DOCTORAL DISSERTATIONS IN THERMOTECHNICAL SCIENCES APPROVED BY THE SUPREME CERTIFYING COMMITTEE

P. D. Lebedev*

The Supreme Certifying Committee has conferred the Doctor of Technical Sciences degree on the following staff members of scientific institutions, higher institutes of learning, engineering bureaus, and industrial plants.

1. Boris Petrovich Mironov (born in 1930) for defending his thesis on the subject "Study of a turbulent boundary layer at a permeable surface."

The paper deals with an experimental study concerning the structure and the laws of a turbulent boundary layer at a permeable surface. The conditions are established under which a displacement layer appears and thorough measurements of this flow mode are reported. The effects of the Mach number, of the temperature factor, and of the pressure gradient on the heat transfer and on the critical injection parameters are analyzed thoroughly and systematically. Design recommendations are made. Data are given pertaining to the stability of a laminar sublayer under various modes of injection.

2. Andrei Leonidovich Kuznetsov (born in 1933) for defending his thesis on the subject "Study of the heat transfer and the temperature field in turbine components and of the thermal process in a runner during industrial operation of gas turbines in gas pipeline systems."

The heat transfer and the flow of coolant air in the face cavities of gas turbine runners during jet or radial-jet injection is analyzed theoretically and experimentally.

Methods are developed for calculating these processes, on the basis of the theoretical solutions to boundary-layer problems with a rotating disc and on the basis of many experimental studies made with models as well as with actual turbines in operation.

Proved is also the method of simultaneously examining the heat transfer and the air flow in the zone of impact between a jet and a rotating disc, taking into account the special characteristics of a developing stream (and its parameters) in a face cavity. Universal relations are derived which explain the heat transfer during various modes of cooling the rotating turbine elements.

The procedure for designing the cooling of gas turbine runners is now widely used in practice.

3. Leonard Stanislavovich Pioro (born in 1925) for defending his thesis on the subject "Increasing the heat transfer rates in ore smelting aggregates."

A general theory of the process is presented in the paper and results are shown of applying it in industry.

The author's main achievement is his solution to problems of immersed combustion in nonmetallic melts. Immersed combustion was studied not only in the laboratory but also under industrial conditions.

4. Boris Petrovich Ustimenko (born in 1918) for defending his thesis on the subject "Study of the aerodynamics and the heat transfer during a rotary flow of a viscous fluid."

The mechanism of turbulent mixing is studied and the general laws of a turbulent stream in a field of centrifugal forces are established. Modern apparatus and procedures are used for measuring the

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stream parameters, including the intensity of velocity fluctuations.

The author's calculations and test data agree closely with those of other researchers.

5. Evgenii Ivanovich Mikulin (born in 1924) for defending his thesis on the subject "Study of multistage cryogenic systems."

A theory is developed for designing and analyzing complex multistage cycles commonly used in large cryogenic apparatus with many components (machines and heat exchangers), where the performance is governed by the amount of energy losses.

Considered are cycles for the liquefaction of gases, particularly hydrogen and helium, and the apparatus for this purpose is discussed along with cryogenic refrigeration apparatus.

A theoretical basis is developed for selecting the proper number of cooling stages in liquefaction cycles, refrigeration cycles, and in gas cooler cycles.

A method is developed for calculating complex liquefaction and refrigeration cycles, by which all heat and mass flows can be found from a universal relation covering all the various cycles.

The P. Kapitsa problem concerning the determination of temperature levels in series cycles is generalized and further extended. A procedure is proposed for optimizing the ratio of flow pressures. A set of formulas is derived for an entropy analysis of systems built with standard components.

6. Aleksandr Dmitrievich Suslov (born in 1923) for defending his thesis on the subject "Study of the working processes in low-temperature thermostaticizing machines and apparatus."

A general method is developed for analyzing microcryogenic engineering machinery and apparatus; machines with built in instruments is analyzed and a design method is proposed. Proposed is also a method for analyzing machines with many expansion cavities, by replacing such a machine with an equivalent single-stage one. A built in regenerator is examined and a method of designing it is proposed where the thermal conductivity of the gas and of the vane as well as the pressure in the cavity and the gas flow rate cannot be assumed constant. A new cycle is proposed for a machine with an expeller and several measures are suggested for improving the characteristics of cryogenic apparatus, etc.

7. Vsevolod Georgievich Tyryshkin (born in 1918) for defending his thesis on the subject "Methods of aerodynamically improving the flow stage of stationary gas turbines."

The main and most important research work by the author over the past years is summarized and new methods are presented for calculating the flow in the interrow clearances of a turbine stage.

The proposed banding of buckets and use of labyrinth seals for a higher reactivity at the root sections of a turbine stage are justified theoretically and are proved out experimentally.

The methods used for the design of a flow stage have contributed to an improvement of the efficiency of steam turbines.

8. Pavel Alekseevich Zhuchkov (born in 1912) for defending his thesis on the subject "Study concerning the effectiveness of various methods of intensifying the thermal processes in desiccators for drying thin and disperse materials in the cellulose-paper industry."

The paper is a result of a manysided experimental–theoretical engineering study of the drying processes, made under industrial as well as under laboratory conditions, and a development of engineering design methods for desiccators with recommendations for a more effective organization of the drying processes to be implemented by the cellulose-paper industry. Methods are developed for the design of convective and convective–radiative drying of sheet and disperse materials under variable conditions in continuous-process apparatus and in multicylinder desiccators. Methods are also proposed for optimizing the process conditions and intensifying the processes.

9. Leonid Aleksandrovich Brovkin (born in 1923) for defending his thesis on the subject "Study of heating and melting processes."

A new method is developed for a composite design of metallurgical heating furnaces, taking into account the interrelation between internal heat transfer (temperature changes in the metal during heating, charring, and melting) and external heat transfer (radiation from the gas stream and from the brickwork; arrangement of burners, circulation of gases, etc.). The thermophysical properties of the materials are

determined, and transient heat conduction processes in metals are analyzed under various boundary conditions.

Nomograms are given for the design of heating furnaces by the procedure developed here.

10. L'ev Davidovich Volyak (born in 1912) for defending his thesis on the subject "Experimental study and calculation of the thermodynamic properties of alkali metal vapors."

Analyzed are the methods and the results of determining the thermochemical constants of alkali metals. Four test stands are developed set up for a precise measurement of the saturated-vapor pressure of alkali metals by the static equilibrium method, one up to 1200°K and the second up to 2000°K. Pressure measurements are given for sodium, potassium, rubidium, cesium, and lithium. The specific heat of superheated potassium vapor at 1 atm and 1100°K is measured. The test results on saturated-vapor pressure are used for calculating the dissociation energy and heat of sublimation of alkali metals.

The test data on the specific heat of potassium vapor are used for calculating the dissociation energy of a molecule. Refined are also the values for the dissociation energy of metal molecules as well as the values for the heat of sublimation of lithium, sodium, and some other metals.

Tables are compiled showing the thermodynamic properties of the alkali metal vapors within the pressure range from 10^{-5} to 10 bars and within the temperature range up to 10 bars and within the temperature range up to 3000°K, also graphs are plotted accounting for dissociation and ionization.

11. Fedor Frantsevich Zigmund (born in 1905) for defending his thesis on the subject "Study of certain process laws in heat exchangers for the chemical and the petrochemical industries."

A study is made of steady-state thermal processes in tubular recuperator-type heat exchangers used by the chemical and the petrochemical industries. A set of relations is derived for determining the mean temperature difference in heat exchangers where the heat carriers flow in complex patterns, suitable for analytical calculations as well as for programming on a digital computer.

12. Boris Mokeevich Gonchar (born in 1919) for defending his thesis on the subject "Numerical simulation of the working process in Diesel engines."

For a description of the working cycle in Diesel engines, a universal system of differential equations is proposed which applies to all the processes during a cycle, including the highly complex gasodynamic processes in manifold intake and exhaust systems.

In order to justify the boundary conditions necessary for solving this system of differential equations, the working process in Diesel engines is thoroughly examined both theoretically and experimentally.

A program for mumerical simulation is designed which can be used on many different digital computers.

With the method developed here, it is often possible to avoid testing original systems and to substitute numerical simulation on a digital computer instead, with only the final variant proved out on the test stand.

13. Nikolai Ivanovich Nikitenko (born in 1934) for defending his thesis on the subject "Analysis of transient heat and mass transfer processes by the grid method."

An original difference scheme is developed for solving the three-dimensional Stefan problem applied to heat transmission through a system of bodies with movable interphase boundaries.

An algorithm is developed for a numerical analysis of the ingot crystallization process. The paper deals also with explicit computation schemes based on the grid method, for solving several complex problems concerning heat and mass transfer during high-rate thermal processes as well as problems concerning thermal and hydrodynamic boundary layers.

All the problems are treated thoroughly, beginning with their formulation, developing the numerical method of their solution, evaluating the convergence of the computation process, through the actual calculation on a digital computer and the making of approriate recommendations.

14. Vladimir Elifer'evich Nakoryakov (born in 1935) for defending his thesis on the subject "Heat and mass transfer in oscillating and pulsating streams."

A theorm is developed concerning heat and mass transfer between an oscillating stream and a body in the absence of any unidirectional flow of the stream, whereupon the electrochemical method of measuring tangential stresses is justified theoretically and proved out experimentally. It is shown that the machanism by which acoustic vibrations affect the heat and the mass transfer is not the same at low values and at high values of the Prandtl number.

15. Nikolai Aleksandrovich Rubtsov (born in 1927) for defending his thesis on the subject "Study of radiative and combined heat transfer."

Some intricate problems of combined radiative–convective heat transfer are solved with the air of electronic computer techniques and modern numerical methods, solutions are obtained also to many problems of transient radiative–conductive heat transfer. A comparison between the calculated solutions (taking into account the spectrum selectivity) and experimental data establishes the limits within which models of the medium are applicable. The method of numerical solution shown here is characterized by an excellent convergence and is widely used in practice for engineering calculations.

16. Vladimir Ivanovich Metenin (born in 1916) for defending his thesis on the subject "Study of the working processes and cycles in air-type refrigerators."

Studies are made concerning the optimization of the operating mode of a vortex tube, and the optimum thermodynamic process in it established. A vortex tube which satisfies the established criteria has on the average 40% better characteristics than those of earlier known designs.

A general theory is developed for calculating ideal and real cycles, for analyzing such cycles theoretically at various levels of refrigerating capacity and with technological requirements as well as plant improvement taken into consideration.

17. Aleksei Petrovich Chernobrovkin (born in 1920) for defending his thesis on the subject "Study concerning the efficiency of cycles and the development of high-power gas turbines and compound machinery."

New gas-turbine and compound cycles are analyzed thermodynamically in this study, whereupon the definition of optimum parameters for various cycles (open, semiclosed, closed with the properties of real gases taken into account, compound MHD-gas, and gas-turbine) is generalized theoretically.

The paper is characterized by a practical approach, which combines theoretical analysis with ample application of several promising gas-turbine designs and their engineering-economic evaluation, and by the experimental approach to proving out a few basically new gas-turbine components.

18. Vladimir Maksimovich Rushinskii (born in 1926) for defending his thesis on the subject "Mathematical models of the vapor generation process in boiler aggregates and the feasibility of their application to inspection-and-control system."

An engineering method is proposed for the design of mathematical models to represent boiler aggregates with a subcritical or a supercritical working medium, considering the distribution of individual parameters along one coordinate.

Both analog and digital computers are used to a large extent for determining the frequency characteristics of the total system and of its components.

New schemes are proposed for the inspection and the control of an energy generator, based on more thorough information about the evaporation process coming from the control computer, in which the parameters of the mathematical model of the process are stored and continually corrected.

19. Yakov Prokhorovich Starozhuk (born in 1910) for defending his thesis on the subject "Study of the working process in heavy-draft combustion chambers and development of design methods."

The paper presents results of a long study cycle concerned with the combustion chamber of power gas turbines and steam-gas turbines. The thermal field in the material of such a chamber, with a characteristic presence of soot in the flame, is determined on the basis of tests.

The author evaluates the convective and the radiative components of thermal flux at the walls, the emission characteristics of a fuel-oil torch and the attenuation factor over a wide range of operating conditions, and the effect of such important parameters as pressure in the chamber, excess air, type of fuel, variation of soot content along the chamber, etc., on the absorption of radiant energy.

Extensive studies are made of the flow in the reverse-flow zone. It is proved that an approximate simulation of homologous chambers is feasible.

20. Zenon Filimonovich Nemtsov (born in 1929) for defending his thesis on the subject "Thermal economy of power systems."

The paper is devoted to a study of fuel consumption rates in thermoelectric power plants and to finding means of their optimization.

Scientific methods are proposed for calculating and analyzing per unit rates of heat flow and fuel consumption in power systems, also for improving the economy with respect to several indicators.

These complex problems are solved, within an accuracy acceptable for practical purposes, with the aid of modern computer techniques. Generalizing relations are derived for an evaluation of available data on existing and future thermal power plants, whereupon recommendations are given on ways to improve the fuel economy.

21. Grigori Naumovich Zlotin (born in 1925) for defending his thesis on on the subject "Study of the performance characteristics of a carburetor engine under certain operating (transient) conditions."

A study is made concerning the combined effect of several operating parameters (number of rpm, rate of throttle change, speed of choke opening, initial carburetor adjustment, etc.) during transient conditions on the amount of torque, on the fuel economy, on the volumetric efficiency, on the temperature field, on the air–fuel ratio, and on the characteristics of the basic phases in the combustion process.

The results of this study reveal a few typical features of internal-combustion engine performance during transient conditions and will help to improve the economic indicators of carburetor engines as well as to reduce the toxicity of exhaust gases. Several mathematical relations based on this study make it feasible to analyze the probable effect of operating parameters on engine parameters and thus either to eliminate or at least to reduce the number, the time, and the cost of special tests otherwise needed for evaluating the engine performance under transient conditions.

22. Nikolai Mikhailovich Zinger (born in 1923) for defending his thesis on the subject "Study of hydraulic and thermal modes in central heating systems and development of design methods."

The author solves the problem concerning a composite analysis of almost all basic components in multibranch and multiring water heating systems.

The feasibility of using hydraulic and electric analogs for the analysis of such systems is studied and verified, a general algorithm is developed, and a procedure is developed for appropriately using here a digital computer.

The advantages of using a digital computer here are pointed out and are illustrated on examples. It is demonstrated that the use of a digital computer ensures not only a satisfactory precision but also fast results, which becomes especially important when switchovers are necessary for a reliable and effective operation during emergencies.

23. Evgenii Fedorovich Ratnikov (born in 1912) for defending his thesis on the subject "Study of cycles and systems in atomic steam-gas plants."

A composite study is made of atomic steam-gas plants and a comparison is made with atomic gas turbines. The effects of various parameters on the economy of an atomic steam-gas plant are shown, and conclusions are drawn concerning the optimization of gas–turbine systems, steam power plants, and atomic steam-gas plants; variable operating conditions are considered and also the technical-economic aspects of an atomic steam-gas plant. The feasibility is demonstrated of gaining an appreciable economic advantage by converting to atomic steam-gas power.

24. Iosif Semenovich Disker (born in 1922) for defending his thesis on the subject of "Variational methods of experimentally analyzing the thermophysical and the electrophysical properties of solids."

The paper deals with problems concerning the physical justification and the technical feasibility of experimentally analyzing the properties of solids by variational methods proposed by the author for determining the thermophysical and the electrophysical properties of solids in thermal, electric, and magnetic fields.

The methods of measurement developed here yield a composite determination of the thermophysical and the electrophysical properties of a solid in a single test, and they yield the maximum amount of information about a given test object in a specified number of force fields within a sufficiently high accuracy. The high accuracy is achieved because of the possibility of separating the basic effects from the superposed effects in a given test. These methods are used in practice.

25. Érik Ivanovich Asinovskii (born in 1933) for defending his thesis on the subject "Experimental Studies, with the aid of electric arcs, of the optical and the transmission properties of a low-temperature plasma."

A composite study is made of the optical and the transmission properties of low-temperature plasmas generated from various gases. Data are obtained on the relation between the kinetic factor and the degree of ionization, over a wide range of plasma parameter values.

A method is proposed for simultaneously determining the temperature field, the bulk heat generation, and the divergence of the radiant flux. Rather reliable data are obtained on the thermal conductivity and the electrical conductivity of argon, nitrogen, air, and gaseous carbon dioxide over a wide temperature range. The optical characteristics of a low-temperature plasma are also examined.

Further studies concern the shifting of photoionization thresholds in an argon atom due to an increasing electron concentration in the plasma, the effect of photoadhesion between electrons and a neutral nitrogen atom on the optical properties of the nitrogen plasma and of air plasma. The intensity distribution in the continuous spectrum of gaseous carbon dioxide is found from measurements.

26. Georgii Borisovich Narinskii (born in 1925) for defending his thesis on the subject "Thermodynamic principles of partioning air by low-temperature rectification."

The paper deals with theoretical and experimental studies concerning phase equilibria and the process of rectifying the oxygen–argon–nitrogen system, also with the development of methods by which the rectification of this mixture can be analyzed and apparatus for partitioning air can be designed.

A method is developed for checking the thermodynamic validity of test data and then quantitatively evaluating the results of such a verification, applicable to the entire concentration range as well as to separate portions of that range. The method is based on comparing true deviations from the equilibrium equation with those possible because of measurement errors. Important is the method developed here of mathematically describing the equilibrium relations for a binary and for a ternary system, on the basis of which are then derived equations relating the relative volatility, the fluid composition, the temperature, and the pressure.

These equations yield tables and graphs which are necessary for calculating the air partitioning process.

27. Redzhinal'd Evgen'evich Krzhizhanovskii (born in 1928) for defending his thesis on the subject "Thermal conductivity and electrical conductivity of alloys and pure metals."

A study is made concerning both the thermal and the electrical conductivity of 53 different grades of steel, from pure iron up to high-alloy (of the order of 50%) grades, also of nickel and titanium alloys. The study covers a temperature range from 100 to 1100°C, which is very important for an analysis of transfer phenomena in liquid metals.