

PRODUCT

Basic Refractory SV Plate “SVR-FB9” for Ca-treated API Steel Grades

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Abstract

For steelmaking of Ca-treated API steel grades, two component SV plate in which a small piece of ZrO_2 plate with superior corrosion resistance to Ca component is inserted at the critically damaged area (central bore and major sliding area) of $\text{Al}_2\text{O}_3\text{-C}$ SV plates. However, difficulties such as localized damages on the ZrO_2 plates by sticking or FeO corrosion caused by oxygen gas cleaning as well as exfoliation of the ZrO_2 plates out of the base $\text{Al}_2\text{O}_3\text{-C}$ SV plate during inspection/repair work with full-opening of SV mechanism accompany such two component SV plates. In this regard, new basic refractory SV plate material, SVR-FB9, is developed. Sticking damage is suppressed through the addition of carbon in SVR-FB9, and its basicity also gives it sufficient durability against oxygen gas cleaning. SVR-FB9 implements enhanced corrosion resistance to Ca-treated API steel grades as well as improved strength, so it is applicable for large-sized single material SV plates, so it is expected that, because of the compatibility of SVR-FB9 plate to the $\text{Al}_2\text{O}_3\text{-C}$ SV plate commonly applied for general steel grades, coped with sudden schedule changes in the steelmaking process will be more easily.

1. Introduction

Because of well-balanced spalling and corrosion resistance, $\text{Al}_2\text{O}_3\text{-C}$ refractories are commonly applied for the slide valve plate (hereinafter referred to as “SV plate”) mounted onto the steel ladle or tundish for continuous casting. In the steelmaking process of Ca-treated API steel grades, which are adopted for crude petroleum or natural gas steel pipe products, however, use of $\text{Al}_2\text{O}_3\text{-C}$ type SV plate is inadequate because of severe corrosion by the Ca component contained in molten steel¹⁾. For this reason, ZrO_2 which is, characterized by superior corrosion resistance to Ca component has been adopted for the steelmaking of Ca-treated API steel grades. Since the high density ZrO_2 material

makes the product weight heavier and the volume changes greatly with temperature, ZrO_2 material is locally applied in two component SV plate, especially, for large-sized SV plates for the steel ladle. That is, as schematically illustrated in Fig. 1, a small piece of ZrO_2 plate is inserted in the central

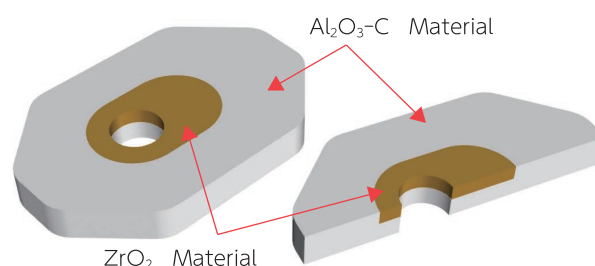


Fig. 1 Schematic illustration of two component SV plate.

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area of the Al_2O_3 -C SV plate with refractory mortar so that it covers the area that is critically damaged where molten steel contacts directly. The following difficulties accompany to two component SV plate in its production process as well as in several scenes of practical steelmaking operation; (1) The manufacturing load is increased by additional process of assembling work. (2) The inserted ZrO_2 plate piece tends to be exfoliated from base Al_2O_3 -C SV plate when inspection/repair work is carried out on SV plates which are damaged by sticking and peeling during full-opening of the SV mechanism. (3) Due to the inferior corrosion resistance of ZrO_2 to the FeO component, ZrO_2 plate is corroded by the FeO generated by oxygen gas cleaning of the SV plate or by the reaction between molten steel and sucked air. (4) Since SV plate with the inserted ZrO_2 component plate is exclusively used for Ca-treated API steel grade, sudden schedule changes in steelmaking process may cause difficulties. To avoid difficulties caused by ZrO_2 component containing two component SV plate, a large-sized single material SV plate made of basic refractory with high corrosion resistance to Ca component needs to be developed.

We have been developing a basic refractory SV plate, with improved spalling resistance, called SVR-FB8, which can be used for multiple heats with satisfactory performances in actual continuous casting operations²⁾. Because of relatively low mechanical strength, however, it is thought not to be usual for large-size SV plates, onto which large external force is loaded. In addition, since thermal spalling can be induced by large differences in temperature between the central bore area and outer peripheral in large-sized SV plates, further improvement of spalling resistance was necessitated. In order to put large-sized single material basic refractory SV plate into actual usage, a new basic refractory material for SV plate, SVR-FB9, with better mechanical strength and spalling resistance than those of SVR-FB8, was developed. The major characteristics of SVR-FB9 are introduced in this article.

2. Characteristics of SVR-FB9

Newly developed basic refractory material for SV plate, SVR-FB9, is characterized by high mechanical strength and greatly improved spalling resistance, which was realized by (1) adoption of aggregate spinel raw material, (2) firing at higher temperature than the conventional firing temperature for basic refractory materials, and (3) optimization of particle size distribution. The major properties of SVR-FB9 are described along with spalling and corrosion resistance results in the following sub-sections.

2. 1 Physical properties

The typical properties of SVR-FB9 compared with those of SVR-FB8 are shown in Table 1. As shown in Fig. 2, in which the modulus of rupture of SVR-FB9 is compared with that of SVR-FB8, the bending strength of SVR-FB9 has been increased almost 3 times that of SVR-FB8's. The attained mechanical strength of SVR-FB9 is sufficient to endure the large external force loaded onto large-sized SV plates.

Table 1 Typical properties of SVR-FB9 and SVR-FB8

Brand name	SVR-FB8	SVR-FB9
Quality	MgO-Spinel-C	Spinel-C
Chemical composition / mass%		
MgO	50	20
Al_2O_3	38	70
C	6	4
Metal	$\alpha + \beta$	β
Apparent porosity / %	9	10.5
Bulk density / $\text{kg}\cdot\text{m}^{-3}$	2990	2950
Cold crushing strength / MPa	105	130

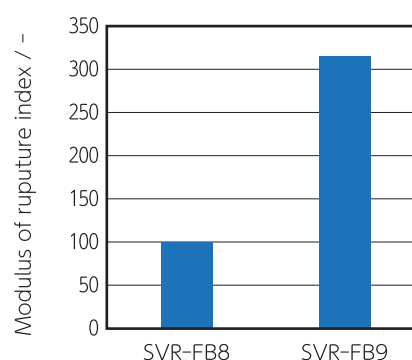


Fig. 2 Comparison of modulus of rupture (index) between SVR-FB8 and SVR-FB9.

2. 2 Evaluation of spalling resistance

The spalling resistance of SVR-FB9 was evaluated along with SVR-FB8 and Al₂O₃-C material commonly applied for SV plate using hot metal dipping method. Rectangular spalling test specimens with 35 mm square base face were dipped into hot metal kept at 1600 °C for 1 minute, followed by air cooling. After reinforcing the crack-initiated portions by impregnating resin, test specimens were cut into halves to evaluate their cross sections. The cross sections of the halved spalling test specimens are comparatively shown in Fig. 3, in which the red color dotted line indicates the hot metal bath surface. SVR-FB8 exhibits four initiated cracks in the cross section, one at vicinity of the hot metal bath surface and three in the hot metal bath. While, only two initiated cracks are observed on the SVR-FB9 cross section, which is equivalent to Al₂O₃-C material, which is commonly applied for SV plate. It can be concluded from the spalling test results that the

improved spalling resistance of SVR-FB9 reduces thermal spalling cracks around bore that tend to occur in large-sized SV plates. It is expected to have a durability equivalent to that of Al₂O₃-C materials for general steel.

2. 3 Evaluation of corrosion resistance

In comparison with SVR-FB8, the percentage of MgO in SVR-FB9 has been lowered to secure spalling resistance so as to be applicable to large-sized SV plates. It is known as indicated in Fig. 4, that the corrosion resistance of basic refractories is lowered in accordance with lowering the MgO fraction in MgO-spinel system³⁾. It should be noted that the degree of deterioration of corrosion resistance by lowering MgO component is greatly influenced by substituted spinel particle size, namely, less deterioration occurs with substitution of aggregate spinel particles for fine spinel particles. Referring to such knowledge, the raw material blend design of SVR-FB9 was created by adopting aggregate spinel

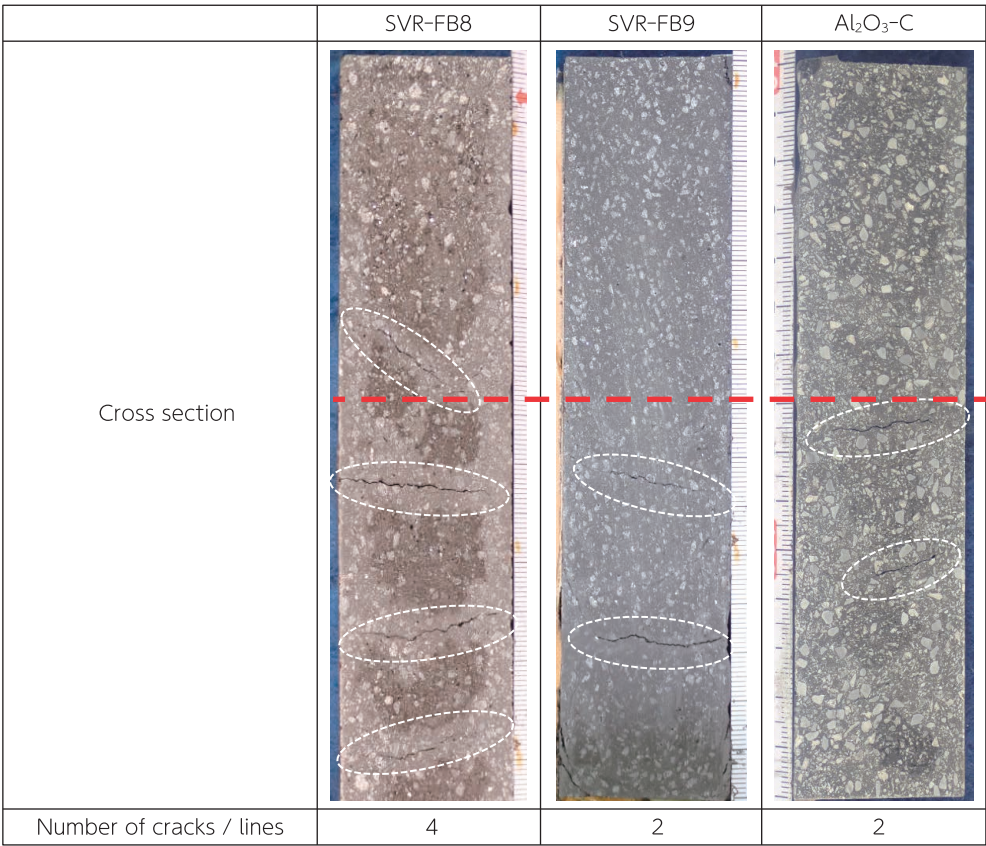


Fig. 3 Cross section of spalling test specimens.

material and optimizing particle size distribution.

Corrosion resistance of SVR-FB9 was evaluated by rotary crucible corrosion test. The schematic illustration is shown in Fig. 5. The corrosion test was conducted at 1650 °C for 5 hours with CaO-Al₂O₃-SiO₂-FeO synthetic slag, which was exchanged every hour. Cross section of corrosion test specimen of SVR-FB9 compared with SVR-FB8 is shown in Fig. 6 along with corrosion resistance which was calculated from the corroded depth of

test specimen. In comparison with SVR-FB8, the corrosion resistance of SVR-FB9 was improved by roughly 25 %. It is inferred that the corrosion resistance of SVR-FB9 is sufficient for application to steelmaking of Ca-treated API steel grades.

3. Conclusion

A new basic refractory SV plate material, SVR-FB9, with improved corrosion resistance and sufficient spalling resistance to be applicable for large-sized

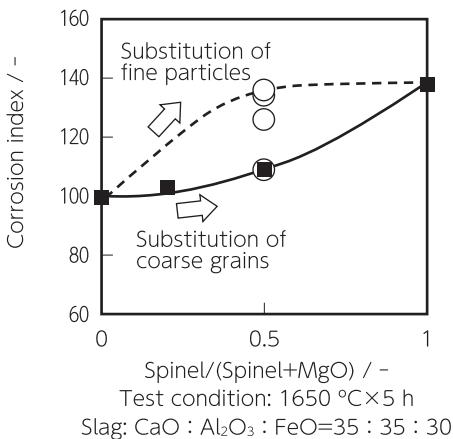


Fig. 4 Influences of MgO content in MgO-spinel system and spinel grain size on corrosion resistance of basic refractory³⁾.

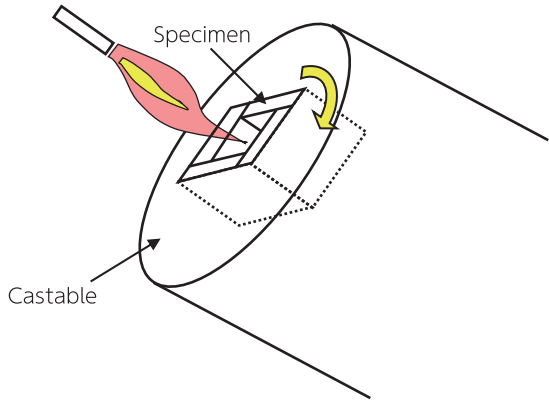


Fig. 5 Schematic illustration of rotary crucible corrosion test.

	SVR-FB8	SVR-FB9
Cross section		
Corrosion resistance index / -	100	76

Fig. 6 Cross section of corrosion test specimen and calculated corrosion resistance.

SV plate has been developed. To be used in place of the ZrO_2 piece inserted in two component SV plate, which has been used for Ca-treated API steel grades. It is expected that SVR-FB9 single material plate, is adequate to be used for steelmaking of

Ca-treated API steel grades with compatibility to the Al_2O_3 -C SV plate commonly used for general steel grades. It will also permit sudden schedule changes in the steelmaking process with little trouble.

References

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