Development of Novel ZrO_2-CaO-C Material for High Performance Anti-Adhesion Nozzle

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1. Introduction

Clogging of continuous casting nozzles due to alumina adhesion adversely affects steel quality and productivity by entrapping air bubbles, powder, and other substances caused by the drift flow of molten steel in the molds. The application of ZrO_2-CaO-C (hereinafter referred to as ZCG) material, known as one of the countermeasures against this phenomenon, has traditionally been difficult to sustain anti-adhesion properties. In this study, we successfully developed ZCG (hereinafter referred to as ZL1) materials with excellent adhesion control effects on alumina inclusions in steel and low erosion loss by using a ZrO2-CaO material with high CaO content to improve the adhesion resistance of ZCG material. This report presents a comparative study of alumina anti-adhesion properties and changes in molten steel composition before and after the test, using the developed ZL1 material alongside general-purpose materials, including conventional ZCG, in a molten steel stirring test[1].

2. Sample and Experimental Method

Table 1 shows the chemical compositions of the samples used in this test. For the alumina adhesion test, approximately 12 kg of low-carbon steel was melted at 1550 ℃ in flowing Ar, and 0.2 mass% Al was added to produce Al-killed steel with an oxygen concentration of less than 10 ppm in the steel. All specimens were mounted on the end of a refractory stirring jig and rotated continuously at 200 rpm for 120 min in the molten steel. The average erosion rate of each specimen was calculated from the dimensional change before and after the test. To investigate the effect of refractory material type on molten steel composition, the crucible and stirrer, which are in contact with molten steel, were made of the same material. Stirring tests were conducted for each material, and the molten steel composition was analyzed by taking samples before and after the tests.

Table 1 Composition of the refractory specimens

Sample		ZL1	ZCG	C less	AG	ASG
Composition / mass%	Free C	9	25	2	18	25
	ZrO_2	48	51	-	-	-
	CaO	42	16	1	-	-
	SiO_2	-	5	-	4	24
	Al_2O_3	-	-	72	77	45
	MgO	-	-	23	-	-

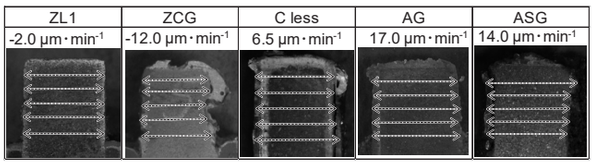

Fig. 1 Cross section view of each sample and measured erosion or alumina adhesion rates after test.

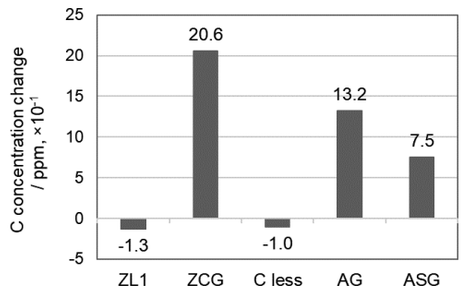

Fig. 2 Change of C concentration in molten steel.

3. Results

Figure 1 shows a cross-sectional view of the specimen after the alumina adhesion test and the average adhesion rate. Conventional ZCGs are primarily subject to erosion, but the erosion rate of the newly developed ZL1 is only 1/6 of that of conventional ZCGs. Additionally, all other general-purpose materials exhibited a predominant tendency to adhere. Figure 2 demonstrates that the change in carbon concentration in the steel before and after the test was minimal for ZL1 and C less. A continuous dense high CaO slag layer with ZrO2 was observed at the refractory interface of ZL1 after the test. The formation of this slag layer improved the wettability of the molten steel and suppressed the transfer of refractory components to the molten steel, resulting in the high anti-adhesion property and high erosion resistance for an extended period.

4. Summary

The use of the newly developed ZL1 material as a continuous casting nozzle is expected to contribute to more stable operation and higher quality.

References

1) S. Koga, J. Amano, K. Morikawa and K. Asano: *Taikabutsu*, 57 [2] 84-85 (2005).