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THE SECOND ALL-UNION HEAT- AND MASS-TRANSFER CONFERENCE

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THREE YEARS AGO, the First All-Union Heat- and Mass-Transfer Conference was held in Minsk.* In accordance with the decision made at that conference, the Second All-Union Heat- and Mass-Transfer Conference took place in Minsk on 5–9 May 1964. The aims of this conference were to discuss the vast theoretical and experimental material on various branches of heat and mass transfer accumulated during the previous three years, and to choose basic directions for further investigations.

Four hundred and thirty-eight delegates, who represented all the main Institutions in the Soviet Union concerned with heat- and mass-transfer problems, took part in this conference. Among them were sixty-seven academicians, professors and doctors, one hundred and ninety-three candidates of science, readers and senior scientific workers. Thirty-five leading foreign scientists from fourteen countries also took part, including J. Schneller, L. Strach, J. Zemanek and others from Czechoslovakia; Professor E. A. Brun from France; Professor D. B. Spalding and A. J. Ede from Great Britain; Professor A. Endrényi from Hungary; Professor R. Toei from Japan; Professor D. A. de Vries from the Netherlands; Professor J. Ciborowski from Poland; Professor R. Eichhorn, Dr. C. Gazley Jr., Professor J. P. Hartnett, Professor T. F. Irvine Jr., Professor E. M. Sparrow and Professor N. Zuber from U.S.A.; Professor U. Grigull from West Germany; Professor M. Novakovich from Yugoslavia.

The papers submitted were circulated to participants of the conference in advance. They were classified according to subject; and the co-chairmen of each section, who were usually leading specialists working on appropriate problems, gave review reports, in which they critically analysed the papers submitted to their particular section. After this, particular problems were discussed, followed by a general discussion. One hundred and twenty-seven persons took part in the discussions.

At the evening sessions, prominent native and foreign scientists delivered the following lectures: Professor D. B. Spalding (England) *A Unified Theory for Friction, Heat and Mass Transfer in the Turbulent Boundary Layer and Wall-Jets*; Professor E. A. Brun (France) *Experimental Methods for Studying Heat and Mass Transfer at Supersonic Velocities*; Professor E. M. Sparrow (U.S.A.) *Radiant Emission and Transmission Characteristics of Cavities and Passages*; Professor N. Zuber (U.S.A.) *On the Problem of Hydrodynamic Diffusion in Two-phase Flow Media*; Professor S. S. Kutateladze (U.S.S.R.) *Turbulent Heat and Mass Transfer with Physical and Chemical Conversions*; Professor A. V. Luikov (U.S.S.R.) *Application of Thermodynamics of Irreversible Processes to Heat Transfer*. These lectures enabled the participants of the conference to acquaint themselves with the progress in the heat- and mass-transfer field achieved in the U.S.S.R., U.S.A., Great Britain and France.

The working language of the conference was Russian. There was a simultaneous translation into English and German. Some of the discussions and lectures of the foreign scientists were made in Russian, and we should note in particular that Professor D. B. Spalding delivered his lecture completely in Russian; as he said, in

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token of respect to the successes achieved by Soviet science and Soviet scientists.

Professor A. V. Luikov, Chairman of the Organizing Committee of the conference, Academician of the B.S.S.R. Academy of Sciences, opened the conference. In his opening speech he emphasized the significance of heat and mass transfer in modern science. This subject, he said, included the complex of scientific knowledge of the hydrodynamics of solid media, molecular physics, thermodynamics, physical and chemical dispersed media and other branches, and was of great practical use in modern industry. Heat- and mass-transfer problems were of great importance in new techniques and technology. The application of the methods and solutions of one branch of science to another was the peculiarity in the development of modern science and technology. A conference on the general subject of heat and mass transfer made it possible to receive valuable information, to exchange experiences of the investigations and to find out optimum ways for conducting transfer processes.

Professor A. V. Luikov underlined the fact that for the second time Minsk had been chosen to hold such an important and representative conference. It was a great honour and a high appreciation of the successes achieved by the local Heat and Mass Transfer Institute.

He then reviewed the theoretical and experimental research work in heat and mass transfer carried out during the period between the first and second conferences, and laid down the following tasks for the second conference: the determination of the main directions in the development of heat- and mass-transfer theory, the development of particular proposals on urgent problems of the theory, and recommendations on the intensification of heat- and mass-transfer processes.

After explaining the procedure of the conference, Professor A. V. Luikov welcomed the foreign and native delegates, wished them success, and expressed the hope that the conference would favour the further strengthening of co-operation between Soviet and foreign scientists, as well as the strengthening of friendship and collaboration between nations of all the world.

The review reports on the nine basic problems of heat and mass transfer were delivered by the co-chairmen of nine sections at this conference.

Professor B. S. Petukhov reported on *Convective Heat Transfer in a Single-Phase Medium.* This section contained sixty-one papers. He divided them into the following five groups:

1. Heat transfer and friction drag under the conditions of a considerable change in physical properties of a liquid or gas with temperature, mainly for flow in tubes.
2. Heat transfer and resistance in geometrical configuration systems, mainly in tubes and channels.
3. Convective heat transfer under transient conditions.
4. Hydrodynamics and heat transfer in jets.
5. Intensification of convective heat transfer.

He described the state of the investigations on each of the above groups and suggested the following important topics for further work: the effect of variable physical properties of a medium upon turbulent transfer characteristics; the study of a mechanism of a fluidization process observed with heat transfer in a supercritical region of substance parameters; the study of the geometry effect of a heat-transfer system upon heat transfer over a wide range of the Prandtl numbers; the study of transient convective heat-transfer processes in a turbulent fluid; the study of hydrodynamics and heat transfer both in subsonic and supersonic jets at different jet interactions under the conditions of the considerable effect of radiant heat transfer with chemical reactions and phase-conversions; and the development of methods for intensifying convective heat-transfer processes, etc. The detailed analysis given by Professor B. S. Petukhov favoured a lively discussion on this problem.

Professor I. P. Ginzburg delivered a review report on *Heat and Mass Transfer with Interaction of Bodies with Liquid and Gas Flows.* After a short theoretical definition of this problem, he reviewed the forty papers presented. He noted that, from the theoretical viewpoint, this problem was connected with the solution of the equations defining the motion of an ideal gas mixture in a boundary layer with diffusion, chemical reactions, radiation, electrical and magnetic fields. The papers submitted were devoted to the following basic problems:

1. Investigations into the effect of the factors given in the theoretical review upon heat- and mass-transfer processes in a laminar gas flow, and the methods for solving such problems.
2. Consideration of general problems on energy transfer in gas flows, and heat and mass transfer in a gas flow past bodies.
3. Theoretical solution of boundary-layer problems with physical and chemical conversions at a surface.
4. Theoretical and experimental solution of heat- and mass-transfer problems when turbulent liquids move with different velocities and temperatures.
5. Investigation of turbulent gas jets and heat flows in separation zones.

The review report on *Heat and Mass Transfer with a Change of Phase* was given by Professor V. M. Borishansky. The forty papers submitted were divided into three groups:

1. Diffusion in a critical region.
2. Heat transfer and mass transfer with nucleate and film boiling. Conditions for disturbance of steady boiling conditions.
3. Heat transfer and mass transfer with evaporation, sublimation, condensation, melting, crystallization and other problems.

Regarding the first group of the reports, it was noted that up to now there were no theoretical or experimental bases for choosing or deriving the necessary analytical relations, and, consequently, the reduction of the diffusion equation in the critical region to Fick's law appearing in some papers was questionable.

On the second group of papers Professor V. M. Borishansky said that some of the problems raised require more investigation and study in future. In particular, he noted that there were no proposals for rationalizing the theory of heat transfer with nucleate boiling. The theory of film boiling was developed much better. The greatest successes had been achieved in work on the boiling crises.

Regarding the third group of papers, the speaker said that the heterogeneity of the problems made it impossible to draw general conclusions. He dwelt only on two important problems:

(a) cooling of a surface with high rates of heating by a liquid–gas flow (the speaker noted that this heat-transfer method was very promising);

(b) evaporation from a solid state in a rarefied medium.

It should be noted that the problem of the application of two-phase gas–liquid heat agents (dispersoids) had already been considered at the First All-Union Heat- and Mass-Transfer Conference, Minsk, 1961.*

Professor V. M. Borishansky recommended a study of the following problems of heat and mass transfer with change of phase: with high heat stresses, high flow velocities, high vacuum, high pressures and temperatures.

Professor P. G. Romankov and Professor I. I. Paleev gave a review report on *Heat and Mass Transfer with Chemical Conversions and in Chemical Engineering.*

Professor P. G. Romankov considered the papers which gave the results of investigations carried out on the mass-transfer processes in chemical engineering. After noting the importance of the problem in connection with the development of chemical industry, he considered the papers from the point of view of the solution to the problem. He divided the papers into the following groups:

1. Thorough investigations into the physical and chemical nature of the process (determination of a physical model of a process, its mathematical description) and formulation of the kinetic laws of the process.
2. Development of the similarity theory which allows a reliable reproduction of chemical-engineering processes on a large scale.
3. Obtaining the generalized design equations verified in practice. Many papers dealt with transfer kinetics in vapour–liquid, gas–liquid and liquid–liquid systems which included such widespread mass-transfer processes as rectification, absorption and liquid extraction. In the review report much attention was paid to mass-transfer theory and, particularly, to the application of similarity-theory methods to chemical

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engineering processes, to the development of the mass-transfer process theory, to the study of the mechanism of mass-transfer processes, to transfer processes in two-phase flows, etc.

In conclusion, the following problems for prospective work were suggested in the review report: physical, analogue and mathematical simulations of mass-transfer processes, the mathematical description of physical and chemical processes, the introduction of probability statistical methods for studying transfer processes, scaling, etc.

Professor I. I. Paleev reviewed the papers on heat and mass transfer in combustion processes. He noted that it was impossible to consider all combustion problems at a general conference, and divided the papers into the following groups:

1. Stability of combustion, detonation conditions, ignition and extinction, time of an induction period.
2. Determination of the effect of kinetic and diffusion factors upon combustion.
3. Combustion of coal–water suspensions.
4. Particular problems of combustion processes (combustion of fuel particles with volatile yield, pyrolysis).

He discussed all the papers of each group in detail.

Professor S. S. Zabrodsky delivered a review report on *Heat and Mass Transfer in Dispersed Media (fluidized bed, two-phase flows)*. Twenty-seven papers were presented in this group, including twenty-four from the U.S.S.R., one from Poland, one from the U.S.A. and one from West Germany. General and particular problems of heat and mass transfer, hydrodynamics of dispersed systems and methods for conducting technological processes in coarse dispersed systems (medium–solid particles) were considered in these papers. Much attention was paid to fluidized beds (fourteen reports), and to suspended and fixed beds (12 reports). The spouting bed was studied in two reports. Some other types of dispersed systems (counter jets, rotating devices, etc.) were investigated in three reports.

The speaker mentioned that many peculiarities of heat and mass transfer in different dispersed systems were caused by their hydrodynamics and by the nature of the interaction and phase motion.

Professor S. S. Zabrodsky reviewed all the papers presented and emphasized their negative and positive points. His review stimulated a lively discussion.

Professor P. D. Lebedev and Professor A. S. Ginzburg reviewed thirty-nine papers on *Heat and Mass Transfer in Drying Processes.*

Professor P. D. Lebedev discussed modern developments of heat and mass transfer in drying processes, as well as possible further developments in that field. Particular attention was paid to the development of new high-efficiency techniques of drying and the construction of driers, to studying unsteady and transient operating conditions of driers, and to other problems.

The papers presented in this group may be classified as follows:

1. General problems of drying (analytical and experimental study of the mechanism of internal and external energy mass transfer).
2. Drying theory and its application (sublimation drying, drying in a fluidized bed and in a suspended state, infrared drying, spray drying, combined drying methods).

Professor A. S. Ginzburg reviewed all the papers in detail, and discussed the possible future development of the theory of drying and its application.

Professor Yu. A. Mikhailov considered the thirty-two papers submitted on *Analytical Methods for Solving Heat- and Mass-Transfer Problems.*

In his review report he mentioned the great successes achieved by thermal physics during recent years, and its ever-increasing importance in the development of new techniques and progressive technology. The thermodynamics of irreversible processes played its essential role in the development of thermal physics. It was gradually becoming a universal theoretical basis of physical-kinetic processes and macroscopic transfer processes.

The successes of thermal physics were, he said, closely connected with the application of the

analytical theory, whose significance increased continuously.

However, certain pseudo-scientific investigations had been occurring recently. Problems had been studied which were estranged from practice, and did not contribute anything new to the subject.

Professor Yu. A. Mikhailov maintained that the demands for analytical investigations should be more severe. It was not only necessary that these investigations should satisfy mathematical correctness in all the transformations, but that the advantage of a particular method or investigation over others should be shown, and the results of these investigations should be conveniently useable in practice. Such demands would raise the mathematical and physical level of the specialists and contribute to a wider use of their results.

The papers on analytical methods for solving heat- and mass-transfer problems presented at the conference satisfied these demands as a whole, he said, and reflected the main trends in the development of the subject. They were devoted to the following problems:

1. Non-linear problems.
2. The development of new methods for solving a system of differential heat- and mass-transfer equations.
3. The calculation of unsteady transfer potential-fields in laminated systems.
4. The same in systems with a moving boundary.
5. Approximate methods of solution of heat conduction equations.
6. Methods of calculating radiative heat transfer.

Professor Yu. A. Mikhailov reviewed in detail the papers belonging to each group. In addition, he noted that it was necessary to expand the theoretical methods of investigation in the field of radiative heat transfer, which basically differed from the methods used in conduction and convection, and also in diffusion and in transfer in the fields of electromagnetic and other mass forces.

Professor P. N. Romanenko reviewed the twenty-eight papers on *Calculation Methods and Simulation of Heat- and Mass-Transfer Processes.* These were mainly concerned with heat transfer; mass-transfer processes were considered only in papers concerned with problems on heat transfer complicated by mass transfer. Approximate methods of calculation and simulation of heat conduction processes and of convective and radiative heat transfer under different boundary conditions were studied, and new applications of these methods for solving practical problems of modern techniques were proposed in the majority of the works.

At the end of his review report, Professor P. N. Romanenko mentioned that the content of the papers presented showed that Soviet scientists and thermal engineers were successfully developing methods of calculation and simulation of heat- and mass-transfer processes in those practically important fields of modern techniques, for which it was impossible to obtain exact solutions.

Professor A. F. Chudnovsky and Professor G. N. Dulnev gave a review report on *Thermal Properties of Various Materials, Heat Conductors and Methods of Their Determination.*

In the opening part of their report they noted that many thermal physicists showed a wrong attitude towards the problems of determination of physical constants. Some thought that no fundamental matters were involved, and that it was simply a matter of solving auxiliary problems: values of thermal properties of bodies were merely determined with this or that degree of accuracy. Such an opinion was radically incorrect, since the formulation of the problems and the theoretical solutions themselves depended on the character of the thermal properties and the factors which influenced them. In many cases physical "constants" were not constant, and the whole problem had an entirely different solution.

Thirty-five papers were presented on this subject. These were divided into three sections:

1. The development of the theory of thermal properties and the calculation of their physical nature.
2. Methods for determining thermal properties, calculation and experimental methods.
3. The establishment of relations between thermal properties and the numerous factors which influence them.

Before considering the individual papers, the speaker dwelt on the present position of the assessment and analysis of thermal properties of materials. The specified concepts of the thermal properties of materials describes the scheme for the classification of these thermal properties.

The critical review of all the papers was made on the basis of this analysis.

The Conference was concluded by a general discussion and the adoption of a resolution.

The wide opportunities afforded by the Conference for the presentation of new information, the exchange of views and mutual consultations were of great value, both to the participants themselves and to the general development of the subject of heat and mass transfer.

The Second All-Union Heat- and Mass-Transfer Conference will undoubtedly favour both the further development of scientific investigations in heat and mass transfer, and the consolidation of the friendship and co-operation between scientists all over the world.