EFFECT OF SATURATION WITH CARBON ON THE QUALITY
OF FOUNDRY IRON

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In recent years the carbon content of pig iron and foundry iron has increased substantially by (0.4 - 0.9%) as is
evident from data in the literature.

In previous work we derived an equation for calculating the equilibrium concentration of carbon in pig iron:

$$[C]_{eq} = 1.27 + 2.57 \times 10^{-4} t_{pig} - 0.34 [Si],$$

where $[C]_{eq}$ is the equilibrium carbon concentration (%) in pig iron; $t_{pig}$ is the temperature of the pig iron (°C); [Si]
is the silicon content of the pig iron (%).

The effect of the concentrations of S, P, and Mn on the carbon solubility is slight and is taken into account in
the equation by a correction factor (−0.03%). The concentration of Si in pig iron and foundry iron has remained
substantially unchanged for the past 30 - 40 years. Thus, the effect of this element on the carbon content is negligible.

Fig. 1. Variation of carbon content and degree of saturation with carbon in passing from melting pig iron to foundry
iron. a) Cherepovets plant; b) Donets plant.

Fig. 2. Relationship between silicon and carbon concentrations of pig iron (furnace No. 2, Donets plant, 1965-1966). The
rectangles show the range of the carbon content of foundry pig specified for various cast irons; 0-5 are the
grades of the foundry pig. The numbers on the curves are the concentrations of manganese, %.

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Basicity of CaO/SiO₂ slag

Fig. 3. Variation of tapping temperature with basicity of slag. I) Blast furnace No. 1, Donets, March, 1968; II) tests at Kalbe.

According to the equation, a change in the temperature of pig iron by ± 100°C changes the carbon solubility by 0.26% (absolute). In the past 20-30 years the temperature of pig iron and foundry iron has increased by 50-100 °C, which is the main reason for the increase in the carbon content.

The actual increase in the carbon content somewhat exceeds that calculated and also the equilibrium concentration, which is due to the favorable effect of raising the temperature on the degree of saturation with carbon. Other conditions being equal, an increase of the silicon content by 0.1% leads to an increase in the degree of saturation with carbon by 0.25%, while an increase of the temperature by 10°C leads to an increase in the degree of saturation with carbon by 1.9%.

The substantial increase in the degree of saturation with carbon during melting of foundry pig is due to the combined effect of increasing the temperature and the silicon content (Fig. 1). The increase in the degree of saturation with carbon also depends on the direct reduction of iron in the furnace. The positive effect of intensifying this process on the carburizing of pig iron is explained by the increase in the melting temperature and the actual temperature of the charge in the lower zone of heat transfer, and also by the limiting of the oxidation of carbon in the lower zone by the first and last slags, which contain smaller amounts of iron oxides.

The degree of saturation with carbon is 4-7% higher at the Cherepovets plant than at the Donets plant (Fig 1). The difference in the temperature and the extent of direct reduction of iron are negligible and should not be responsible for such a difference in the degree of saturation with carbon. In our opinion, the effect of temperature and the degree of direct reduction of iron must be accompanied by qualitative changes in the carburizing process in the lower zone of heat transfer.

The carburizing process can be divided into four stages:

I. Carburizing of iron in the solid state;
II. Carburizing in the liquid state as the metal drops to the hearth;
III. Oxidation of carbon by the first and last slags and also by oxygen in the blast from the tuyeres;
IV. Carburizing in the hearth with carbon from the coke.

The first stage results from the deposition and subsequent diffusion of carbon in the pores of the spongy metal. The relatively small probability of contact between the solid carbon and the spongy metal, the low diffusion rate, and the small amount of spongy metal in the upper part of the blast furnace limit the possibility of carburizing. As a rule, the carbon content of the unmelted sponge reaches 1.0-1.5%, with the limit solubility of carbon in solid iron at 1.76%.