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P 3.1 - Slags, refractories and inclusions in the continuous casting process, 07/2015 - 06/2019, multi-firm

Investigation of mold slag crystallization under near service conditions (written by Nathalie Kölbl)

The already established Double Hot Thermocouple Technique has been implemented to study the crystallization behaviour of mould slags in the continuous casting process under near service conditions. Nevertheless, it suffers from some deficiencies, e.g. a minimum temperature within a drop like slag film. Therefore, the set up was modified. The sample is now located in a furnace chamber preheated to the minimum temperature and it is stretched to a thin, rectangular slag film. In addition, graphical representations of the results were suggested in order to compare the crystallization behaviours of different mould slags.

Problem definition and approach

The Double Hot Thermocouple Technique is already used to characterize the crystallization behaviour of different mould slags for the continuous casting of steel under near service conditions. Nevertheless, it has some disadvantages: Simulations of the temperature distribution within the sample located the minimum within the slag film and not at the cold end as intended. Due to the U-shaped thermocouples stretching the slag, a drop like shape is formed, which enables only the investigation of transparent liquids. Furthermore, results are only presented via snap shots of the crystallization process and a comparison of different slags is not possible. Thus, the setup has been modified and a suitable graphical representation of the results is suggested.

A furnace made of a refractory material is preheated to the desired minimum temperature of the cold end. This reduces heat loss from the sample surface to the surrounding. Mineralogical investigations compared to results of thermochemical calculations in equilibrium confirm a constant temperature gradient within the slag film without a minimum in between.

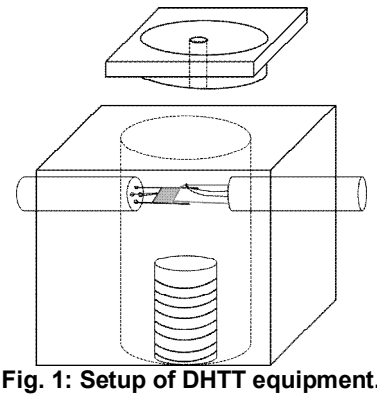

Fig. 1: Setup of DHTT equipment.

An H-shaped heating wire heating the slag to its maximum temperature (depending on its melting temperature) is used to stretch the melt within the legs of the H. This guarantees the formation of a thin, rectangular slag film and subsequently

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enables the investigation of translucent transparent and also translucent liquids.

During the experiment pictures representing the crystallization process in dependence on time are taken. For data evaluation, the crystalline fraction of the area where crystallization can take place is determined. Furthermore, the viable perimeter of the already crystallized domain is used together with the crystalline area to calculate the crystal growth rate in dependence on time. For further evaluation, the slag film of 3 mm is divided into sections of 0.1 mm. For all of them the crystalline fraction is calculated in dependence on the experimental time. Based on these information, a diagram representing the time until the e.g. end of crystallization (defined by 95% crystal fraction) is achieved, can be plotted. Additionally, the depiction of the maximum, absolute crystalline fraction in dependence on the position within the slag film is possible.

Results

First investigations were carried out with slag compositions showing a different crystallization behaviour. These differences are also evident in the suggested diagrams. Liquids with a congruent crystallization behaviour show a sharp decrease in the crystalline fraction at the position within the slag film representing their liquidus temperature. Contrary, for slags, where chemical diffusion is the rate limiting step, a smooth curve progression is observed. Furthermore, they show a significant lower crystal growth rate at the start of crystallization. Whether crystals precipitate from the stretching device or nucleate within the slag film can also be seen form the curve progression.

Impact and effects

Due to the modification of the set up and the development of a proper graphical representation the applicability and the information content of the DHTT results is improved significantly.

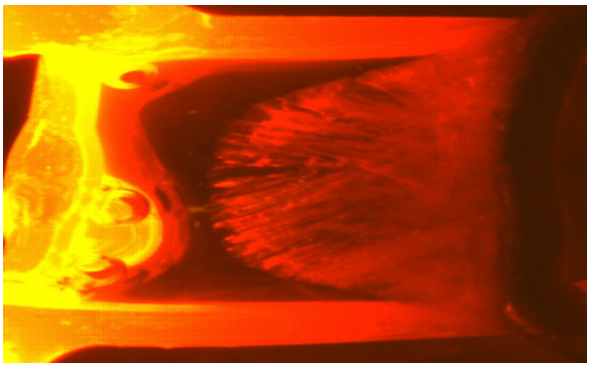

Fig. 2: Crystallization for the temperature gradient of 1150°C/700°C.

Due to the representation of the experimental results via diagrams different slags can be compared regarding their crystallization behaviour. Thus, this method can now been applied for both mould slag evaluation for the continuous casting process and for new mould slag development.

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