



METHODOLOGY OF CHROME (CR) ELEMENT RECOVERY DURING MELTING OF LOW-ALLOY STEEL ALLOY IN AN ELECTRIC ARC FURNACE

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The main purposes of adding alloying elements to steel are:

- 1) improvement and expansion of existing properties of ordinary carbon steels;
- 2) development of new properties that do not exist in ordinary carbon steels.

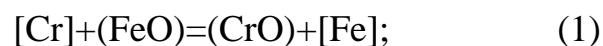
Thus, the addition of a small amount of chromium leads to the improvement of its main properties, such as strength and purity, while a large amount of these elements also improves the properties of austenite, such as the stabilization of austenite at room temperature, the loss of magnetic properties, and very high resistance to corrosion.

Today, the use of alloy steels is limited because they are expensive materials compared to plain carbon steels.

The main influence of alloying elements on the microstructure and properties of steel can be classified as follows [1-3].

Influence of alloying elements on the formation and stability of carbides. Some alloying elements form very stable carbides when added to steel. This generally increases the hardness properties of steels, especially when the carbides formed are harder than iron carbide. One of these elements is chromium. It often forms intermediate compounds. Some of these elements form separate hard carbides in the microstructure, for example, Cr_7C_3 .

Chromium, like manganese, can be oxidized or reduced during smelting, depending on the composition of the metal and slag, as well as the temperature of the process. The oxidation (reduction) reaction of chromium occurs at the metal-slag interface and can lead to the formation of CrO and Cr_2O_3 . In acidic slag, chromium is found predominantly in the form of CrO , and the oxidation reaction for the acidic process is:



$$K_{Cr} = \frac{a_{CrO}}{a_{[Cr]} \cdot a_{(FeO)}} = \frac{(CrO)}{[\%Cr](FeO)} \cdot \frac{f_{CrO}}{f_{FeO}}; \quad (2)$$

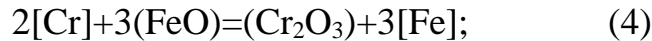
Replacing, as a first approximation, the activities of CrO and FeO in the slag with concentrations and expressing the distribution coefficient of chromium, we obtain:

$$(CrO)/[Cr] = K_{Cr} (FeO) \quad \text{or} \quad 1.31(Cr)/[Cr] = K_{Cr} (FeO); \quad (3)$$

where 1.31 is a coefficient that takes into account the replacement of concentration (CrO) with concentration (Cr) .

Consequently, the distribution of chromium between the metal and the slag, i.e. the degree of oxidation of chromium is proportional to the FeO content in the slag. In basic slags, Cr_2O_3 predominates, which, having acidic properties and

binding to CaO, is stable in such slags. Therefore, during the main process, the reaction occurs preferentially.



According to experimental data for this reaction:

$$\lg K_{\text{Cr}} = \lg \frac{(\text{Cr}_2\text{O}_3)}{[\% \text{Cr}]^2 (\text{FeO})^3} = -\frac{19950}{T} + 12.54; \quad (5)$$

When replacing the activities of Cr_2O_3 and FeO in the slag with concentrations, as was done in equation (5), we can simplify it by writing:

$$(\text{Cr}_2\text{O}_3)/[\text{Cr}]^2 = K_{\text{Cr}}(\text{FeO})^3 \quad \text{or} \quad 1.47 (\text{Cr})/[\text{Cr}]^2 = K_{\text{Cr}}(\text{FeO})^3; \quad (6)$$

where 1.47 is a coefficient that takes into account the replacement of concentration (Cr_2O_3) by concentration (Cr).

Consequently, during the main process, the distribution coefficient of chromium between the metal and the slag, which characterizes the degree of its oxidation, increases with increasing FeO content in the slag [4, 5].

Since Cr_2O_3 , having acidic properties, binds with CaO in the slag into quasi-molecules, with increasing basicity the activity of chromium oxides decreases, and this causes an increase in its distribution coefficient between the slag and the metal (Figure 1). However, the role of slag basicity appears to manifest itself not only in its direct influence on the activity coefficient of chromium oxides. As noted above and can be seen in the activity change curves (FeO), also plotted in Figure 1, almost to the value of $(\% \text{CaO}) / (\% \text{SiO}_2) = 3$, a simultaneous increase in α_{FeO} and $(\% \text{Cr}) / [\% \text{Cr}]$ is observed. But with a further increase in basicity, its direct influence on the chromium distribution coefficient predominates - it also increases under conditions of decreased activity of iron monoxide.

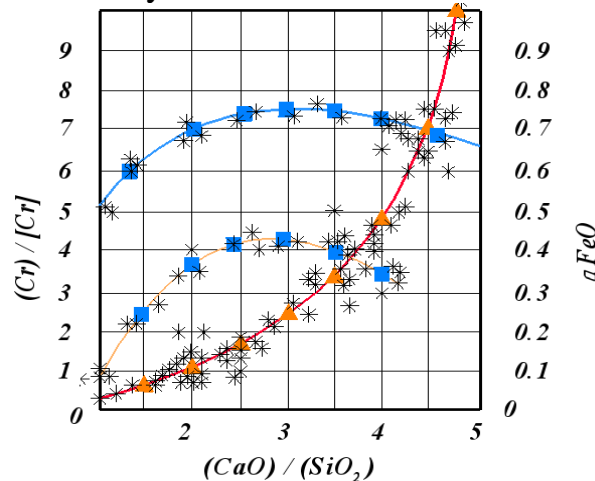


Figure 1. The influence of slag basicity on the chromium distribution coefficient (1) and the activity of iron monoxide at (FeO) 10% (2) and 30% (3): points - experimental data related to curve 1.

As follows from equation (5), temperature has a significant influence on the distribution coefficient of chromium between slag and metal: with increasing temperature it decreases. Consequently, with decreasing temperature, the



equilibrium content of chromium in the metal decreases, and more complete oxidation of chromium dissolved in the metal occurs [6-10].

Conclusion is in order. To increase the activity of Cr_2O_3 and, as a result, obtain a greater degree of chromium reduction, i.e. less waste; when smelting high-chromium [$\text{Cr} > 14\%$] stainless steel in arc furnaces, the slag of the oxidation period has low basicity: CaO 10...15%; SiO_2 15...20%; $(\% \text{CaO}) / (\% \text{SiO}_2) = 0.7...1.0$. But, such slag FeO has a significant effect on the distribution coefficient of chromium between the slag and the metal: with increasing content (FeO), this coefficient increases, i.e. chromium waste increases during the smelting process. This effect of iron monoxide is obvious when analyzing equation (5).

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