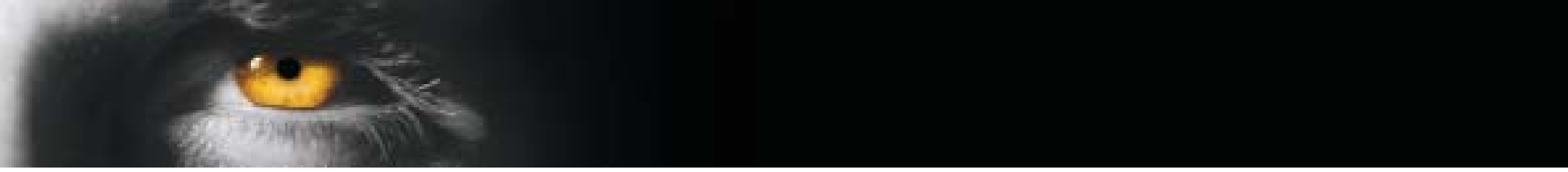


Increasing Productivity in Horizontal Continuous Casting

e-Tips

Nr. 1

Productivity is a crucial issue in continuous casting, as well as in all other industrial processes. The key to an increase in productivity remains often in the control of all operational parameters. However, the relative influence of each experimental parameter has traditionally to be determined using long and expensive trial runs. Simulation is another, more convenient and accurate method to understand and analyse the importance of each casting parameter. The influence of operational data such as casting speed, cooling condition or inlet temperature can be analysed rapidly, independently and cost efficiently.

In this case study, simulation has been used to increase the productivity of an horizontal continuous casting machine. The key factors influencing the heat extraction in the cooling system have been determined. The process modifications proposed have led to a net productivity increase of 25%.

The Process

Horizontal continuous casting is a process in which solidifying metal is extracted horizontally through a cooling unit. Figure 1 illustrates schematically this process.

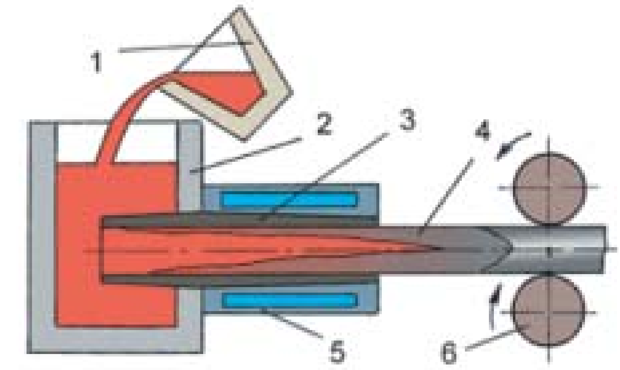


Figure 1: Horizontal continuous casting. (1) foundry ladle, (2) crucible, (3) graphite sleeve, (4) casting, (5) cooling unit & (6) withdrawal rolls. (Ref.: Institute of Technology of Metals, Belarus)

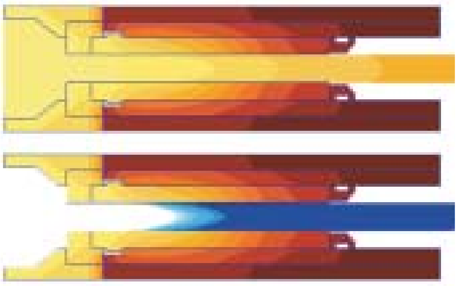
Generally a saw is set up after the withdrawal rolls, in order to cut the casting at constant lengths. This process is used mainly for copper alloys and cast iron. Such a casting unit can typically produce 300 to 600 Kg/h of bronze, or 700 to 1'400 Kg/h of cast iron.

The castings are semi-finished products, which are further processed in extrusion, drawing, rolling or remelting operations. The quality of the castings depends mainly on the processing conditions. In this respect, the position and the shape of the solidification front (light blue in the bottom image of figure 2) plays a significant role. Therefore, it is of prime importance to closely control the cooling conditions.

The Case

A copper alloy rod producer has undertaken a complete re-evaluation of its continuous casting process. The objective was to increase productivity by a factor 3 but keeping the same metallurgical properties. The engineers had therefore to find a way to increase casting speed without affecting the shape of the solidification front.

Figure 2 : Temperature field (top) and solidification front (bottom) in the horizontal continuous caster (simulation run with calcosoft®-2D)



The Analysis

In terms of casting parameters, increasing productivity, keeping the same material properties, means casting faster and extracting more heat. Foundry experience can feed many casting improvements, but it is not possible to know accurately where and how the metal solidifies in the mould. Therefore, it was rather difficult to run proper process optimisation in the foundry.

In order to actually see what is happening inside the casting machine, simulation was used. Figure 2 shows 2D crosscuts of one of the casting setups. The upper image represents the temperature field whereas the lower image represents the liquid zone in white, the mushy zone in light blue and the solid in blue.

Simulation also allows foundrymen to run castings in unrealistic situations. An optimal cooling condition would be to remove all the mould elements and to cast directly into water. This would not be possible in practice, as liquid metal would flow directly into the water, without solidifying into a consistent casting. This case has been run and showed a maximal increase in casting speed of 70%. Far from the requested productivity increase and still an unrealistic solution, this simulation was the starting point for the process optimisation, setting the maximum theoretical velocity. From there on, the mould elements have been added step by step, rebuilding hereby the casting.

The thermal analysis of the complete setup showed where the heat extraction could be increased. Figure 3 shows the temperature profile from the outside of the mould to the inside of the billet in the solidification region.

The temperature jumps correspond to the interfaces. The main resistance to heat flow is therefore located at the boundaries between the elements of the mould. The highest temperature drop appears to be between the casting and the graphite sleeve. Any improvement in the quality of the contact between these two elements would lead to a dramatic increase of the heat extraction capacity.

The cooling conditions could be optimised by modifying the geometry of the various cooling elements. This in turn opened the possibility to cast faster but still keeping the same solidification front. The casting speed increase was around 25% of the initial casting speed. Once the changes on the machine had been operated, it represented an equivalent increase in productivity.

Conclusion

The importance of each parameter, such as the thickness of the graphite shell or the contact between the graphite and the cooling jacket have been analysed separately. Thermal modelling of the process showed that the interfaces between the mould components represent the main resistance to heat extraction. Working on the different elements constituting the mould, the engineers could develop a new casting design, allowing a net production increase of 25%.

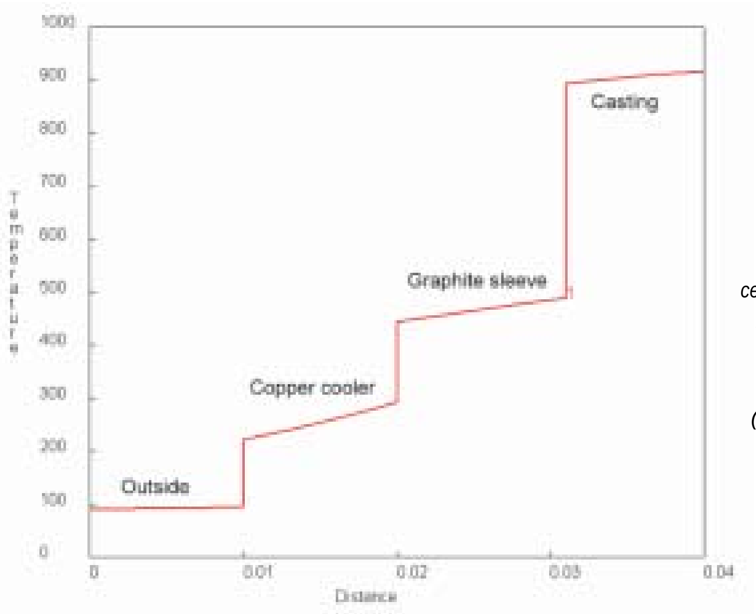


Figure 3: Temperature profile from the outside of the mould to the center of the casting, through the copper cooler and the graphite sleeve (simulation run with calcosoft®-2D)

calcosoft® is a registered trademark for a software dedicated to continuous casting.

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