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Approaches to carbon-reduced and carbon-free mold powders in the continuous casting of aluminum-alloyed steels

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During the continuous casting of steels, a carbon-enriched layer forms on top of the liquid slag. Owing to fluctuations in the mold, liquid steel may come into contact with this layer, leading to re-carburization. Previous attempts to mitigate this phenomenon seemed insufficient for the intended applications; therefore, mold powders with reduced or zero carbon content are desired. For mold powders used in the casting of ultra-low-carbon (ULC) steels, the substitution of carbon with SiC, combined with a novel approach that separates components into two types of granules according to their basicity ("basic"and "acidic"), has already been demonstrated to provide suitable melting behavior. Based on these findings, this concept was extended to two mold fluxes designed for aluminum-alloyed steels. Both fluxes contain 2.2 wt.% Li_2O in the liquid state but differ in their chemical compositions: Flux MP 1 has a CaO/SiO_2 ratio of 0.61 and contains 6.8 wt.% MnO in the molten state, whereas flux MP 2 has a CaO/SiO_2 ratio of 1.17 and an Al_2O_3 content of 29.0 wt.%. In a first step, MP 1 was prepared from two types of granules, heated in a preheated furnace at selected temperatures between 900-1200℃ for 10 minutes, quenched to room temperature, and subsequently analyzed mineralogically. However, due to the high content of volatile components, the results did not meet expectations. As a next step, CaC_2 was evaluated as a melt-controlling additive. In contrast to SiC, CaC_2 produced free carbon during heating, rendering its use unnecessary. Consequently, the suitability of SiC was also investigated for both mold powders, despite the relatively low SiO_2 content of MP 2. Both compositions exhibited melting behavior comparable to that of the respective standard mold flux, while in the case of ULC mold powders the samples containing SiC even outperformed the standard mold powder and SiC was still detected even at 1200℃. The beneficial behavior of SiC at temperatures above 1000℃ could not be observed for MP 2, as it had already been consumed by reactions with other components. These results indicate that while the replacement of carbon by SiC is favorable for MP 1, this is not the case for MP 2. Subsequently, MP 2 was further investigated using the two-granule concept, in which basic and acidic components were prepared separately, mixed, and heated. In contrast to MP 1, this separation delayed the formation of new phases, particularly at lower temperatures, while resulting in a similar liquid phase fraction at elevated temperatures when compared to the standard flux. In summary, for mold powders used in the continuous casting of aluminum-alloyed steels, the necessity of SiC as a melt-controlling additive depends strongly on chemical composition. For fluxes with low CaO/SiO_2 ratios and significant MnO contents, the use of SiC remains beneficial. Conversely, for fluxes with high Al_2O_3 contents and associated high basicity, the two-granule approach allows the complete elimination of a melt-controlling additive from the mold powder.

Author: GRUBER, Nathalie (Montanuniversität Leoben)

Presenter: GRUBER, Nathalie (Montanuniversität Leoben)

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