Thermal analysis techniques applied to study wear mechanisms of black refractories used in the steel continuous casting process

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The continuous advances in the technology of refractory materials promote the development of materials operating at extreme conditions. The effects of different damage mechanisms are critical and it is necessary to provide detailed information about the thermal behaviour of the nozzle-mould flux system, at steel continuous casting process condition. It is possible to describe the attack of the refractories as a complex phenomenon involving not only chemical wear (corrosion), also it is important to consider the combination of physical and mechanical wear. The corrosion affects the internal structure of the nozzles and all the properties. For these reason, it is important a deep understanding and evaluation of the problem in order to prolong the nozzle life in service avoiding the interruption in the continuous casting production and promoting a decrease of the costs on refractories.
Mould fluxes used in the steel continuous casting process provide suitable heat extraction and lubrication [2]. These powders are formed by a complex mix of oxides and carbonaceous materials (coke, graphite, etc.). They also contain fluorite (CaF_2) [3]. Mould flux physical properties (viscosity and surface tension) evolution are strongly dependent on the chemical composition and controls corrosion rate. Both physical properties were determined by experimental tests. For this paper, viscosity is determined by the rotating cylinder method at 1600 ºC and the surface tension is estimated by contact angle measurements using hot stage microscopy (HSM), at similar temperature condition.

The submerged nozzle are constituted with a body of Al_2O_3-C and a insert of ZrO_2-C, in the critic wear zone to protect the material due to the mould flux contact. The structure transformations produced in the refractory material at such conditions also contribute to explain the corrosion mechanisms. In these circumstances the use of thermal analysis techniques (DTA-TG and dilatometry) can provide specific information about phase transformations, mass changes and volumetric variations which occur in the system of study. In this paper, the results are correlated with information obtained through conventional techniques such as optical microscopy (OM) and scanning electron microscopy (SEM) including EDS analysis and EBSD, that are used to characterize different structural aspects on the refractory material and of the interface with the mould flux adhered on the nozzle. The thermodynamic simulation of the corrosion also contribute with relevant information associated to the main goal of this paper. By the thermochemical simulations, the chemical reactions in the system between nozzle and mold flux are justified. All this information is useful to establish the corrosion mechanisms and to predict the dynamic process conditions that cause the damage in the refractory material, in order to improve the nozzle performance.

References

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