

THE GAS INSTITUTE — HISTORY AND MODERN SCIENTIFIC ACTIVITIES

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The Gas Institute has a more than 60-year history. It was established because of the necessity to solve various scientific and practical problems related to the supply and use of natural gas in industry and municipal sectors. For many years the scientists of the Institute have been carrying out important fundamental and applied researches aimed at the development of advanced energy-saving technologies and equipment for solving the above-mentioned problems. Recently, the shortage of fuel and energy resources has set the priority of their more efficient usage, as well as application of alternative and nontraditional energy sources, along with utilization of wastes.. The finding of solutions for these problems, along with the new research directions, are the basis for contemporary research and development activities in the Institute nowadays.

KEY WORDS: *Gas Institute, metallurgy, industrial heating, gas processing, gas transport, ecology*

The Gas Institute was founded in 1949 and now is a part of the National Academy of Sciences of Ukraine (NAS of Ukraine), Department of Physical-Technical Problems of Power Engineering. The founder of the Institute and its first director was Academician N. N. Dobrokhotov, an outstanding metallurgist. Academician V. F. Kopytov, who was director of the Institute from 1952 to 1985, and Academician I. N. Karp, the director from 1986 to 2002, made great contributions to the formation and development of the Institute. Since 2003 the Institute has been under the directorship of Academician B. I. Bondarenko.

The necessity for founding the Institute was indispensable because of the rapid development of the gas industry, construction and operation of gas pipelines, as well as because of the need for solving common problems of gas supply and its usage in many branches of national economy at the end of the 1940s.

During the entire period of its activities, the Institute has combined fundamental and applied researches. From the first days of its creation, the Institute started and then broadly developed basic studies in the high-temperature thermodynamics and thermochemistry, applied theory of combustion, heat and mass exchange in furnaces, the study of the thermophysical properties of hydrocarbons, separation of gas

mixtures and their processing, natural gas conversion, dynamics of gas-transportation systems, fluidized-bed processes, mathematical simulation and automation of technological processes. These studies have enabled the Institute to accomplish the tasks of efficient and rational natural gas utilization in industry and municipal engineering.

The Institute's researchers have developed a number of major projects on re-equipment of industrial furnaces for using a natural gas in metallurgy, re-equipment of glass-melting furnaces, as well as building-material industry and heating systems of communal services. The technology and equipment have been developed for nonoxidizing metal heating, direct iron reduction from iron ore, thermal treatment of electric steels in a protective gas atmosphere, indirect radiation heating of materials in heating furnaces, production of high-quality iron powders using hydrogen atmospheres, for generation of low-temperature plasma of hydrocarbon gases combustion products and plasma spray-coating of materials, steam reforming of methane and its catalysts, etc. Practically all of these projects have been implemented in the industry in order to reduce specific consumption of energy and raw materials, increase of product quality, and improve the labour conditions.

In the 1960s, the Institute began studies on the formation of toxic substances during fuel burning. The studies owed their origin to the need to develop scientific recommendations on air protection against gaseous industrial pollutions. The Institute has by now developed a scientific basis for revealing the generation of high-toxic nitric oxides in burning and devising effective methods and technical means of reducing it in fuel-burning units, as well as the methods of thermal and catalytic-thermal purification of technological and gas vent discharges from toxic organic admixtures.

The world-wide fuel and energy shortage calls for energy saving, which includes a more efficient use of energy resources, the use of secondary, alternative, and nonconventional power sources, and development of energy-saving technologies and equipment. These are the problems that determine the Institute's research, scientific, and technological activities today.

A concise description of the main Institute's developments from the very beginning of its foundation is given in what follows.

In metallurgy, Academician N. Dobrokhotov initiated the studies on the use of natural gas in the production of steel. As a result, a scientific basis has been developed for re-equipment of open-hearth furnaces for using a mixture of coke-oven and blast-furnace gas and fuel oil, instead of a natural gas. The results of these developments were applied at many metallurgical and machine-building enterprises, improved the performance of industrial furnaces, and decreased the consumption of fuel. The Institute occupied a leading position in the USSR in the field of metal recovery and especially direct production of iron. The Institute was the first in the USSR to introduce an installation for metallization in the shaft furnace and in a fluidized-bed reactor. The Institute participated actively in building the "Zaporozhstal" plant in the 1960s.

A considerable amount of research into the processes of heating and thermochemical treatment of steels has been done under the supervision of V. Kopytov. On the basis of the results obtained, the technologies of metal and material treatment in special gaseous media, including automobile body sheet and electric steel, have been devised, which resulted in the radical improvement of the quality of steel.

The Institute occupies a leading position in Ukraine and CIS countries in the field of technology of production of metal powders. Here attention should be paid to the development of the technology and equipment for the first, in the USSR, production of iron powders. It helped to stop the import of high-quality powders from Sweden and to create the first Soviet production of rechargeable iron powders for alkaline batteries under the supervision of Academician B. Bondarenko.

In the field of industrial heat engineering, the theory of radiant heat exchange in furnaces under nonuniform temperature conditions along the gas flow has been developed under the leadership of Prof. N. Zakhariukov. The results of these works have been widely introduced in glass industry.

The specialists of the Institute proposed and elaborated the method of indirect radiative heating of metal in the metallurgy and mechanical engineering furnaces and designed burners for its realization. This method provides 25% fuel economy in metal heating, reduced losses of metal from oxidation, and increases the productivity of furnaces. The method is widely introduced at the metallurgical enterprises of Ukraine, CIS countries, and also in Hungary, Bulgaria, Algeria (Prof. A. Erinov, Prof. B. Soroka).

In the field of gas processing and transport, Prof. A. Klimenko with co-workers has devised refrigeration cycles in natural gas liquefaction. Such cycles became classical in refrigerating technique and were used in designing of installations for gas liquefaction in Algeria. Also, investigations in the field of the thermodynamics of hydrocarbons, processes of liquefaction and separation of gases, efficiency of gas-transport systems, use of pressure drop in pipelines, etc. have been started. The horizontal cassette absorbers for natural gas separation, drying and treating before gas transport have been developed with participation of the Institute's scientists. At the present time, such absorbers with productivity of up to 40 million m³/day are used in processing all natural gas exported from Ukraine. The Institute has developed a software for calculating gas processing.

In the field of processing fuel and minerals, we should specify the investigation of thermodynamic properties and mass transfer in a low-temperature plasma of the natural gas combustion products of in the electric discharge are being investigated (Academician I. Karp). Based on the results of these studies, an installation for thermal spraying of coatings has been devised and widely implemented in practice. Instead of inert gases and hydrogen, a mixture of a gas with air is used.

Also, the Institute's researchers have developed methods and equipment for submerged combustion of gas fuels in mineral melts for the production of insulation ma-

terials. Expensive development has been carried out in the field of technologies and equipment for carbon sorbents production in the fluidized-bed furnaces. Important results have been obtained in the field of industrial catalysis.

Researches in the field of ecology based on the study of the formation of nitrogen oxides under natural gas combustion conditions in power plants have been conducted. The theory and methods of neutralization of the nitrogen oxide formation such as recirculation of combustion products, regulation on zones of the thermal capacity of a boiler have been developed and introduced at many power plants and heating boiler houses (Prof. I. Sigal).

Effective boiler plants for hot water supply with low nitrogen oxide emission and commercial plants for thermal-catalytic neutralization of harmful industrial emissions have been developed which obtained a wide distribution.

Under the supervision of Prof. B. Soroka, fundamental researches in the field of energy-ecology were conducted that include solving the systems of equations of chemical kinetics and dynamics aimed at determining the conditions for the reduction of nitrogen oxide by burning a natural gas. On the basis of the conducted research, scientific recommendations on the creation of combustion systems with low nitrogen oxide emission have been worked out for the first time.

The Institute is carrying out basic researches in the field of the thermodynamics of gas systems, heat and mass transfer, dynamics of gases, and thermochemistry. Based on the results of the research, new technologies and equipment for effective use of a natural gas and other heat carriers in the basic branches of industry — metallurgy; energetic, chemical, and mechanical engineering; construction materials industry, and municipal economy have been created. Among them, mention should be made of the technologies of re-equipment of natural gas-based smelting furnaces, intensification of smelting steel in electric steel making furnaces, new method of indirect heating of metal by radiant heating in chamber furnaces of metallurgy, industry of construction materials, and in production engineering of high-quality iron powders, plasma spraying coatings, thermochemical metal treatment in protective gases. Scientific foundations for calculation of gas-main pipelines have been originated, and catalysts of hydrocarbons steam reforming have been developed. A considerable contribution has been made to the environment protection for solving the problems of pollution from power plants. All the above-mentioned developments and many others are applied in the industry with great total benefits. The results obtained have been achieved owing to the creation of new research lines and science schools in the field of ferrous and powder metallurgy, industrial heat engineering, industrial ecology.

Based on the results of researchs, new technologies and equipment for effective use of a natural gas and other heat carriers in the basic branches of industry — metallurgy; energetic, chemical, and mechanical engineering; industry of construction materials; municipal economy are created.

At the present time, the scientific efforts of the staff of the Institute are directed at:

- developing scientific fundamentals for effective use of a natural gas and alternative heat carriers as a basis for creating new technological processes and proper equipment;
- research in the field of applied combustion, thermodynamics, interphase heat and mass exchange for developing, on this basis, new technological processes and equipment;
- research in the field of environment protection for creating scientific and technological fundamentals of air cleaning from pollutions, thermal neutralization of solid domestic waste, and especially dangerous substances and wastes;
- processing of biomass and a bio- and landfill gas;
- research in the field of nanotechnologies and nanomaterials.

Along with the items mentioned above, further developments of the Institute are directed at diversification of energetic resource bases, creating new energy-saving technologies to ensure energy security of the country.

The Institute structure includes seven research departments:

- Department of Natural Gas Processing and Transport (Dr. A. Piatnichko);
- Department of Atmospheric Air Protection Against Pollution (Prof. I. Sigal);
- Department of Combustion Processes (Dr. S. Pianukh);
- Department of Gas-Thermal Processes in Metallurgy (Prof. B. Bondarenko, Academician of NAS of Ukraine);
- Department of Thermal Layer Processes (Prof. Y. Khvastuhin);
- Department of Plasma Technologies (Dr. V. Zhovtiansky, Corresponding member of NAS of Ukraine)
- Department of Industrial Heating Engineering (Dr. V. Pikashov).

The structure of the Institute also includes Department of Computer-Based Systems; Department of the Technologies of Transfer, Innovation Activity, and Intellectual Property; Design office; Production department.

The Institute has a Specialized Academic Council for defending theses for receiving scientific degrees of doctor and candidate of sciences in the specialty "Engineering thermal physics and industrial heat and power engineering".

The Institute publishes scientific and technical journal "*Energotechnologies and Resources Saving*" (6 numbers per year, circulation 550 copies, index 74546) illustrating a wide range of problems, including efficient use of resources, state of environment, energy-saving and resources-economy technologies in industry, technology of waste recovery and processing, biotechnology, etc. The Institute has a research library with 110,000 printed entities.

This Special issue of the International Journal of Energy for Clean Environment combines the results of selected research and development efforts that have been performing at the Gas Institute during the last years.

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