Analysis of DTA and dilatometric data used to study the behaviour of a mould flux

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Mould fluxes, known also as casting powders or mould powders, are used in steel continuous casting in order to control both (i) the heat extraction rate, during the solidification of the steel, and (ii) the lubrication of solidifying steel shell against the mould wall. Suitable heat extraction and adequate lubrication guarantee the stability of this process. These powders are synthetic slags formed by a complex mix of oxides and minerals. The main oxides present are SiO_2, CaO, and Na_2O, with a binary basicity (CaO/SiO_2 ratio) between 0.7–1.3. They also contain fluorite (CaF_2) and carbonaceous materials (coke, graphite, etc.) in their compositions. During process, formation of crystals in the zone of the gap between the steel solidified shell and refrigerated copper mould (at temperatures between 600-900°C) plays a fundamental role because increase the thermal resistance changing the heat extraction rate from the steel to the mould [1].

In the present work a casting powder containing ≈ 36 wt% SiO_2, ≈ 31 wt% CaO, 13 wt% Na_2O, and 10 wt% CaF_2, was used as starting material. A mass of 10 g of the mould powder was placed in a graphite crucible and melted at 1300°C. After 15 minutes at this temperature, the melt was poured onto a stainless steel inclined plate. By this method, solid glass layers were produced, which were sectioned into bars 10–15 mm in length to be used in dilatometric tests. Some of these bars were ground to powder to perform DTA runs. Both tests (DTA and dilatometry) were carried out at different heating rates: 5, 10 and 15 ºC/min, in air atmosphere, up to 900°C. Data of glass transition temperature (Tg), and crystallization peak temperature (Tc) were obtained from DTA and dilatometric runs. From these data, several non-isothermal methods based on Kissinger [2], Augis-Bennet [3], Ozawa [4], and Cheng [5] models, were used to study the crystallization kinetics. Based on these models, the activation energy of crystallization (E), the frequency factor (ν) and the crystallization rate constant (k) were calculated. A subsequent study was followed to determine the Avrami exponent and the crystallized fraction. The crystallographic phases were determined by XRD and the microstructure of samples, treated between 400–900ºC, was observed by optical and electronic microscopy.

Both methods (DTA and dilatometry) showed a Tg about 480°C and two crystallization peaks, the first appears around 600°C (Tc1) while a second peak occurs around 700°C (Tc2). A good correlation of both E and ν values, determined by DTA and dilatometry, was obtained. According to the average of non-isothermal models, the peak Tc1 has associated to crystallization energy of 290 kJ/mol (DTA) or 330 kJ/mol (dilatometry) and a frequency factor ≈ 10^{16} s^{-1} (DTA) or ≈ 10^{19} s^{-1} (dilatometry). The second peak Tc2 presented smaller Ec (≈ 190 kJ/mol from DTA or ≈ 230 kJ/mol from dilatometry) and smaller ν (≈ 10^{9} s^{-1} from DTA or ≈ 10^{11} s^{-1} from dilatometry) than the peak Tc1. Thus, a lower crystallization rate for the peak Tc2 was

obtained. From the degree of crystallization at different heating rates, the kinetics of formation of crystals was analyzed. The influence of these results on the heat extraction during the continuous casting process of steel is discussed. Finally, from the width of the glass transition region, determined by DTA and dilatometric curves, a model proposed by Moynihan [6] to estimate mould flux viscosity was successfully used.

References

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