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Role of Basic Research in Solving Current Problems of Iron & Steel Industry

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Current state and development trends of iron & steel industry in Ukraine and in the world are analyzed, the ways of metallurgical production advancement are considered, the new methods of investigation of diffusion in alloys, phase boundary and surface properties of melts, high-precision measurements of viscosity of metallurgical melts are presented.

Keywords: STEELMAKING, METALLURGICAL EQUIPMENT, DIFFUSION, PHASE BOUNDARY, SURFACE PROPERTIES, VISCOSIMETER

Introduction

Improvement of metal quality, its reliability and service life, decrease of metal consumption level at simultaneous intensification and improvement of metallurgical processes are primary tasks for scientists and practicing metallurgists. Solution of problems specified should be combined with simultaneous improvement and intensification of processes.

At present, application of scientific research results and technical achievements with the purpose to improve technical potential of metallurgy can be accomplished in two ways: by means of practice and adoption of technologies related to current level of manufacture re-equipment and by means of application of nonconventional environmentally sound high-effective technologies. The second way is the most favorable but requires considerable expenditures and intense work of scientists.

Results and Discussion

The theoretical fundamentals of classical steelmaking practice were created by works of known native and foreign contributors - P. P. Arsentyev, S. I. Popel, A. M. Samarin, S. I. Filipov, V. I. Yavoyskiy, V. I. Baptizmanskiy, M. Ya. Mezhdiozhskiy, I. S. Kulikov, S. G. Afanasyev, D. Grant, J. Chipmen, G. Shenk, et al. The regularities they obtained were confirmed many times by practical, laboratory investigations and experiments carried out during many decades on various units and under varying technological conditions.

It is very important to create continuous automated process of hardware production with required level of reliability directly from ore, which corresponds to ESID program. This program of stable ecologically friendly industrial development is focused on reduction of power and resource consumption, deletion of toxic materials, reduction of waste amount in the manufacturing cycle for the purpose to minimize environmental pollution.

A comprehensive approach to the problem of defect-free steelmaking is necessary now. Processes of structure formation and development of properties of steels and alloys start from their smelting in steelmaking units and end at the rolling and heat treatment stages. However, there are no generalizing investigations and analysis of interrelation between structure formation and development of properties of steels and alloys in domestic and foreign literature, starting from the liquid state, their crystallization and then during heat treatment and rolling processes. The processes of genetic relation between structure and properties of molten and solid metals and alloys are covered not enough [1-3]. The special attention of scientists working in the area of high temperature physics, physical chemistry of melts, heat and power engineering on the basis of current theoretical

statements should be paid to comprehensive complex analysis of properties of iron based alloys. In view of this, it is supposed to create theoretically based physic-chemical melt structure model [4-8].

Today, a new insight into particular provisions of iron based alloy structure theory is needed. Working out complex methods of investigation of melt properties includes creation of quality control system provided with flaw inspection and defect prevention means, creation of devices for technological process automatic control. Application of control means and prediction of hardware properties during melting and heat treatment with the use of computer programs enables to make defect-free steel and control the course of metallurgical process.

The issues related to creation of experimental data bank with the object of further advancement of metallurgical manufacture should be considered. These data can be obtained only as a result of present-day experiment with a high level of reproduction. When creating a databank for control and prediction of metal properties, the contributor-metallurgist must obtain reliable results that can essentially improve current technologies.

The features of melt nature stipulate high-temperature measurements, application of complicated systems of obtained experimental data processing. The specified peculiarities featured for experiment on metallurgical liquid systems analysis make it difficult to obtain correct scientifically based results of diffusion, interphase interaction in systems metal-slag, surface tension, viscosity, adsorption metal-gas, metal-nonmetallic inclusion characteristics, etc.

There is a number of problems devoted to formation and purification of molten metal from nonmetallic inclusions, in particular: objective definition of their amount, which is related to the problem of estimation of minimum sizes of inclusions; definition of range of nonmetallic inclusion sizes; working out new investigation methods applied to systems inclusion–matrix in both liquid and solid state; analysis of dispersed phase and regularities of particle motion in melts.

The experimental base on analysis of iron based alloy properties has been created, research techniques and necessary instrumentation were developed at Priazovskiy State Technical University during last several decades. Scientific groups have analyzed the current problems of present-day experimental base. The new perspective methods of analysis of viscous, smelting, surface and diffusion characteristics of metals and slag were worked out and created on the basis of laws of metallurgical heat engineering and physical chemistry

Our specialists have experimented with the use of measurement cells of complex analysis of surface and diffusion characteristics, vibrational viscosimeters. Method and device for diffusion constant definition [9, 10] were worked out in order to analyze diffusion processes in molten iron-base alloys.

Phase boundary properties are known to define a pattern of slag and metal melts interaction. Therefore, improvement and accuracy of methods measuring these characteristics have a prime value when creating a theoretical melt model. We have developed an original method to define interfacial tension on the interface metal-slag in order to increase measurement accuracy by providing stability of melt drop under equilibrium conditions [11]. This method consists in forming a slag drop in delve on solid metal surface with its subsequent heating up to melting and system photographing. The developed method allows improving accuracy of interfacial tension definition and, thereby, increasing efficiency of investigation of physic-chemical properties of multicomponent metallurgical melts.

The researchers paid a special attention to method of definition of surface and phase boundary properties of melts [12]. In this method, a special technique is used when measuring phase boundary properties. This technique consists in preforming of investigated materials in the form of drops, their subsequent crystallization and binding in the heating zone on a set distance taking into account thermal expansion. Drops slowly come to contact during melting.

This method allows obtaining stable results reproduced with accuracy approximately 2 times higher due to stabilization of experiment conditions and due to control of process of formation of two melts contact area. Besides, application of this method considerably facilitates experiment statement.

The method of drop forming by its pressing from internal bulk of the melt through a vertical channel of set diameter on a solid surface of investigated material was worked out in order to obtain reliable experimental data when measuring wetting angle [13].

At such course of experiment it is possible to avoid inaccurate definition of wetting quality due to possible formation of oxide films on the melt surface. The method described above is used also for definition of dependence of phase-to-phase

energy on *n*-component content in molten metal on the interface with oxide system. Reliable data obtained as a result of experiments allow determining effect of phase-to-phase tension on the work of adhesion [7, 9].

When developing a high-temperature vibrational viscosimeter and technique of high-precision measurements of metallurgical melt viscosity, we first of all considered the nature and physic-chemical properties of measuring objects, range of operating temperatures and pressures, makeup and magnitude of oxidative potential, time factor of experiment, etc.

Transducer module, heating system and precision temperature control have been worked out for the first time in construction of high-temperature vibrational viscosimeter [14].

Conclusions

It is necessary to engage scientists working in the field of theory and experimental metallurgy in solving urgent problems, as radical development of current technologies and creation of new ones related to production of steels and alloys with required properties are impossible without thorough scientific analysis of these problems.

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Роль фундаментальных исследований в решении актуальных проблем производства чёрных металлов

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В статье выполнен анализ современного положения и тенденций развития чёрной металлургии в стране и мире, рассмотрены пути усовершенствования металлургического производства, представлены новые методики изучения диффузии в сплавах, межфазных и поверхностных свойств расплавов, прецизионных измерений вязкости металлургических расплавов.