A SUMMARY OF THE WORK OF BELORUSSIAN THERMOPHYSICISTS ON THE OCCASION OF THE FIFTIETH ANNIVERSARY OF SOVIET BELORUSSIA

The development of Soviet Belorussia, which recently celebrated the fiftieth anniversary of its foundation, is a clear demonstration of the realization of Lenin's national policy in the Soviet Union. During the years of Soviet rule, Belorussia – previously the most backward region of tsarist Russia – has developed into an industrial republic with an advanced level of culture and science.

Illustrative of this fact is the development in the BSSR of the science of heat and mass transfer, in addition to the development of the thermophysical research reported in our journal.

Recently, on the occasion of the fiftieth anniversary of the Great October Revolution, the Journal of Engineering Physics reported on the achievements of Soviet scientists, including the Belorussians, in connection with the research being done in the field of heat and mass transfer.

To avoid repetition, we will recall here only certain of the projects, among which are new efforts not mentioned earlier, in addition to certain specific facts which characterize the development, in the Republic, of scientific research in this branch.

Prior to the days of Soviet rule, there was not a single educational institution in Belorussia, nor any physics or engineering science laboratory.

Presently, in Belorussia, there are scores of scientific research institutes and higher educational institutions. Among these there are facilities in which general or specialized research is being conducted into the processes of heat and mass transfer. Suffice it to cite the Institute of Heat and Mass Transfer of the BSSR Academy of Sciences (ITMO), the Institute of Nuclear Power of the BSSR Academy of Sciences, the Belorussian Branch of the Krzhizhanovskii Power Engineering Institute, the Institute of Water Problems, the Belorussian Polytechnic Institute, the Scientific Research Institute of the BSSR Building Materials Industry, and the Kirov Technology Institute of Belorussia.

Some of these institutes – the Institute of Nuclear Engineering, the Institute of Water Problems, the Belorussian Branch of the Krzhizhanovskii Power Engineering Institute – eventually evolved as independent scientific institutions out of the Institute of Heat and Mass Transfer of the BSSR Academy of Sciences.

The Institute of Heat and Mass Transfer of the Belorussian Academy of Sciences is the chief organization in the Soviet Union concerned with the problem of mass and heat transfer in technological processes. The presiding officer of the Science Council of the State Committee of the USSR Council of Ministers, responsible for this field of endeavor, is the director of the institute, Academician A. V. Lykov, who simultaneously serves as the deputy director of the National Committee on Heat and Mass Transfer of the USSR Academy of Sciences, and of the 12 members of the committee, two are active in Belorussia. Of the two representatives from the Soviet Union in the international congress on heat and mass transfer, one is from Belorussia.

Belorussia publishes 3 science–engineering journals dealing with the various problems of heat and mass transfer and thermal engineering: the All-Union Journal of Engineering Physics and "Énergetika," the Bulletin of the Higher Educational Institutions, as well as the Physics-Power Engineering Series of the Bulletin of the BSSR Academy of Sciences. It is in Belorussia that we find the editorial offices for the Soviet Union of the International Journal on Heat and Mass Transfer. A Belorussian scientist is the USSR editor for this journal.

Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 16, No. 1, pp. 5-8, January, 1969.

Equally natural is the regular convening in Belorussia – in Minsk – of the All-Union conferences on heat and mass transfer, attracting an ever-increasing number of participants, not only from the USSR, but from abroad as well. Thus, while the first conference in 1961 attracted a total of only 740 people, including 15 foreign scientists from 8 countries, the proceedings of the 3rd All-Union conference in Minsk in 1968 were attended by 1217 people, including 82 foreign scientists from 15 countries (Czechoslovakia, the German Democratic Republic [GDR], Bulgaria, Hungary, Poland, Yugoslavia, the USA, England, the Federal Republic of Germany [FRG], Japan, France, Holland, etc.). The largest foreign delegation (24 people) participating in each section of the conference in 1968 came from Czechoslovakia, which maintains the closest of relations with the scientists of Belorussia.

The plans calling for the direct cooperation of the institutes with various scientific institutions of the socialist countries are being put successfully into effect. As an example, we can cite the scientific cooperation between the ITMO [the Institute of Heat and Mass Transfer] and the Czechoslovak Institute of Machine Building and the Institute of Thermal Mechanics of the Czechoslovakian Academy of Sciences; during the course of this cooperation, the Czechoslovakian scientists familiarized themselves in Minsk with the work being done in the laboratories of the ITMO of the BSSR Academy of Sciences and with the results of this research. The scientists of the ITMO paid return visits to the Czechoslovak Soviet Socialist Republic.

An agreement has recently been concluded for the direct cooperation between the ITMO and one of the research institutes of the Ilmenau Engineering School in the GDR. Negotiations are underway to conclude cooperation between Belorussian and French scientists from the Laboratory of Thermoaerodynamics at the National Center of Scientific Research in France. A number of young Belorussian scientists, specialists in heat and mass transfer, have been and are continuing to be trained in the leading scientific institutions of the USA, England, and France. Scientists and engineers from Bulgaria, Czechoslovakia, India, and the USA are being trained in a number of Belorussian institutes.

Scientists from the ITMO and the Institute of Nuclear Power of the Belorussian Academy of Sciences have traveled to deliver lectures in Bulgaria, Czechoslovakia, the USA, England, and France.

The Lenin State University in Belorussia is the second school in the USSR to train specialists in the field of thermophysical research (the university is staffed with a special department of thermophysics).

Several score of Belorussian postgraduate students are preparing their dissertations on various problems of heat and mass transfer.

In Belorussia, in particular at the ITMO, important results in the development of the science and its new techniques have been achieved along a broad front in heat- and mass-transfer research. The work of the Minsk school on the theory of heat conduction and on heat and mass transfer is widely known. Texts in these important areas of science have been translated in various countries (England, the USA, Hungary, the Chinese People's Republic [CPR], etc.).

In Belorussia, as noted in the earlier-cited anniversary article, systematic research has been conducted on the hydrodynamics and heat transfer of fluidized systems, these being of great promise for numerous technological processes. On the basis of this research, a new method has been developed, in particular, for the nonoxidative heating of metal.

Fundamentally new and important results have recently been achieved in research on free convection. The phenomenon of anomalous convection had been predicted theoretically and observed experimentally (the excitation of motion of medium through heating from above). An effective pore size has been found for a capillary-porous body to ensure the best convection.

Research important for science and the national economy is being conducted by a number of departments and problems laboratories of the Belorussian Polytechnic Institute in the field of structural thermophysics, industrial aerodynamics, and the transfer of heat in industrial furnaces. Note should be taken of the work on nonisothermal air jets, streams of air in enclosures, dehydration of materials through sudden pressure reduction, as well as the development of new heat-exchange equipment.

The thermophysicists at the Kirov Technology Institute of Belorussia are doing important work in the field of heat and mass transfer in the hardening of concrete in a vapor medium, and in the transport of heat and matter in equipment for the production of polymers.

Interesting work is being done in the field of heat and mass transfer at the Institute of Construction and Architecture of the State Ministry of Construction of the BSSR, at the Institute of Building Materials, at the Mogilev Machine-Building Institute, and at a number of others.

In recent years particularly intensive studies are being conducted at the ITMO into the processes of transport in rheological systems, i.e., in flowing media exhibiting combinations of properties in various ratios: plasticity, shear, high elasticity, mechanical retention, strength, and the entire range of relaxation characteristics.

The experiments and calculations based on the measurements of convection mass transfer employing the method of electrochemiluminescence in a polymer solution led to the establishment of a new quantitative relationship for the separation of the boundary layer from the surface of poorly streamlined bodies. In the regions of those values of effective Reynolds numbers for which, in normal (Newtonian) liquids and gases, the point of separation on a laterally streamlined circular cylinder is stationary with the azimuth between 80 and 90°, an unusually great retardation of the separation is observed in viscoelastic polymer solutions, all the way to an azimuth of 165-170°. Longitudinal self-oscillations of the separation lines with a rather large amplitude and the degeneration of the small-scale structure of the vortices in the trailing region are observed simultaneously. This kind of quantitative relationship must apparently prevail for all separation streamlining of bodies, whether external or internal (particularly in diffusers).

Precision measurements have led to the establishment of the interesting fact that the addition of comparatively small quantities of high-molecular substances into the laminar boundary layer reduces its stability and result in its premature turbulization. Here the value of the critical Reynolds number may diminish by a factor of 10 and even of a hundred. This interesting and little-studied phenomenon is of fundamental importance not only for hydromechanics, but primarily for the theory of convection heat and mass transfer.

Totally unlimited prospects are offered by the new and virtually untouched field of electromagnetic rheology. We refer to the rheological behavior of flowing systems in electric and magnetic fields. Experiments performed in the USA and at the ITMO demonstrate that the application of comparatively moderate electric fields (with strengths of approximately 3-5 kV/mm) leads to an increase in the effective shear viscosity by 2-3 orders of magnitude, as well as to a pronounced change in the very nature of the rheological relationship between the frictional stress and the rate of shear. A linearly viscous fluid seemingly becomes non-Newtonian.

This phenomenon is interesting not only from the physical or physicomechanical standpoint, but it offers a wealth of possibilities for numerous applications (for example, the regulation and measuring of flow rates in closed conduits, down to the virtually complete blockage of the channel).

Many flowing systems, isotropic prior to the onset of motion, in the process of shear flow become anisotropic and are capable of maintaining this new state on occasion for any length of time (systems with permanent retention).

Under such conditions we naturally encounter the problems of convection transport in nonisotropic media. Till now such problems have been primarily the concern of crystal physicists, and only to the extent that they related to the problems of molecular transport (heat conduction, diffusion). Research performed at the institute showed a noticeable relationship between the conduction of heat and the rate of shear for viscoplastic systems with great mechanical retention. A relationship has been established between the isotropic heat conduction (prior to the onset of plane flow) and the components of the heat conduction across and along the shear surfaces.

As a result of extensive theoretical and experimental research, a new rheological law has been proposed for nonlinear viscoplastic systems such as printing inks, water-repellent slurries, charged fuels, and similar substances.

On the basis of these quantitative relationships a number of important boundary problems relating to resistance and heat and mass transfer have been solved for motion in tubes and channels. This research was reported at the Third All-Union Conference on Heat and Mass Transfer in Minsk, May, 1968.

From 1963 through 1968 basic theoretical research was performed at the ITMO into the problems of the boundary layer for purely viscous rheological systems. An extremely significant, useful, and valuable result of this research is the determination of a class of self-similar boundary-layer problems, important from both the theoretical and the applied standpoints. This research was published in 62 papers and in reports read at international and domestic conferences.

Research is being done at the Institute of Heat and Mass Transfer of the BSSR Academy of Sciences on the development of gas lenses for laser beams. The research in this new scientific branch, known as aerothermooptics, is significant for the development of lightguide lines. The problem of aerothermal optics is one of the concerns of the theory of heat and mass transfer; it arose through the merger of such sciences as aerodynamics, heat and mass transfer, and optics.

Belorussian scientists are reporting on heat and mass transfer at numerous international conferences and symposia. More than 30 of their papers have been published in the International Journal on Heat and Mass Transfer.

The thermophysicists of Belorussia are striving toward the most rapid dissemination of the results of their scientific endeavors throughout the national economy of the USSR.