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Mathematical Model to Simulate Liquid Metal and Slag Accumulation, Drainage and Heat Transfer in Blast Furnace Hearth

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Abstract : It is utmost important for a blast furnace operator to understand the mechanisms governing the liquid flow, accumulation, drainage and heat transfer between various phases in blast furnace hearth for a stable and efficient blast furnace operation. Abnormal drainage behavior may lead to high liquid build up in the hearth. Operational problems such as pressurization, low wind intake, and lower material descent rates, normally be encountered if the liquid levels in the hearth exceed a critical limit when Hearth coke and Deadman start to float. Similarly, hot metal temperature is an important parameter to be controlled in the BF operation; it should be kept at an optimal level to obtain desired product quality and a stable BF performance. It is not possible to carry out any direct measurement of above due to the hostile conditions in the hearth with chemically aggressive hot liquids. The objective here is to develop a mathematical model to simulate the variation in hot metal / slag accumulation and temperature during the tapping of the blast furnace based on the computed drainage rate, production rate, mass balance, heat transfer between metal and slag, metal and solids, slag and solids as well as among the various zones of metal and slag itself. For modeling purpose, the BF hearth is considered as a pressurized vessel, filled with solid coke particles. Liquids trickle down in hearth from top and accumulate in voids between the coke particles which are assumed thermally saturated. A set of generic mass balance equations gives the amount of metal and slag intake in hearth. A small drainage (tap hole) is situated at the bottom of the hearth and flow rate of liquids from tap hole is computed taking in account the amount of both the phases accumulated their level in hearth, pressure from gases in the furnace and erosion behaviors of tap hole itself. Heat transfer equations provide the exchange of heat between various layers of liquid metal and slag, and heat loss to cooling system through refractories. Based on all that information a dynamic simulation is carried out which provides real time information of liquids accumulation in hearth before and during tapping, drainage rate and its variation, predicts critical event timings during tapping and expected tapping temperature of metal and slag on preset time intervals. The model is in use at JSPL, India BF-II and its output is regularly cross-checked with actual tapping data, which are in good agreement.

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