CLOSING THE QUALITY CHAIN: REFRACTORIES AND THEIR INFLUENCE ON INGOT STEEL QUALITY

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KEYWORDS: REFRACTORIES – BOTTOM POURING – CHEMICAL RESISTANCE – STEEL FLOW – QUALITY

INTRODUCTION

Ingot-casting continues to play an important role in producing high-quality semi-finished products of high-alloy steels for large machinery. The final products are critical components, including crankshafts and similar products, which are exposed to elevated levels of mechanical stress. Therefore, it is essential that they meet high quality standards. The quality of the steel is influenced by various factors throughout the entire process. During casting, the use of suitable refractory materials with appropriately designed channel geometries is crucial to prevent the formation of inclusions or surface defects. Whilst products must meet the highest quality standards, economic factors frequently influence the selection of refractory materials, resulting in the application of low-quality materials.

INTERACTION BETWEEN REFRACTORY AND STEEL

Influence of refractory composition

It is well known that certain alloying elements can reduce components of Al_2O_3-SiO_2 refractory materials, such as free SiO_2 and Fe_2O_3, which leads to the re-oxidation of the alloying elements. The specific elements involved can be estimated by consulting the electrochemical series. Based on this knowledge, suitable materials can be selected to decrease the reactions between liquid steel and the refractory material and thus inclusions in the product. Cup tests are commonly used to examine the reactions between steel and refractory materials in laboratory settings.

40 % Al_2O_3 1520 °C / 5 h 42CrMo4	65 % Al_2O_3 1520 °C / 5 h 42CrMo4	90 % Al_2O_3 1520 °C / 5 h 42CrMo4

Fig. 1 – Cup Tests (Steel) with various refractory grade

Figure 1 shows different pattern formations on the steel surface due to the contact with various refractory materials. It stands out, that the steel surface inside the 40 % Al_2O_3 cup is the only one to show overheating and spilling over, which leads to the conclusion that the extent of the reactions between steel and refractory is more severe than in the other samples. The steel surface inside the sample with the 90 % Al_2O_3 refractory shows the least impact, which results from the high chemical resistance of high alumina materials. Overall, a higher Al_2O_3 content—and thus improved chemical resistance—reduces the risk of ceramic inclusions in the steel.

Influence of refractory design

An additional measure that has the potential to enhance the quality of the ingot surface is the creation of an advanced channel design to ensure a constant flow of steel with minimal turbulence. A stable steel flow is crucial for producing an ingot with good surface quality, which subsequently results in reduced scrap.

Fig. 2 – Inside view of the innovative SmartCast-Spiderbrick

A design change of the SmartCast spider brick with a central chamber, which fills first and overflows, fills the horizontal channels with a lower flow velocity and results in less turbulence during casting, which results in an improved surface of the steel ingot as seen Fig. 3.

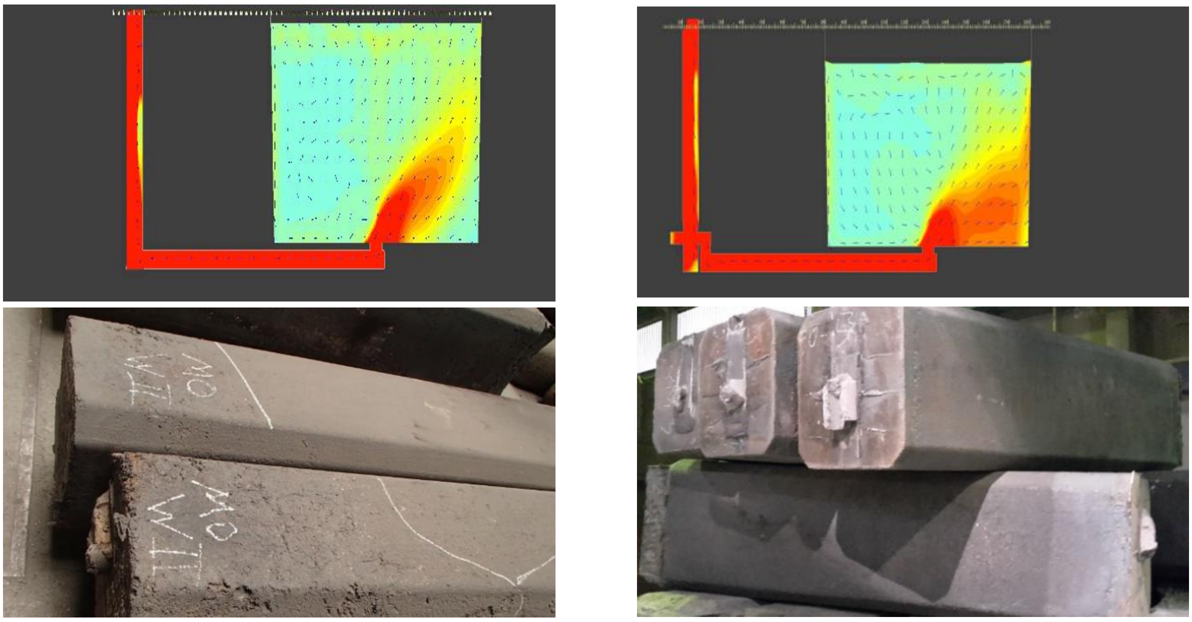

Fig. 3 – Simulation steel-flow and resulting ingot surface in comparison: conventional spider brick (left) vs. SmartCast spider brick (right)

CONCLUSION

The chemical resistance of the refractory increases with increasing Al_2O_3 content, which can result in fewer impurities and inclusions in the steel. This is particularly important for components exposed to high mechanical stress, where steel cleanliness and the avoidance of inclusions are critical safety factors.

With regard to design choices, it is important to note that calming the steel flow into the mold can significantly improve the surface quality of the ingot. This leads to reduced scrap rates and lower finishing costs.

The refractory material used during casting has a clear impact: Investing in refractory material means investing in the quality of the ingots.