Prognostic models for Electroslag Remelting process and slag engineering

G. Stovpchenko[1], L. Medovar[1], L. Lisova[1], D.Togobitskaya[2], D.Stepanenko[2]

1 Chief Scientist, E.O. Paton Electric Welding Institute, Kyiv, 03680, Ukraine
2 Department Chief, Z.I. Nekrasov Iron & Steel Institute, Dnipro, 49050, Ukraine

Classical electroslag remelting of consumable electrodes is a drop-by-drop melt feeding through a layer of slag into a renewing molten metal bath, which slowly solidifies into a homogeneous, dense, defect-free ingot in a copper water-cooled mould. The new look at the additive nature of the ESR process in a protective atmosphere allowed us to formulate the principles of a comprehensive thermodynamic-based model able to predict dynamic changes of slag and metal composition at certain ingot remelting. The model considers drastically different slag-to-metal mass ratios at the beginning and end of remelting and predicts gas, slag and metal composition in a chain of thermodynamic systems. Despite consisting of calcium fluoride and stable oxides, the ESR slag can oxidise active alloying elements from steel and alloys (primarily aluminium, titanium, silicon) due to chemical reactions between slag and metal. ESR is not intended as electrochemical process but exploited slags are ionic melts with semiconductor properties causing partial rectification of alternating current and connected electrochemical reactions.

Another important understanding derived from the nowadays metallurgy practice is that ability to refine metal from impurities is not priority for the ESR because consumable electrode has already passed all stages of refining and deep degassing at ladle treatment that changes ESR slags' engineering principles. The critical importance became slag's ability to generate process' heat and to keep composition of melt coming in metal bath unchanged (except non-metal inclusions assimilation). Slag engineering for ESR requires compromise between chemical inertness to metal composition and desired from technological reasons physical properties. Theretofore, prognostic models of viscosity and specific conductivity of fluoride-oxide slag from their chemical composition were built based on the concept of direct chemical bonds using complex stoichiometry parameter of a multicomponent oxide system.

Using both models helps to design a customised composition of effective slags for steel and alloys groups or individual grades.For example, the results of TiO_2-added slag improvement to facilitate Inconel 718 remelting in short collar mould are presented.