DEVELOPING AND IMPLEMENTING A SERIES OF MEASURES TO INCREASE THE PRODUCTION AND QUALITY OF STEEL MADE IN OXYGEN-CONVERTER SHOPS


The modern converter shops at the Magnitogorsk Metallurgical Combine (MMK) and the company Severstal’ are large industrial complexes equipped with 400-ton converters and high-productivity continuous casters, units for desulfurizing pig iron and treating steel outside the furnace, and systems that automatically control production operations. With respect to their technical sophistication and production capabilities, they rank among the best converter shops in the world.

The restructuring that the economy underwent at the beginning of the 1990s was accompanied by a reduction in the consumption of metal products, which in turn led to a decrease in the output of steel and rolled products. The search for new sales markets – including foreign markets – for finished rolled products required a continual improvement in the quality and variety of such products at minimal additional cost.

The MMK and Severstal’, working with research institutes and planning organizations, have developed and introduced a series of technological measures and equipment to increase the capacity of the converter shops to eight million tons a year, radically improve the quality of the steel that is produced (concentration of W < 0.005%; N < 0.004%; H < 0.0002%; (Cu + Ni + Cr) < 0.15%), and make high-quality steels of grades 22GYu, 10G2FBYu, 10KhSDN, and 10KhNDP, steels for tin plate and automobile sheet, and dynamo, transformer, and relay steels.

To increase the capacity of the converter shops, the combines have developed and introduced a complex of technologies that will help shorten the heats, increase the productivity of the continuous casters, and eliminate bottlenecks. For example, to shorten the heats, the Magnitogorsk combine has developed, made, and installed a unit to measure the parameters of the heat. The unit consists of a water-cooled lance and a measurement block. Introduction of the unit has more than halved the incidence of overblowing and shortened the heats by 3 min.

Productivity has also been increased and the quality of the steel has been improved by measures that increase the cross section of the continuous-cast semifinished products, provide for asymmetric casting of slabs, and make the components and the mechanisms of the caster more reliable. The combine has also developed new compositions of slag-forming mixtures and technologies for using them.

The above series of measures made it possible to increase the productivity of the continuous casters from 173 tons/h in 1994 to 225 tons/h in 1999. The implementation of the measures, along with the startup of converter No. 3, increased the annual volume of steel production at the MMK from 4.29 to 6.63 million tons in 1999. At Severstal’, the length of the casting operation has been cut from 1.91 to 1.83 h and average casting rate has increased from 185.3 to 194.45 tons/h.

The introduction of steel-finishing unit No. 4 at Severstal’ has increased the capacity of the section that treats steel outside the furnace from 6.7 to 8.2 million tons/yr, while the construction of an additional section to transport slabs on the slab production line has increased the capacity of the line from 6.5 to 8.5 million tons of slabs/yr. On the whole, Severstal’ increased its output of converter steel from 4.546 to 7.35 million tons/yr during the period 1995–1999.
TABLE 1. Process Parameters for Vacuum Degassing by the Batch and Circulation Methods

<table>
<thead>
<tr>
<th>Type of treatment</th>
<th>Circulation ratio</th>
<th>Argon discharge, m³/h</th>
<th>Treatment time, min</th>
<th>Pressure in the chamber at the end of vacuum degassing, mm Hg</th>
<th>Consumption of aluminum AV86 before vacuum degassing, kg</th>
<th>Consumption of aluminum shot during vacuum degassing, kg</th>
<th>Carbon content, ×10⁻³, % before treatment</th>
<th>Carbon content, ×10⁻³, % in the finished metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circulation</td>
<td>2.4–10.1</td>
<td>32–85</td>
<td>7–26</td>
<td>0.5–3</td>
<td>0–500</td>
<td>250–640</td>
<td>32–75</td>
<td>3–20</td>
</tr>
<tr>
<td></td>
<td>5.3</td>
<td>53.8</td>
<td>17.5</td>
<td>1.3</td>
<td>128</td>
<td>429</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td>1.8–4.5</td>
<td>—</td>
<td>12–32</td>
<td>0.5–9</td>
<td>0–450</td>
<td>300–800</td>
<td>26–77</td>
<td>8–45</td>
</tr>
<tr>
<td></td>
<td>2.8</td>
<td>22.3</td>
<td>22.3</td>
<td>1.9</td>
<td>134</td>
<td>580</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. The numerator shows the minimum and maximum values, respectively; the denominator shows the average.

To increase the service life of the linings of the converters, the MMK and Severstal’ worked extensively on choosing quality refractories. Positive results were obtained when a slag crust composed of specially prepared converter slag was applied to the periclase-carbon lining of the converters by using high-pressure nitrogen. The use of a technology for making steel under converter slags having a high (10–11%) concentration of magnesium oxides and guniting of the converters with the slag crust have made it possible to increase the life of the converters to 2500 heats at the MMK and 4500 heats at Severstal’, which is greater than the average life of converters in Russia.

Severstal’ has developed and introduced a converter steelmaking technology in which the slag-forming material is an iron-enriched lime-magnesian flux. Use of the flux makes it unnecessary to conduct the converter heat with burnt dolomite, which has a high melting point. This improves slag formation, decreases the degree of oxidation of the final slags and increases their content of magnesium oxides, and halves the number of heats that require additional blowing – especially to correct the temperature of the steel.

Optimization of the chemical composition of the pig iron, limiting the amount of mixer slag which is used, and optimization of the steelmaking technology – including by using the above-described flux – have made it possible to reduce the amount of converter slag which is formed by 15–20%. A converter steelmaking technology which uses synthetic slag-forming materials in the charge has been developed and introduced. Use of this technology reduces the nitrogen content of the finished steel by 0.005% (by mass).

Both combines have also developed and introduced a technology that produces ultra-low-sulfur steel and includes out-of-furnace desulfurization of the pig iron, the use of an oxygen converter to obtain a semifinished product from a clean metallic charge, out-of-furnace treatment of the steel with solid slag-forming materials based on the system CaO–Al₂O₃, and the addition of powders which are based on metallic calcium and are either injected or introduced in wire form. Use of this technology has made it possible to increase the production of automobile sheet, tube steels with a maximum sulfur content of 0.010%, and special grades of steel with a sulfur content below 0.05%.

The MMK developed a technology for vacuum degassing steel and began using it in 1996, coinciding with the startup of the unique vacuum-degassing unit designed for the combine by VNIImetmash (All-Union Scientific Research, Planning, and Design Institute of Metallurgical Machinery) and Magnitogorsk Gipromez. The combination vacuum-degassing unit for steel makes it possible to treat liquid metal in a 30-ton pouring ladle by either the batch method (DN-process) or the circulation method (RH-process), depending on the type of bottom the vacuum chamber has (Table 1). More than 400,000 tons of steel were vacuum-degassed in 1988. Vacuum degassing of steels such as 08Yu has allowed the combine to increase the production of cold-rolled plates of drawing grade OSV to 98.8%.

The combine has also developed and introduced a method of blowing metal in the ladle with argon through special injection equipment in the bottom of the ladle. This has reduced the level of oxidation of the ladle slags to 1–2%, which in turn has substantially alleviated fluctuation of the chemical composition of the steel and its content of nonmetallic inclusions.

A technology has been developed and introduced for protecting liquid metal on the section between the ladle and the continuous-caster mold. The technology uses a sealing material and involves feeding argon into the protective tube and the dif-