# PRESENT STATUS OF EXPERIMENTAL AND THEORETICAL RESEARCH IN COMBINED HEAT TRANSFER (FROM THE CONFERENCE HELD BY THE "RADIATIVE HEAT TRANSFER" SECTION OF THE SCIENCE COUNCIL ON PROBLEMS IN "MASS AND HEAT TRANSFER IN ENGINEERING PROCESSES," GOVERNMENT COMMITTEE ON SCIENCE AND ENGINEERING AT THE COUNCIL OF MINISTERS OF THE USSR)

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Problems of research in combined (complex) heat transfer are becoming more and more urgent in connection with the more stringent performance criteria and the higher rates sought in mass and heat transfer processes. Radiative heat transmission is accompanied by an appreciable convective component in almost all modern thermal apparatus. Heat transmission through many semitranslucent media, furthermore, is governed by the radiative–convective interplay. Until now, however, extremely little theoretical and experimental research has been done on this subject of combined heat transfer.

Most of the theoretical analyses made so far are either essentially approximate in scope or restricted to some specific range of parameter values. The greatest obstacle to obtaining theoretical solutions to combined heat transfer problems is the lack of sufficient experimental data.

The status of problems in combined heat transfer and the coordination of research activities in this area were covered at the conference held by the "Radiative Heat Transfer" Section of the Science Council on "Problems of Mass and Heat Transfer in Engineering Processes," September 15-17, 1971, at the Institute of Thermophysics (Siberian Branch, Academy of Sciences of the USSR), within the framework of the 14th Siberian Seminar on Thermophysics.

The conference was opened with an introduction by S. S. Kutateladze, Corresponding Member of the Academy of Sciences of the USSR, who spoke of the present need for a concentrated effort in experimental research dealing with the characteristics of heat radiation as well as with the interaction between electromagnetic radiation and matter.

The overview by N. A. Rubtsov (Institute of Thermophysics, Novosibirsk) covered today's state of research in combined heat transfer. Referring to results of Soviet and foreign studies, the speaker discussed the interrelation between the radiation field pattern and the structure of a substance. Problems of radiative–conductive and radiative–convective interplay were also brought out. Known methods of calculating complex heat transfer with the aid of digital computers were analyzed from the point of view of agreement with experimental data, whereupon several possible solutions were presented to the problems of heat transmission through selectively absorbing or random dispersing media and of heating semitranslucent objects with radiant flux.

Results of experiments in attenuating laser beams by turbulent pulsations in various fluids were presented by Corresponding Members of the Academy of Sciences of the USSR S. S. Kutateladze (Institute

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of Thermophysics) and D. I. Avaliani (Georgian Polytechnic Institute, Tbilisi). Their work is very significant not only as far as radiative heat transfer is concerned but, particularly, for the study of turbulence.

B. A. Grigor'ev (Institute of High Temperatures, Academy of Sciences of the USSR, Moscow) discussed the parameters of surface temperature waves and the conditions under which such waves are generated during the heating of an infinitely large plate by radiative heat pulses of various shapes.

The presentation by N. A. Rubtsov, A. L. Burka, and F. A. Kuznetsova (Institute of Thermophysics) dealt with problems of radiative–convective heat transmission through plane layers of selectively absorbing media. In their study the authors have calculated not only the temperature fields but also temperature gradients and dependent on them radiative as well as convective thermal flux distributions across a layer section, all as functions of the salient physical, optical, and environmental characteristics. They have shown that the interaction processes which accompany radiative–convective heat transmission represent essentially smooth transitions from one mode to another mode of energy transfer and are determined not only by the optical density of a layer but also on the boundary conditions constraining it.

Ya. P. Storozhuk and Yu. P. Cherkun (Central Boiler-Turbine Institute, Leningrad) reported on studies concerning the processes in furnaces of steam generator aggregates during the combustion of gaseous and liquid fuels. An analysis of experimental data and the characteristics of complex heat transfer established as a result indicate a greater role of convection in the total heat intake in high-blast than in low-blast furnaces.

The presentation by V. M. Kostylev and V. Ya. Belostotskaya (Zhukovskii) dealt with the interrelation between conductive and radiated heat transmission through optically thin layers of fine-dispersion media. The thermal conductivity of such layers had been measured. It was then shown that in this case the additivity-of-thermal-fluxes hypothesis is not valid and that the heat transmission processes here cannot be analytically described on this basis.

The presentation by N. A. Rubtsov and A. É. Verte (Institute of Thermophysics) dealt with the thermal state of surface layers on metals heated by a constant flux. Experiments performed by the authors have confirmed the existence of anomalies in the temperature distribution in surface layers (Zhak effect) of several pure metals (Al, Sn, Fe, etc.). Several possible physical models were also proposed for an explanation of this phenomenon.

The presentation by V. N. Timofeev,* F. R. Shklyar, and A. Kh. Bokovika (VNIIMT, Sverdlovsk) dealt with studies of the complex heat transfer in laminar and turbulent flows through open channels. V. P. Lukash (Moscow) discussed some problems in calculating the complex heat transfer in high-blast combustion chambers.

Results of the first large-scale experimental-physics study concerning the temperature distribution produced by a thermal radiation field in the laminar sublayer of a turbulent boundary layer were the subject of the presentation by A. I. Leont'ev (Institute of High Temperatures, Academy of Sciences of the USSR, Moscow) and A. M. Pavlyuchenko (Novosibirsk State University). These very interesting results had served as a basis on which various analytical methods of calculation were then developed. The magnitude of errors incurred by applying the additivity-of-thermal-fluxes hypothesis was very convincingly demonstrated. This work represents one of the most important achievements in the research concerned with radiative heat transfer and revealing its basic physical mechanism.

The presentation by V. S. Pikashov, K. E. Makhorin, A. I. Il'chenko, and I. F. Zemskii (Gas Institute, Academy of Sciences of the Ukrainian SSR, Kiev) dealt with the complex heat transfer between a fluidized bed and an immersed surface.

A. L. Burka and V. A. Sinitsyn (Institute of Thermophysics) reported on a numerical analysis of the thermal state of a selectively radiation absorbing smoke.

The presentation by A. E. Erinov and B. S. Soroka (Gas Institute) dealt with various problems in experimental and theoretical research concerning the directivity pattern of complex heat transfer from a radiant surface during combustion.

I. R. Mikk, K. I. Ingerman, T. M. Lausmaa, and V. A. Sel'g (Tallin Polytechnic Institute, Tallin) reported on determining the radiative and the convective component of heat transfer to contaminated heat absorbing surfaces during the combustion of shale products.

* Deceased.

V. M. Eroshenko (ÉNIN, Moscow) reported on studies concerning the injection of disperse media as a protective shield against radiation in high-pressure ($p = n \cdot 100$ atm) and high-temperature (10,000-20,000°C) processes.

In the discussion participated G. L. Polyak, A. S. Nevskii, V. V. Mitor, A. G. Blokh, and others.

A resolution was passed concerning the main directions to be taken in further research activities in the area of complex radiative–convective and radiative–conductive heat transfer. The need for establishing priorities for experimental programs was emphasized.

A special section meeting was held on coordinated planning of scientific research activities in the area of radiative heat transfer.