MODERNIZATION OF OPEN-HEARTH STEELMAKING

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The nature of the open-hearth process gives it several advantages over other processes when evaluated on the basis of considerations related to heat engineering and flexibility. The process makes it possible to conduct the steelmaking operation within a broad range of ratios of pig-to-scrap in the metallic part of the charge. It also allows the use of different types of fuels, and the steel being made can be subjected to preliminary deoxidation and alloying in the furnace or in ingot molds.

Even in the context of the continuing downturn of Russian industry, this method accounts for 40% of the total steel production of the country, and it can satisfy large orders for a wide range of different steels with specific properties and requirements. At the same time, the competitiveness of OH steel is continually declining. Since 1970, the amount of steel made in Russia with the use of liquid pig iron has decreased from 65 to 25 million tons/yr, while the amount made with the use of solid pig iron has declined from 16 to 6 million tons/yr. The modernization of OH shops has long stagnated, limiting the possibilities for making new types of metal products. This applies in particular to products characterized by a high degree of purity and uniformity of chemical composition. Such products are in great demand by customers, thanks to the stability of the properties and the potential for significantly resulting the weight of machines and structures made with those products.

The current level of purity and uniformity of chemical composition in steelmaking has been achieved by using charges with a high content of primary materials (pig iron and metallized pellets), using more efficient processes for additional refining in separate units, and employing operations that stabilize the chemical composition of the steel during deoxidation, alloying, and crystallization and maintain a narrow range of element concentrations. These changes have been instituted with the use of highly productive, highly mechanized and automated continuous-flow electrical and converter steelmaking facilities, various types of treatments administered outside the furnace, and continuous casting. However, even while in the planning stage, attempts at reconstructing OH shops on the basis of such equipment have made it clear that it will be necessary to fundamentally change the infrastructure of this division of steelmaking with respect to both equipment and investment patterns. The investment needed to modernize OH steelmaking is comparable to the investment that would be required for the construction of completely new facilities.

For the OH shops in Russia that still have good buildings and good hoisting and transportation equipment but limited financing, it would obviously be expedient to continue to search for optimum solutions to modernizing OH production at a new level — with allowance for their cumulative experience and the more stringent demands now being made in regard to the energy content and environmental cleanliness of production.

The modernization strategy of OH shops should be based on a multistage approach to its realization, the ultimate goal being to reach a new, advanced level of steel production. Doing so will require a critical analysis of present production indices and the establishment of objectives that will raise those indices after the introduction of new steelmaking equipment.

In the leading steelmaking processes of today, temperatures in the hearth region are within the range 2500-3500°C and refining is accompanied by vaporization and dissociation of the reaction products. Thus, the reactions that take place are characterized by a low level of utilization of available heat and materials and continual expenditures on environmental measures. The integrated energy content of the entire steelmaking complex has increased sharply and shows a trend toward increasing further, due to the concomitant reduction in the quality of the available ores and energy carriers and the absence of solutions that are expedient from a heat-engineering standpoint. The low thermal efficiency of current steel production necessitates the use of the outgoing gases as secondary energy carriers, which in turn has increased capital and operating expenditures.
Due to the periodic nature of steelmaking technology, it is also characterized by a low level of equipment use, capital intensiveness, and losses of material resources.

Converter steelmaking and modern high-volume electrical steelmaking are rapid processes, which limits the possibilities for taking corrective actions during refining. In practice, the refining operation in the furnace produces a semifinished product, and the latter is subjected to additional operations in the ladle. This scheme means that the composition of the charge materials must be consistent. Despite this, such an important element of the charge as scrap is not classified according to chemical composition. Some consistency is now being achieved through fractioning and sorting, but this has not prevented large fluctuations in composition and losses of production. Since we can expect an increase in the volume of reusable dormant and prompt industrial scrap and a tightening of requirements on the constancy of its chemical composition, we can also expect an increase in scrap prices. Scrap is already more costly than pig iron in several countries. In addition, scrap contains valuable alloying elements whose reserves are limited. Thus, any new technological developments in this area should also provide for the conservation and use of these elements.

For several years, foreign firms have recommended steelmaking units of the EOF and FUCHS types. The operation of these units involves the multistage heating of scrap in a vertical channel above the furnace chamber and the use of a combination oxygen blow for the melt in the furnace. The units also have all of the deficiencies mentioned above. In addition, heating scrap with the outgoing gases is inefficient because under the given heat-transfer conditions, it is impossible to heat the scrap to 700°C during the blowing period (20-25 min) with a flame temperature of 800-1200°C. The use of scrap that has been separated into fractions significantly increases production costs. As regards blowing the melt with oxygen delivered from below the hearth, domestic experience with converter steelmaking and extended blowing in OH steelmaking has shown that the method used to supply the oxygen is not important in processing a carbon-bearing melt. This is because the mixing of the melt achieved by the decarbonization reaction is an order of magnitude greater than the mechanical mixing done by the oxygen jet. Meanwhile, the jet may adversely affect the life of the furnace lining.

Improving the method used to teem steel should be one of the first priorities in the reconstruction of OH shops. Although the traditional method of casting the metal in ingot molds offers flexibility, it is characterized by high labor and energy costs and low useable output and adversely affects the quality of the resulting rolled products. However, attempts to install the first generation of continuous casters in OH shops met with problems related to the low elevation of the craneways (10-20 m, depending on the tonnage of the shop's supply of ladles). There is now a wide range of types of continuous-casting equipment to choose from, including horizontal models. For example, continuous casters with a working platform 5 m high are now being used for the production of 300 × 300 mm sections or rounds of equivalent cross section. The relatively low height of these units makes it possible to install them in bays with a craneway elevation of 13-14 m. The casters can teem metal in 60-300-ton ladles with a productivity of 200,000-600,000 tons/yr. For smaller ladles and productivities below 150,000 tons/yr, the casters can be used in buildings with craneways at an elevation of 10-12 m. Although difficulties may be encountered in installing continuous casters for the casting of large (larger than 350 mm) semifinished products, the restrictions are relatively minor and can possibly be overcome through design changes.

Continuous and semi-continuous methods of casting steel make it possible to obtain cast semifinished products of different cross sections and dimensions that represent the entire spectrum of metallurgical products. This includes the products mass-produced in accordance with GOSTs 380, 1050, 4543, 5950, and other standards. These methods also significantly reduce production costs. Thus, there are now nearly no restrictions on the introduction of these methods in OH shops in regard to either the type or size of product that can be obtained. Their addition to the shop should be accompanied by the introduction of modern methods of treating steel outside the furnace, as well as some modifications of the OH furnaces. Continuous casting imposes stringent requirements with respect to the temperature and composition of the metal. Thus, continuous-flow methods of treating steel outside the furnace must be employed.

The equipment for administering such treatments — units that finish steel in a pouring ladle in terms of chemical composition and temperature, vacuum degassing units, and AKOS-type units that heat the steel — is already in use in OH shops and has been for some time. However, their efficiency remains low due to the impossibility of performing the whole range of operations needed to effectively treat the steel outside the furnace. The limited use of the equipment can be attributed to insufficient crane capacity in the pouring bays, as well as space limitations in the bays that make it difficult to organize flow-line production.

An analysis of the setups of existing OH shops, their equipment layouts, and material flows in the shops showed that the greater the number of furnaces operating in a given shop, the more disorganized the production routine (mainly due to the fact that the steel is tapped on the pouring-bay side), the more frequent the disruptions in that routine, and the larger the area