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Study of the oxidation process in electric arc welding

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ABSTRACT: This article provides a study of the oxidation process during arc welding and surfacing of low-carbon and low-alloy steels.

KEY WORDS: arc welding, flux, low alloy steel, low carbon steel, slag.

I. INTRODUCTION

Welding metallurgy differs from other metallurgical processes by the high temperatures of the thermal cycle of welding and the short lifetime of the weld pool in a liquid state, that is, in a state accessible for metallurgical processing of the weld metal. In addition, the processes of crystallization of the weld pool, starting from the fusion boundary, and the formation of a heat-affected zone metal that has changed in its properties are specific.

II. LITERATURE SURVEY

Metals, having a small number of electrons at external energy levels, easily donate them to atoms of elements with high electronegativity (F, Cl, O, S, and others.) [1,2]]:

$$\left.\begin{array}{l} Me^{0} - 2e \rightarrow Me^{2+} \rightarrow \\ O^{0} + 2e \rightarrow O^{2-} \rightarrow \end{array}\right. MeO \qquad (1)$$

The processes of loss of electrons from the external energy level and the transition of metals into combination with atoms of an electronegative element is called oxidation [3].

It is not necessary that the metals form only oxides; combining with halogens or sulfur, the metal will also oxidize, turning into a state of a positively charged ion: $Me^{+2}F_2^{-2}$; $Me^{+2}Cl_2^{-2}$; $Me^{+2}S^{-2}$ [4].

The reverse process of metal reduction will be determined by the thermodynamic stability of their halides, oxides or sulfides [5].

The thermodynamic stability of a given compound is determined by the change in the Gibbs ΔG energy during its formation under given physical conditions (p, T). The decomposition of this compound requires the expenditure of the same energy, and thus the possibilities of this metallurgical process are determined [6].

III. METODOLOGY

At high temperatures, metal compounds with elemental oxidants (O, S, N, H) can decompose, releasing the oxidizer into the gas phase, for example [2,3]:

$$2FeO_{TB} \leftrightarrow 2Fe_{TB} + O_{2\text{газ}} \uparrow \qquad (2).$$

The equations for the interaction reactions between the metal and the oxidizing agent are written as a decomposition reaction, defining the coefficients of the equation in such a way that one gas molecule is obtained on the left side, for example [3,4]:

$$2MnO \leftrightarrow 2Mn + O_2$$
$$SiO_2 \leftrightarrow Si + O_2 \qquad (3)$$

In this case, the standard change in the Gibbs ΔG^0 energy for all reactions will be expressed by the general equation [4]:

$$\Delta G^0 = \Delta H - T\Delta s = -RT \ln N_{O_2} \qquad (4)$$

A heterogeneous system in which this equilibrium exists (Fig. 1.1 will have one degree of freedom) [3], that is

$$P_{O_2} = f_1(T) \text{ or } T = f_2(p_{O_2}) \qquad (5)$$

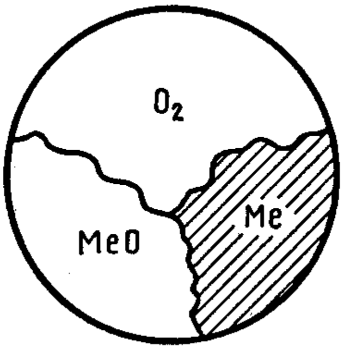

Fig. 1. Metal-oxygen interaction system

The dependence ΔG on temperature within certain limits (without phase transformations) changes linearly, and the logarithm of the oxygen pressure will change along a curve, as shown in fig. 2.

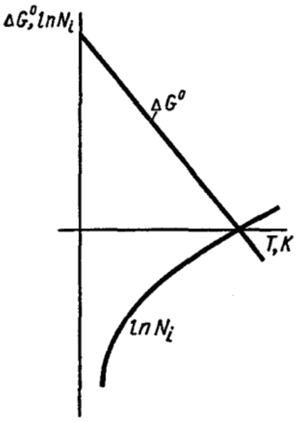

Fig. 2. Dependence ΔG^0 and logarithm of the pressure of dissociation of metal oxide on temperature

The point of intersection with the temperature axis will correspond to the condition:

$$\Delta G^0 = 0;\ \ln N_{O_2} = 0;\ N_{O_2} = 1 \qquad (6)$$

The physical meaning is that at temperature T_0, the equilibrium pressure of oxygen over the oxide will be equal to the external pressure of pure oxygen, that is, even in pure oxygen, the metal will not oxidize. For active metals, this temperature is very high and lies above the boiling point of the metal, while less active metals, such as copper, satisfy this condition at lower temperatures.

Applying a simplified equation for the standard change in the Gibbs energy ΔG^0, one can obtain the following equations for the dissociation of oxides:

$$2FeO \leftrightarrow 2Fe + O_2;\ \Delta G^0_{FeO} = 527360 - 114{,}75T$$

$$2MnO \leftrightarrow 2Mn + O_2;\ \Delta G^0_{MnO} = 769860 - 148{,}05T$$

$$SiO_2 \leftrightarrow Si + O_2;\ \Delta G^0_{SiO_2} = 1718600 - 181{,}66T \qquad (7)$$

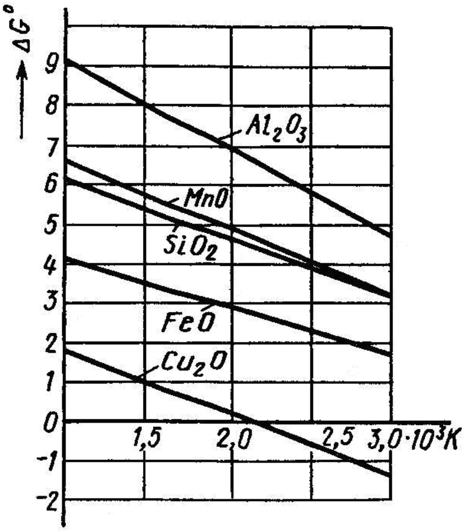

Fig. 3. Change ΔG^0, MJ/mol, depending on temperature

On fig. 3 shows graphs of functions $\Delta G^0 = f(T)$. The thermodynamic stability of oxides increases in the series of elements $Cu \to Fe \to Mn \to Si \to Al$, but in the temperature range of 2500...3000K, the stability of Mn and Si oxides change places. The temperatures at which the thermodynamic stability vanishes are respectively the following: $T_{Cu_2O} = 2230K$; $T_{FeO} = 4600K$; $T_{SiO_2} = 4730K$; $T_{MnO} = 5200K$; $T_{Al_2O_3} = 5330K$. Thermodynamic stability varies significantly depending on the partial pressure of the gaseous reaction product in the environment. Different thermodynamic stability of compounds, such as oxides, allows for redox reactions between them.

When combined with elemental oxidizing agents (O, S, N, H, halogens), the elements can exhibit different oxidation states and the dissociation of compounds will occur in steps from the highest to the lowest oxidation state, for example:

$$4/3CrO_3 \leftrightarrow 2/3Cr_2O_3 + O_2 \uparrow;\ 2Cr_2O_3 \leftrightarrow 4CrO + O_2 \uparrow;\ 2CrO \leftrightarrow 4Cr + O_2 \uparrow;$$

$$2FeS_2 \leftrightarrow 2FeS + S_2 \uparrow;\ 2FeS \leftrightarrow 2Fe + S_2 \uparrow;$$

$$SF_6 \leftrightarrow SF_4 + F_2 \uparrow;\ SF_4 \leftrightarrow SF_2 + F_2 \uparrow \quad (8)$$

The thermodynamic stability of compounds increases greatly if these compounds are in solutions.

IV.CONCLUSION

Scientifically substantiated selection of deoxidizers in arc welding makes it possible to deoxidize the liquid metal to the required extent, despite the short duration of metal processing under welding and surfacing conditions.

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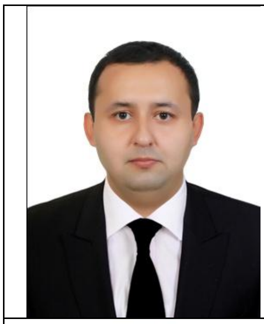	Khudoyorov Sardor Sadullaevich , Associate Professor, Doctor of Philosophy in Technical Sciences (PhD), was born March 7, 1989 year in Tashkent city, Republic of Uzbekistan. Has more than 40 published scientific works in the form of articles, journals, theses and tutorials. Currently works at the department of "Technological machines and equipment" in Tashkent State Technical University.
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