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SEMINARIO DEL IER

"MAGNETOHYDRODYNAMICS IN METALLURGICAL PROCESSES USING ELECTRIC CURRENTS"

In metallurgy, electric currents are applied for heating, melting, and for promoting electrochemical mass transfer. The currents are passed through low conductivity media such as a salt, slags, or plasmas to generate high Joule heating intensity. Typical processes are electric arc furnaces, aluminum reduction cells, welding, electroslag and vacuum arc remelting. Such processes are naturally stirred by the Lorentz forces resulting from the interaction of the applied current with its own self magnetic field (created by the current itself). Electroslag remelting (ESR) and the vacuum arc remelting process (VAR) are two examples of secondary metallurgical process using electric currents. They are aiming at purification of the electrode material from non-metallic inclusions. Thermal energy is supplied to the process through the Joule heating generated in the slag (ESR) or in the plasma (VAR). It results in remelting the primary electrode and formation of droplets. The droplets form pass and reach the liquid pool. The melt pool solidifies directionally and builds the high-grade ingot in a water-cooled mold. Over past decades, these processes have been developed to produce a variety of ferrous and non-ferrous alloys such as steel, nickel-based, and titanium-based super alloys. Diverse application areas exist for remelted products in tool steel, aircrafts, oil and chemical industries, thermal power station, nuclear power plant, and military technology. Nowadays, million tons of remelted ingots are produced in a wide range of sizes and weights in various countries.

These processes involve two liquids, a liquid metal and a low conducting liquid (slag or plasma). The electric current vector field will neither uniform nor steady, it flows preferentially through the metal. Thus strong MHD-multiphase coupling can be expected. To understand such processes, a numerical model was built to simulate the coupling between multiphase and MHD phenomena. The model can predict the electric and magnetic field distribution in function of the metallic distribution in a low electric conductivity media. It is shown that the droplets formation, departure, and movement disturb the distribution of the electric current density. In the ESR process, due to the Lorentz force and to the droplets impacts, the metal/slag interface becomes very unstable. The dynamic of the interface movement is highly related to the applied current intensity and frequency. Some mysterious and puzzling experimental phenomena will be presented.

Dr. Abdellah Kharicha
Investigador
Universidad de Leoben, Austria

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Auditorio Tonatiuh, Instituto de Energías Renovables, UNAM
Priv. Xochicalco s/n, col. Centro, 62580 Temixco, Morelos

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