The Electrosmelting of Steel: An Overview

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DOI: 10.3103/S0967091209010148

The Ninth European Conference on Electrometallurgy, held in Cracow, Poland (May 19–21, 2008), assembled metallurgists from 29 countries in Europe, Asia, and the Americas. Practically all the leading countries where steel is produced in arc furnaces were represented. As part of the conference, more than ten companies exhibited their wares. The largest display was by SMS-Demag, which specializes in the development of metallurgical equipment. Conference participants also took an excursion to CELCA Steel Works (Huta Ostrowiec), in Ostrowiec-Swiętokrzyski.

Around 70 papers were presented at the conference, including four plenary addresses. The thematic sections covered batch materials; design solutions; slag foaming; simulation; monitoring; metallurgical aspects; and optimization of arc-furnace processes. The papers were of very high quality. Only three or four papers were submitted to each of the sections on simulation, monitoring, metallurgical aspects, and optimization of arc-furnace processes. Attention focused on local problems and particular approaches for specific electrosteel shops.

At the plenary session, D. Ameling, the president of the German Steel Federation presented a paper on innovations for energy and resource conservation in the steel industry, with an analysis of the efficiency of resource use in steel production in an era of globalization. In the author’s opinion, a key factor in the development of European metallurgy is the maximum utilization of natural, human, and financial resources while increasing new grades of steel for manufacturing components. This will permit the harmonization of steel demand and environmental impact.

The subsequent plenary presentations were devoted to specific developments improving the efficiency of electrosteel production. In particular, F. Kongoli (Flogen Technologies, Canada) offered a paper on monitoring, optimization, and automation in electrometallurgy as means of increasing efficiency and productivity in an era of high metal and power prices. The author outlined a nonequilibrium model of electrosmelting, permitting the evaluation, in particular, of the behavior of the slag and metal and any other solid particles in the liquid bath. This model improves the prediction of the processes that accompany smelting.

Closing the plenary session, specialists from SMS Demag (Germany) and Midrex Technologies (United States) presented a paper on their integrated approach to minimills as a short-cut to long-term success. In June 2007, Midrex, Kobe Steel, and SMS Demag formed a consortium to design integrated minimills with the Midrex technology for direct iron reduction, the arc-furnace production of steel, and casting in a casting and rolling unit. The basic system employed in the mill is illustrated in Fig. 1. In the authors’ view, this approach not only offers the shortest technological route from the ore to the steel product but also creates conditions for the minimization of production costs with high steel quality.

Depending on the type of iron ore, the direct reduction of iron may be based on the production of hot-briquetted iron (HBI) or direct-reduced iron (DRI). Steel smelting in an arc furnace includes a control system for the production process and corresponds to an integrated system, with feedback for all the energy and material fluxes. The operating costs of the mill are reduced as a result of maximum productivity, reduced smelting time, reduced energy consumption, and reduced downtime. For example, if 100% DRI is charged in the arc furnace, the power consumption increases by 20 kW-h/t of liquid steel for each 100°C increase in batch temperature. Thus, hot direct-reduced iron (HDRI), supplied to the electrofurnace at 650°C, results in energy savings of around 140 kW-h/t (Fig. 2).

In addition, CSP steel-casting technology on a casting and rolling module reduces energy costs by up to 70% in comparison with traditional casting of thick slabs and subsequent rolling; production costs and investments are reduced by 25 and 50%, respectively. Today, the steel output of the 28 casting and rolling modules in operation around the world (including the Americas, Europe, Africa, and Asia) is ~50 million t/yr. Globally, about 10% of hot-rolled sheet and strip is produced by that technology. Since the introduction of CSP technology, efforts have been made to reduce the product thickness and expand the range. Thus, CSP technology is now used to produce hot-rolled strip as thin as 0.78 mm, with significant expansion of the range: microalloyed, electrical-engineering, and corro-

1 Based on materials presented at the Ninth European Conference on Electrometallurgy.
sion-resistant steel, as well as steel for the auto industry. Analysis of the environmental impact of the system based on HDRI and an arc furnace shows that the CO\textsubscript{2} emission is significantly less than for traditional integrated enterprises (based on hot metal and a converter).

The table presents some characteristics of existing and projected integrated minimills based on the Midrex and SMS Demag approach.

In the section devoted to batch materials, there was great interest in a paper on the demand for and quality of steel scrap, by P. Tardy, a member of the IISI working group on steel scrap. The author noted that the demand for steel scrap is determined by the amount of steel smelted and predictions are based on past metal output. Thus, about 85% of steel scrap is used for smelting in arc furnaces. For integrated mills (steel smelting in converters), the proportion of steel scrap in the batch fluctuates in the range 15–30%. The largest exporter of scrap is Russia, and the largest importer is Turkey. According to estimates taking account of the lifecycle of different types of metal product, the author reached the following conclusions regarding scrap demand in the near future:

- significant acceleration of steel production at the beginning of the new millennium led to an imbalance between the demand for scrap and the supply;
- gradually, the annular output of steel scrap is coming into balance with demand, but complete balance will not be restored before 2010; in the interim, there will be a need to utilize steel scrap that has previously been discarded on account of its relative inaccessibility and low quality;
- China’s imports of steel scrap are gradually increasing on account of the extremely high use of oxygen-converter systems; therefore, China may soon become an exporter of scrap;
- globally, there is no risk of a serious shortage of scrap, but the proportion of low-quality scrap will continue to rise.

The decline in scrap quality is associated primarily with low packing density and high content of harmful impurities that impair the operational stability of smelting furnaces. In practice, problems arise with harmonizing the operation of smelting systems and with limiting the range of steel smelted. As a rule, the latter constraints may be attributed to the rising and uncontrollable content of nonferrous-metal impurity in steel scrap, which is particularly significant for casting and rolling modules used in strip and sheet production.

Siemens VAI MT presented a paper on the design and adaptation of the SimetalCIS Ultimate arc furnace for smelting cold and hot DRI and also on the operation of arc furnaces with up to 40% hot metal in the batch. In the opinion of company specialists, the efficiency of steel-scrap smelting is ensured by design features of the SimetalCIS Ultimate furnace. Thus, the enlarged working chamber permits optimization of preheating of the charged scrap by complete ignition of CO and heating by stationary wall burners. In addition, the large rated power of the furnace transformer (>1 MV A/t) and the increase in surface area of the bath meniscus ensure a stable high rate of decarburization. The successful introduction of a 300-t SimetalCIS Ultimate furnace in