

Blast Furnace Main Trough Castable Refractory “SBC” with Low Temperature Dependence of Setting Time and Suitable Hydrogen Gas Generation Behavior

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Abstract

“SBC”, a new castable refractory for the blast furnace main trough was developed by applying a new binder system. “SBC” is characterized by low temperature dependence setting time as well as suitable hydrogen gas generation behavior. This results in a sound blast furnace trough body with no hollow or void defects induced by abnormal generated gas build-up. Construction can be carried out with reduced fluctuation of setting time, in other words, improper setting of castable refractory, such as, abnormally fast setting or not setting for an extremely long time can be eliminated.

1. Introduction

The blast furnace trough is a facility used to transfer hot metal and slag discharged from blast furnace to the next process. In the main trough, hot metal and slag are separated by their difference in specific gravity and are directed respectively to the iron runner and the slag runner. A low cement Al_2O_3 -SiC-C castable refractory with superior durability is applied as the relining material for the blast furnace trough, which is prone to damage caused by chemical corrosion and/or spalling due to repeated heating and cooling cycles. Especially in the main trough, localized chemical corrosion by blast furnace slag takes place at the interface between hot metal and blast furnace slag (so called “metal line” or “ML” in abbreviation) as well as at the interface between blast furnace slag and ambient atmosphere (so called “slag line” or “SL” in abbreviation). This affects the service life of trough refractories. In order to extend the service life of blast furnace trough refractories in

Japanese blast furnaces, zone-lining method is widely applied using two types of castable refractories which, taking into account the corrosion mechanism at each interface, are exclusively designed for the metal line and slag line zones of the main trough (Fig. 1). In practical blast furnace trough construction work, a joining relining method in which new castable refractory is applied on the surface of the old refractory body still in good condition with the damaged portions removed in advance is generally applied.

However, during installation of blast furnace trough refractory, improper setting of castable refractory or abnormal build-up of generated gas occasionally occur. These issues are believed to be caused by the high temperature dependence of the setting time and unusual gas generation behavior, which is induced by the reaction of metallic aluminum blended into the castable to suppress explosive spalling.

To prevent such incidents, a new castable refractory, “SBC (Stable Cast)”, has been developed. It is

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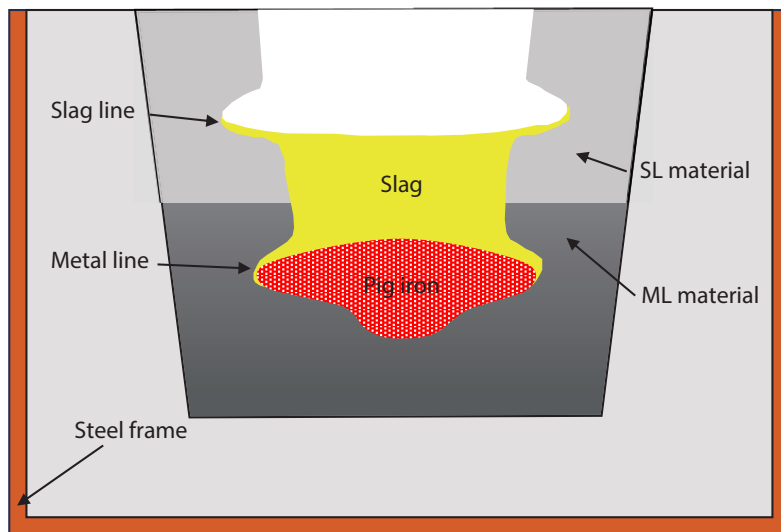


Fig. 1 Zoned ML and SL castable refractory lining of blast furnace main trough.

characterized by low temperature dependence of setting time and suitable gas generation behavior. This article introduces the major characteristics of “SBC” along with its practical applications.

2. Temperature Dependence of Setting Time and Improper Setting Incident

In general, the setting time of low cement castable refractories tends to vary greatly with change in temperature. For example, the setting time of a certain castable refractory is more than doubled by lowering the ambient temperature by 10 °C. Thus, the setting behavior of castable refractory should be accurately adjusted in accordance with environmental conditions of construction work. Even if proactive adjustment work on castable refractory setting time is properly conducted, the setting behavior of castable refractory will change when the ambient temperature changes rapidly or stored heat in the old refractory body (base temperature of old refractory) is largely different than expected. When the ambient temperature is higher than the presumed temperature, castable refractories coagulate and set quite quickly. Contrarily, when the ambient temperature is lower than the presumed temperature, castable refractories

do not set even after one day. In both cases, construction schedule is forced to be changed by such improper setting incidents.

3. Abnormal Build-Up of Generated Gas

In order to suppress or prevent explosive spalling, metallic aluminum is commonly blended in castable refractories for the blast furnace trough. Hydrogen gas is generated by the reaction of blending metallic aluminum with water which is admixed during mixing. The generated hydrogen gas creates micro cracks in the setting body. These functions as passages for vaporized water components to diffuse out of the setting castable refractory body so as to suppress explosive spalling incidents¹⁾. This hydrogen gas generation behavior is highly influenced by castable refractory construction temperature as well as by setting time. More specifically, in accordance with the elevation of the setting castable refractory temperature and with shortening of setting time, hydrogen gas is generated more quickly with higher gas generation rate.

When generation of hydrogen gas takes place before complete setting of the installed castable refractory, in other words, under the circumstance of

fluidic castable refractory mixture partly remaining in the setting refractory body without setting, generated hydrogen gas is locally entrapped. This gas accumulates in the unset area in the installed refractory body as hollow or void defects. It is the abnormal build-up of generated hydrogen gas.

In order to suppress formation of abnormal build-up of generated hydrogen gas, it is important to lower temperature dependence of castable refractory setting time as well as reduce fluctuation of hydrogen gas generation behavior, which is influenced by large ambient temperature change and/or temperature of old refractory body base. In short, proper and fine adjustment is required so that hydrogen gas is generated just after constructed castable refractory is completely set.

4. Characteristics of Newly Developed Blast Furnace Castable Refractory “SBC”

Castable refractory “SBC” is a newly developed product for the ML zone in the blast furnace main trough. “SBC” was developed with a new binder system in which blended cement and other additives have been properly optimized. “SBC” exhibits lower setting time temperature dependence as well as stabler hydrogen gas generation behavior than conventional low cement castable refractory for the blast furnace trough. Construction of the blast furnace trough can be carried out by selecting one of two versions of “SBC” products, the “high temperature version” or “low temperature version”. This permits use throughout the year without use of a fine adjustment retarding or accelerating agent at the construction site. As per Table 1, in which major chemical and physical properties of the newly developed “SBC” and conventional “CST” are comparatively shown, “SBC” exhibits characteristics equivalent to “CST” with no negative influences of change in binder system.

4. 1 Temperature dependence of setting time

The temperature dependence of setting time of two versions of “SBC” are compared with “CST” in Fig. 2.

Table 1 Major chemical and physical properties of newly developed “SBC” and conventional “CST”

		Conventional “CST”	Developed “SBC”
Chemical composition / mass%	Al ₂ O ₃	64	65
	MgO	14	14
	SiC	14	14
	C	4	4
Permanent linear change / %	1000 °C-3 h	-0.07	-0.09
	1500 °C-3 h	0.00	+0.08
Modulus of rupture / MPa	110 °C-24 h	5	5
	1000 °C-3 h	4	4
	1500 °C-3 h	7	6
Bulk specific gravity / -	110 °C-24 h	2.88	2.83
	1000 °C-3 h	2.78	2.76
	1500 °C-3 h	2.79	2.75

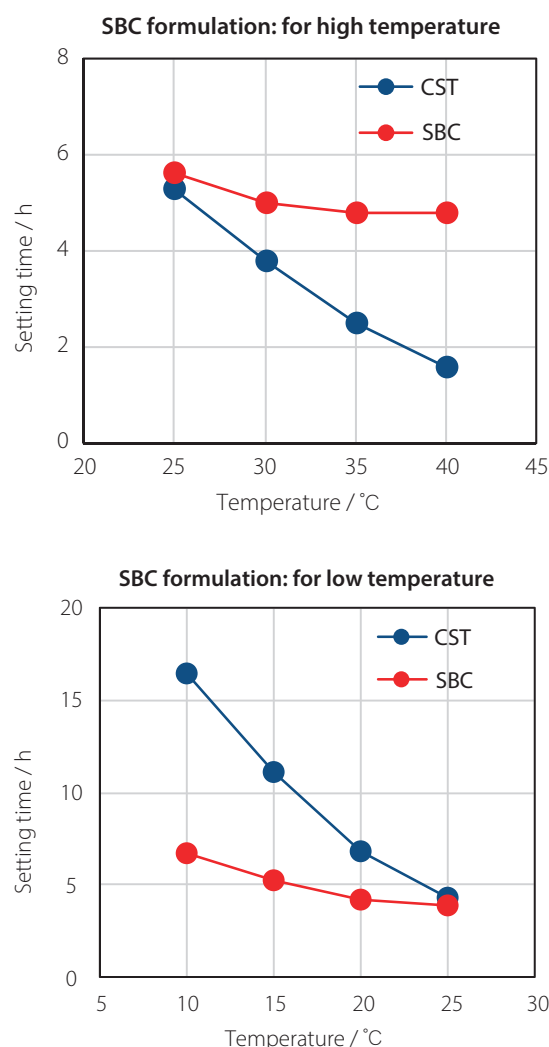


Fig. 2 Temperature dependence of setting time of two versions of “SBC” and “CST”.

For example, in the high-temperature formulation, when comparing 25 °C to the reference temperature of 35 °C, the setting time of the conventional material, CST, is extended to nearly twice as long, whereas the newly developed SBC increases by only about 1.1 times. Since such difference in temperature dependence of setting time is also obvious in the low temperature version (right side in Fig. 2). It can be concluded that the setting time temperature dependence of “SBC” is markedly improved. It is expected that, even though the actual ambient temperature and/or base temperature of old refractory base greatly differs from expectation, castable refractory “SBC” will stably and properly set without incidents of abnormally fast setting or not setting for an extremely long time.

4. 2 Hydrogen gas generation behavior

The hydrogen gas generation behaviors of “CST” and “SBC”, with setting times finely adjusted for construction work at 30 °C ambient temperature, are comparatively shown in Fig. 3. The hydrogen gas generation behavior at 30 °C curing temperature and at 35 °C curing temperature are expressed with a solid line and dotted line, respectively, in Fig. 3. With a change of curing temperature from 30 °C to 35 °C, hydrogen gas generation from “CST” begins earlier with a higher gas generation rate. While hydrogen gas generation from “SBC” is not varied so much by

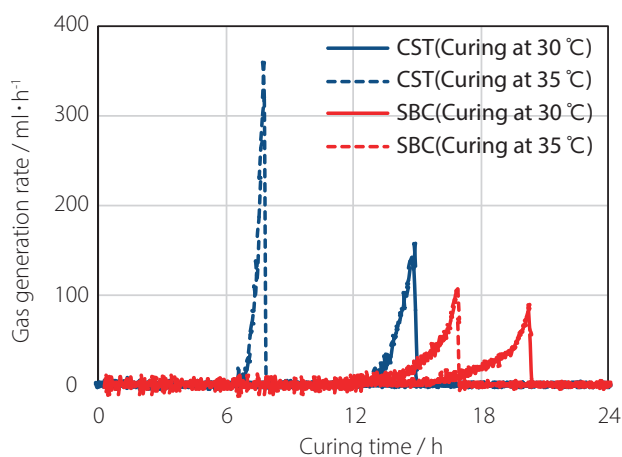


Fig. 3 Hydrogen gas generation behavior of “CST” and “SBC”.

change of curing temperature in generation onset time as well as in gas generation rate. It is expected that, since hydrogen gas generation from “SBC” is stable with minor influence of temperature, abnormal build-up of generated gas is suppressed even when ambient temperature or base temperature of old refractory base is varies from what was estimated.

5. Results of Practical Application

Newly developed castable refractory “SBC” was first applied in summer. Although the 28 °C predicted ambient temperature, the actual ambient temperature was 35 °C at the construction site of “SBC”. The time interval between construction of ML zone castable refractory and SL zone castable refractory was about 6 hours. When construction is carried out with conventional castable refractory “CST” under such construction conditions with large a change in ambient temperature, it was a concern that, because hydrogen gas is generated from the ML zone castable refractory before proper setting of SL zone castable refractory, abnormal build-up of generated gas would take place. However, by applying newly developed castable refractory “SBC”, a sound castable body was realized with no incidents such as abnormal build-up of generated gas. At present, “SBC” is routinely applied with good performance, namely, satisfactory durability with no construction incidents.

6. Conclusion

“SBC” a new castable refractory for blast furnace main trough was developed by applying a new binder system. It is expected that incidents of improper castable refractory setting namely, abnormally fast setting or not setting for an extremely long time, can be prevented by the application of “SBC”. It was also clarified that abnormal build-up of generated gas can be effectively suppressed by application of “SBC”.

Reference

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