DEOXIDATION OF STEEL WITH SILICOMANGANESE ALLOY

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During November and December 1959, 90 trial heats with the use of silicomanganese alloy from the Nova Tuia Metallurgical Works for the deoxidation of steel in the furnace were carried out at the Kuznetsk Metallurgical Works.* In addition to this alloy, a small quantity (0.5-1.0 kg/ton) of ferromanganese or of 19% - ferrosilicon was added to 14 heats.

The tests were carried out in medium and large size open-hearth furnaces. The following steel grades were made: 3 sp, M16S, 3 sudost., 20, 25, 35, 40, 45, axle, St. 5, St. 6 nald., L-53, 50, 60 kan.

To determine the feasibility and economic advantages of the use of silicomanganese alloy, the results of the test heats were compared with those of ordinary heats for the same steel grades, deoxidized beforehand with ferromanganese and 19% - ferrosilicon. The test heats and the ordinary heats were finally deoxidized in the ladle with 45% - ferrosilicon (as calculated) and aluminum (as specified).

In the test heats, to compare them with ordinary heats, one studied the effect of the method on the output of the furnace, the change in phosphorus and sulfur contents in the course of the deoxidation and tapping, the consumption of slag-forming materials (lime and bauxite), the quality of the steel, the loss of silicon and manganese, the consumption of ferroalloys and the change in the cost of deoxidation.

Characteristics of the Alloy

For the test heats grade 2 alloy and grade 3 alloy were used. According to the manufacturer's specifications their chemical composition should be, %:

<table>
<thead>
<tr>
<th>Alloy grade</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.5</td>
<td>40-50</td>
<td>8.1-10.0</td>
<td>0.40 max</td>
</tr>
<tr>
<td>3</td>
<td>3.2</td>
<td>45 min</td>
<td>10.1 min</td>
<td>0.35 max</td>
</tr>
</tbody>
</table>

Actually, the limits of the chemical composition of both alloys were, %:

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,6-3.4</td>
<td>45.0-52.0</td>
<td>8.1-11.2</td>
<td>0.25-0.42</td>
<td></td>
</tr>
</tbody>
</table>

Compared with the ferromanganese, the alloy contained about half as much carbon, 20-27% less manganese, 6-9% more silicon and up to 0.06% more phosphorus in some batches.

As regards its physical properties, the silicomanganese alloy is very similar to the ferromanganese but it is easier to crush.

There are no slag inclusions. 100-300 mm fraction in the alloy constitutes 80%, the remainder consists of particles 20-100 mm in size.

* M. M. Privatov, V. S. Protopopov and I. F. Shinkarev took part in this work.
When one uses an alloy with a large proportion of the fraction below 100 mm, the loss of manganese and silicon increases significantly, apparently as a result of the entanglement of the alloy in the slag. Grade 2 alloy costs 1500 rubles per ton and grade 3 - 1600 rubles per ton.

**Characteristics of the Process**

The carbon content in the metal before the deoxidation was in general similar in the test heats and the ordinary ones.

The use of silicomanganese alloy instead of ferromanganese for the preliminary deoxidation had no effect on the steel temperature.

The temperature of the metal before the deoxidation of the test heats, as well as of the ordinary ones, fluctuated within relatively large limits, the difference between individual heats for the same steel grade varying by as much as 35° C.

The phosphorus and sulfur contents of the test heats changed during the deoxidation and tapping in the same manner as those of the ordinary heats.

The use of silicomanganese alloy for the deoxidation resulted in a reduction of the total duration of the heat because the deoxidation period was shortened by 5 minutes in medium furnaces and by 6 minutes in large furnaces; for steel grades St. 5, St. 6 and L53 the deoxidation period in large furnaces was on the average 6 minutes longer for the test heats, because in the preliminary deoxidation of steel in the ordinary heats in large furnaces, only ferromanganese was used.

**The Quality of the Steel**

The macrostructure and mechanical properties of the steel from the test heats were tested within the requirements of the GOST specifications.

The results of the inspection of the macrostructure of the samples taken from the end pieces of the rolled steel from the test heats and from the ordinary ones are shown in Table 1.

The quality of the macrostructure of steel from the test heats was somewhat better since there was a relatively high percentage of rejects of grade 45 steel from some ordinary heats.

The mechanical properties of all steel grades from the ordinary heats and the test ones do not differ substantially, and satisfied GOST specifications.

**The Consumption of Deoxidizers**

The consumption of deoxidizers was determined only for those test heats in which the deoxidation of the metal in the furnace was carried out with silicomanganese alloy. For comparison, we took those ordinary heats from the same period in which the preliminary deoxidation was made with ferromanganese and 19% ferrosilicon.

In the calculation of the consumption of deoxidizers we excluded the test heats of steel grades St. 5, St. 6 and L53 made in large furnaces because the ordinary heats were deoxidized in the furnace with ferromanganese only. An average reduction of 0.01% of manganese and silicon in the steel from the test heats was not taken into account in the calculations.

Data on the consumption of deoxidizers and on the loss of silicon and manganese in the experimental heats and the ordinary ones is given in Table 2.

The consumption of deoxidizers for the preliminary deoxidation in the experimental heats was 12.8 kg/ton, i.e., 3.6 kg/ton less than in the ordinary heats. The total consumption of deoxidizers in the experimental heats was 17.1 kg/ton, i.e., 3.3 kg/ton less than in the ordinary heats.

The manganese losses constituted 21.4% in the experimental heats, and 22.9% in the ordinary ones; the silicon losses (total) constituted 33.3% in the experimental heats and 31.4% in the ordinary ones. The small increase (1.9%) in the silicon losses in the experimental heats can be explained by an inaccurate determination by volume of the 45%-ferrosilicon, and by rather high losses of silicon in some heats because of a larger proportion of the small-particle fraction (particles below 100 mm in size) in the silicomanganese alloy.