Optimization of operating parameters of an ingot mold during continuous casting - case of slab a content high carbon

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Abstract

Currently, the axes research majority aims to improve continually the quality of continuously cast products. Moreover, to guarantee this quality it is necessary to master operating parameters of casting machine, in particular, the primary cooling phase that takes place at level of ingot mold. The latter animated by an oscillatory movement, generally induces marks and defects on slab surface. Indeed, during descent, the solidified crust is in compression, thus creating a negative sliding, this sliding time will help reduce the sticking risk, to close the rips of solid skin and to reduce the depth of oscillation marks. In addition, this time depends on casting speed and oscillation parameters of ingot mold (amplitude and frequency). The aim of this work is to optimize the operating parameters of ingot mold in this case the casting speed "v" and oscillations (amplitude "a", frequency "f") at means of Box-Behnken's experimental design thus makes it possible to predict the healing rate "τ" which represents the ratio of sliding time and total cycle time. Mathematical model have been obtained and the results show that for the case of carbon steel slab, strong sheet with a thickness of 250mm, it is recommended to use low speeds (v = 0.6m.mm-1) and large frequencies (n = 200cpm) associated with average amplitudes (a = 10mm) to achieve a value of τmax = 0.470 ± 0.048.

Keywords

Healing rate, optimization, experimental design, continuous casting, and primary cooling.

1. Introduction

In steel industry, continuous casting of slabs and billets is a steelmaking process strong widespread (Henri 2009), it is now widely used for mass production of various billets, slabs and sheet thin. This process occupies an important place in production spinneret because of low cost, higher production rates, energy saving and reduce manpower as well as improvement of product quality (Bensouici 2007). Today the tendency of studies is towards a generalized process modeling (Fréderic 2004) (Qin Qin 2017) (Bellaouar 2007). During continuous steel casting, the primary cooling phase is an important step that directly affects the product quality (Heinrich 2003) (Akni.2011) (Cerrit 2007). Indeed, this cooling process takes place in a bottomless ingot mold, in which the liquid steel is poured continuously and is energetically cooled. The main function of ingot mold is to form a solid crust of sufficient thickness to eliminate the risk of breakthrough (Fei He 2018) (Xu Zening 2010) and minimize appearance of surface defects (Wentao 2010) (Dukman 2009). However, the control of certain parameters affecting primary cooling mechanism such as heat transfer, lubrication and oscillation of ingot mold is essential in this process to achieve the desired quality product. As a result, the oscillatory movement contributes to reducing risk of bonding metal to walls, and ensures extraction without incident. (Farhi 2010). This practice is deemed to give a better surface quality and less pronounced oscillation marks. The interest of this work is to optimize the parameters that directly influence mechanism of operation of ingot mold in this case: the amplitude (a), frequency (n) and casting speed (v) to minimize the risk of breakthrough and improve the product quality. Box Behnken's experimental designs at three factors and three levels (-1, 0, +1) were adopted for Simulation, resulting in mathematical models for each case studied.

5. Conclusion

The process of continuous steel casting is very complex and difficult to manage by fact that many phenomena interact at same time, master the parameters that govern it to improve productivity and product quality is the goal of all industrialists. In addition, the primary cooling in ingot mold is an essential step in this process, during this phase is forming a sufficiently strong skin to contain the liquid steel. Therefore, the adoption of parameters of machine (amplitude, frequency and speed) adequate will prevent the phenomenon of sticking and rips that may occur during exit of slab of the ingot mold. Furthermore, Box Behnken experimental designs can be a powerful tool for predicting most appropriate regime, which offers the best healing rate to allow consolidation of formed skin. Therefore, as a result of this simulation, mathematical model offer the advantage of predicting healing rate as a function of parameters (a, n and v) making it possible to optimization of this later contributes to clogging breaches of collage, to reduce marks of oscillations and mitigate risk of breakthrough. Thus, for case studied, low speeds respectively (v = 0.6m.mm-1) and high frequencies (n = 200cpm) as well as average amplitudes (a = 10mm) are most interesting parameters to improve the healing rate thus minimizing surface defects, thereby improving cast product quality.

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