SUCCESS STORY

K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development

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Industrial ESR-plant

REDUCTION OF SPECIFIC ENERGY CONSUMPTION DURING ELECTRO-SLAG-REMELTING (ESR)

SLAGS WITH HIGH ELECTRICAL RESISITIVY AND ADJUSTED COMPOSITION OFFER THE POTENTIAL FOR A SIGNIFICANT REDUCTION IN ENERGY CONSUPTION

Electro-Slag-Remelting (ESR) is a metallurgical process to produce clean steels by remelting an ingot (electrode) with liquid superheated slag and collecting the melt in a mold, forming a new ingot. The slag is heated by its electric resistivity and large currents. From the beginning, specific energy consumption was an important topic. The quoted number for steels is typically specified in the range of 1000-1500 kWh/t, with some data ranging up to 2000 kWh/t. Increased regulatory requirements on sustainability, environmental protection, and emission reduction have created renewed awareness for this topic. Based on an estimated worldwide ESR production of approx. 2 mil. tons/year, ESR accounts for about 2-3 TWh in annual electric energy consumption.

There are several factors affecting the energy consumption, such as plant design and geometrical conditions, the fill ratio of the mold, amount of slag used or the melt rate, which can have a significant effect. However, changes in these parameters can either be difficult to be carried out or may affect the solidification behavior unfavorable. As a further important factor, the slag plays an important role in the heat generation and energy consumption of ESR. Key properties such as the electrical resistivity in the liquid and solid state, viscosity, melting point, and thermal conductivity depends highly on the CaF_2-content. Slag compositions can be changed easily from one melt to the other, independent from the plant design, and therefore provide a simple possibility to affect energy consumption.

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Furthermore, low CaF_2 containing, high-resistivity slags contribute to reduced fluorine emissions, adding another positive effect.

The application of low or no-CaF_2-slags is often restricted due to concerns regarding negative effects on the cleanliness levels of the remelted material. The focus of the investigation conducted within this project was therefore to determine the effect of a wide variation of CaF_2-contents in the slag on different process related effects, especially energy consumption, as well as on quality related aspects, primarily the content, size distribution and type of non-metallic inclusion, using state of the art electrode materials. Thereby the potential for significant energy savings without loss in product quality should be evaluated.

Impact and effects

The experiments were conducted at the laboratory ESR-plant at the Univ. of Appl. Sciences Upper Austria. Using a similar fill-ratio as industrial size ESR-plants, the results show the almost linear relationship between electrical conductivity and energy consumption (see Figure). The electrical conductivity of ESR-slags rages from about 0.5 for CaF_2-free sags to more than 5 [1/Ω.cm] of pure CaF_2. The corresponding specific energy consumption varies between 800 and more than 2200 kWh/t. Compared to commercial standards-slags with a conductivity of about 1.5 [1/Ω.cm], a reduction in energy consumption by 20-30 % is possible. Starting from with high-CaF_2 slags, even higher savings are feasible.

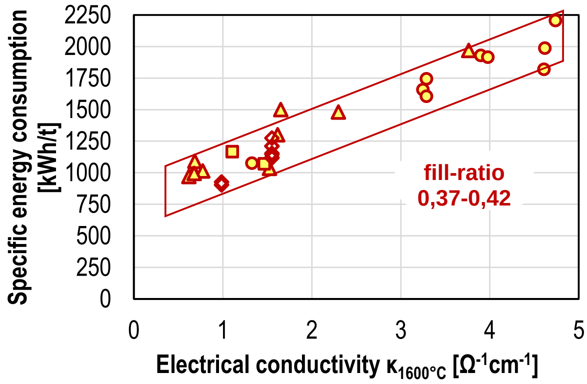

Fig.: Effect of the electrical conductivity on the specific energy consumption during electro slag remelting.

Investigations regarding the impact on steel cleanliness are promising but indicate that the slag composition needs to be adjusted to the specific steel composition. Thereby the activities of the different slag components need to be balanced with the corresponding elements in the steel. First results from industrial trials confirm these good results.

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