In connection with considerable changes in the technology of metallurgical production it was necessary to conduct additional investigations and calculations for determining the effect of qualitative characteristics of conversion pig iron on blast-furnace and open-hearth production.

We investigated blast furnaces with a useful volume of 1719 and 1386 m³ and open-hearth furnaces with a capacity of 250 and 400 tons at a metallurgical plant operating on iron ore of the Krivoi Rog deposit and coke from Donetsk coals.

The analysis and investigations showed that in the production of conversion pig iron with a high content of silicon and manganese and low sulfur content the technicoeconomic operating indices of the blast furnaces decrease considerably. For example, with a 0.1% increase of the silicon content in the pig iron the output of the blast furnaces decreased 0.5–1.2% and the specific coke consumption increased 0.4–1.0%. With a 0.1% increase of the manganese content in the pig iron (within 0.6–1.7%) the output of the blast furnaces decreased 1.0–1.5% and the coke consumption per ton of pig iron increased by about 0.8%. Production of pig iron with a manganese content below 0.6% (0.1–0.6%) on different blast furnaces has a different effect on the technicoeconomic indices of production, which is explained by the instability of the composition of blast-furnace slags. In some cases manganese additions improve the fluidity of the slags and thereby boost the blast-furnace process. In this case the output of the blast furnaces increases 0.2% upon each 0.1% increase of the manganese content in the pig iron and the specific coke consumption increases 0.3%.

The most complex process is the removal of sulfur from the pig iron during smelting – this leads to a noticeable decrease of the output of blast furnaces and increase of coke consumption.

The provision of an assigned composition of slag leads to an additional coke consumption and to loss of furnace output. For instance, at the Dzerzhinskii Dulepr Plant in the investigated period a decrease of the sulfur content in conversion pig iron by 0.01% (within 0.045–0.02%) was accompanied by a 1.0–1.5% (average 1.1%) decrease of the output of the blast furnaces and a 0.7% increase of coke consumption. The best conditions for desulfurization of pig iron are created on increasing the basicity of the slag by increasing the basicity of the sinter. For example, on increasing the basicity of the slag by 0.1 the sulfur content in pig iron decreased 0.005–0.008%, and the silicon content in this case increased 0.1–0.2%.

It was found during the investigation that in a number of cases it is not expedient to increase the basicity of slag by increasing the consumption of limestone. In the case of insufficient basicity of sinter there is a noticeable increase of coke consumption, and consequently sulfur additionally enters the pig iron along with it (the sulfur content in coke from Donetsk coals is 1.36–1.8%). The additional gain of sulfur on increasing the consumption of limestone is often greater than its removal attained as a result of increasing the basicity of slag. Consequently, cases of a high sulfur content in pig iron are generally observed when the specific consumption of limestone is high; It has been calculated that for each additional 10 kg/ton of limestone (2–100 kg/ton) the sulfur content in pig iron increases 0.001–0.002%.

A change of the chemical composition of pig iron can have a noticeable effect on the specific consumption of the charge materials, cost of pig iron, and capital and labor intensity of its production (Table 1).

An analysis of the regression equations and technicoeconomic calculations reveal a rather high dependence of the efficiency of the open-hearth process first and foremost on its organization. The multiple correlation coefficient with consideration of the effect of organizational factors was 0.92–0.95 and without their consideration 0.2–0.5.
TABLE 1. Change (+ increase, - decrease) of Economic Indices of Pig Iron Production upon a Change of Its Chemical Composition

<table>
<thead>
<tr>
<th>Indices</th>
<th>Decrease of pig iron content, %*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>silicon by 0.1</td>
</tr>
<tr>
<td>Cost per ton of pig iron, rubles</td>
<td>-0.17--0.18</td>
</tr>
<tr>
<td>Capital intensity per ton of pig iron, rubles</td>
<td>-0.65</td>
</tr>
<tr>
<td>Labor intensity per ton of pig iron, man-hours</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

*In comparison with the average chemical composition during the investigated period.

Considerable organizational-technical troubles occurring during production strongly affect the economics of production and often do not allow accurate consideration of the effect of the chemical composition of pig iron on production economics. In this connection an incorrect notion about the economic value of increasing the quality of conversion pig iron is created in a number of cases.

It is known that the proportion of hot metal and scrap in the charge has a noticeable effect on the efficiency of the steelmaking process. Investigations revealed cases when for unfavorable qualitative characteristics of hot metal its proportion in the charge was reduced and the proportion of scrap was increased and thereby the technicoeconomic indices of the process were improved. In the case of rather high qualitative characteristics of pig iron and its extremely high proportion in the charge the operating indices of open-hearth furnaces were unsatisfactory. Having eliminated the effect of organizational and a number of technological factors, we established that with the use of hot metal with a high content of silicon, manganese, and sulfur the intensity of the process decreases and the economic indices become worse. For instance, on increasing the silicon content in pig iron by 0.1% (in the 0.32-0.92% range) with an average pig iron consumption of 640 kg/ton of steel the duration of the heat increases 2.2-2.5% and the specific consumption of reference fuel increases 2-2.5%. An increase of the manganese content in pig iron by 0.1% (in the 0.2-0.7% range) led to an increase of the duration of the heat by 0.5-2% and increase of the specific consumption of fuel by 2.5-3.0%.

The greatest decrease of the efficiency of the steelmaking process occurs during desulfurization of the metal. On removing 0.01% sulfur the duration of the heat and the specific fuel consumption in most cases increase by 3.5-4.5%. In the case of a considerable sulfur content it is necessary to increase the basicity of the slag (CaO/SiO2) to 2.5-3.0 (provided its sufficient fluidity is retained). The introduction of a large quantity of fluxes into the furnace leads to slowing of the process and increase of fuel consumption.

Calculations showed that with the combined use of oxygen in the open-hearth process about 3.5 and 0.7 kg of iron ore per ton of steel is required, respectively, for oxidizing 0.1% silicon and manganese. The consumption of limestone in this case is, respectively, 1.4 and 0.3 kg per ton of steel. For slagging 0.01% sulfur the consumptions of limestone, lime, and bauxite are, respectively, about 32.5, 3.2, and 0.4-0.6 kg/ton of steel. The effect of the chemical composition of pig iron on the cost, capital intensity, and labor intensity of the production of 1 ton of steel is characterized by the data in Table 2.

The analysis presented above gives an idea about the effect of each element of pig iron on the economics of blast-furnace and steel-making production. The combined effect of the chemical composition of pig iron on the economics of metallurgical production can be determined relatively accurately on the basis of the total expenditures calculated for the blast-furnace and steel-making plants for all practically possible compositions of conversion pig iron. The chemical composition of pig iron, the manufacture and conversion of which minimum combined expenditures per ton of steel (with consideration of the expenditures for pig iron) are attained, will be optimal from the standpoint of economics.

We investigated possible actual variants of the chemical composition of pig iron manufactured at a metallurgical plant under conditions of the southern part of the USSR and for each of them we calculated the deviations of the production expenditures in comparison with the actual ones. It was established that for each 0.01% decrease of the sulfur content in pig iron the content of silicon and manganese increases, respectively, on the average by 0.06 and 0.02%. If we take silicon as the characteristic (leading) element, which is more