in heat diffusivity of mould material. The process of solidification of pure metals, eutectics and solid solution types of alloys as also the mechanical properties of the metal or alloy cast were very much influenced by the thermal properties of mould materials. Attri [17] presented results of a study on the possibilities of augmenting the thrust obtained from heated jets by placing cylindrical cores of different geometries in front of the outlets. As core diameter increased, the measured thrust increased while flow decreased. The effect of cores was to decrease angle of spread near the outlet but the jet angle was almost constant about eight lengths downstream. Seshadri and Ray Chaudhuri [18] discussed heat transfer problems in building research.

Sinha [19] analysed the superheat properties of liquids. Pushilal [20] presented a method of computing heat absorption in slag tap furnaces for steam generation.

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11. K. SRINIVASAN and A. RAMACHADRAN, Effect of vapour agitation on heat transfer from a horizontal wire submerged in water.
12. A. J. EDE, The heat transfer coefficient for turbulent flow in pipe.
13. E. R. G. ECKERT and T. F. IRVINE, JR., Pressure drop and heat transfer in a duct with triangular cross-section. (Courtesy A.S.M.E.)
14. VALENTINE G. DESA, On spontaneous ignition of liquid fuel droplets.
15. K. KRISHNA PRASAD, K. MAHADEVAN and H. A. HAVEMANN, Flame speeds in oscillating gases in a tube.
16. M. R. SESHADRI and A. RAMACHANDRAN, Influence of thermal properties of mould materials on casting characteristics of aluminium and its alloys.
17. N. S. ATTRI, Effect of core shapes on the flow of jets from unit heater outlets.
18. T. N. SESHADRI and B. C. RAY CHAUDHURI, Heat transfer problems in building research.
19. D. B. SINHA, Superheat properties of liquids.
20. S. N. PUSHILAL, Heat transfer and heat absorption in the design of slag tap furnaces for steam generation.