Recent Approaches in Coke Oven Refractories
～Development of Sole Repair Material and Establishment of Recycling Technology for Door Block～

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Abstract

Two recent developments in coke oven refractories are introduced. In the first place, the development of a sole also referred to as hearth repair material is introduced. This material has excellent peeling resistance due to similar thermal expansion to that of a silica brick, as well as superior abrasion resistance due to high strength. In the second place, the recycling of refractory door blocks is introduced. Recycled materials added to the door block scarcely deteriorate the quality of the door block and the door block has successfully been used in service.

1. Introduction

We have continually been engaged with the development and improvement of coke oven refractories. In this article, recent development of sole also referred to as hearth repair material for the coking chamber and establishment of recycling technology for the door blocks are introduced.

2. Sole Repair Material for Coking Chamber

The trouble in operation called "push clogging" lowers productivity since it disables coke discharging. Excessive surface roughness of the sole is considered to be one of the causes of push clogging. In particular, the sole bricks at the end flues of the coking chamber are cooled below 300℃, resulting in severe damage which increases surface roughness. Thus, in order to reduce the roughness of the sole by suitable repair, we developed sole repair material FRX-K85-D1, which has excellent adhesion to silica bricks. FRX-K85-D1 is a powdery product that is installed after mixing with an adequate amount of water. The mixture is installed by casting. When the repairing position is too far to cast directly, it is possible to deliver the mixture by throwing the mixture-poured plastic bag. FRX-K85-D1 is designed to reduce peeling caused by temperature change by approximating the thermal expansion to that of silica bricks. Additionally, mechanical abrasion caused by coke discharging is reduced by improving strength.

Adhesion evaluation was carried out for newly developed FRX-K85-D1 and conventional SCOAT-A29. Fig.1 is a schematic diagram of adhesion evaluation. A mixture of the repairing material and water was poured into a short stainless steel pipe placed on a silica brick heated at 300℃, followed by heating at 900℃ for 3 hours in an electric furnace. The specimens were subsequently cooled naturally in an electric furnace. Then they were taken out from the furnace and a shear load was imposed to the repair material-filled pipes with continuous load measurement. The adhesive strength was determined by dividing the maximum load by adhesion area. Table 1 summarizes the evaluation results and the general properties of each material. While SCOAT-A29 detached according to the temperature change between 900℃ and room temperature, FRX-K85-D1 showed high adhesive strength, which is considered attributable to it having a similar thermal expansion to the silica brick. Coupled with high adhesive strength and superior abrasion resistance due to high strength, improvement in productivity according to the reduction of push clogging and repair frequency is expected.

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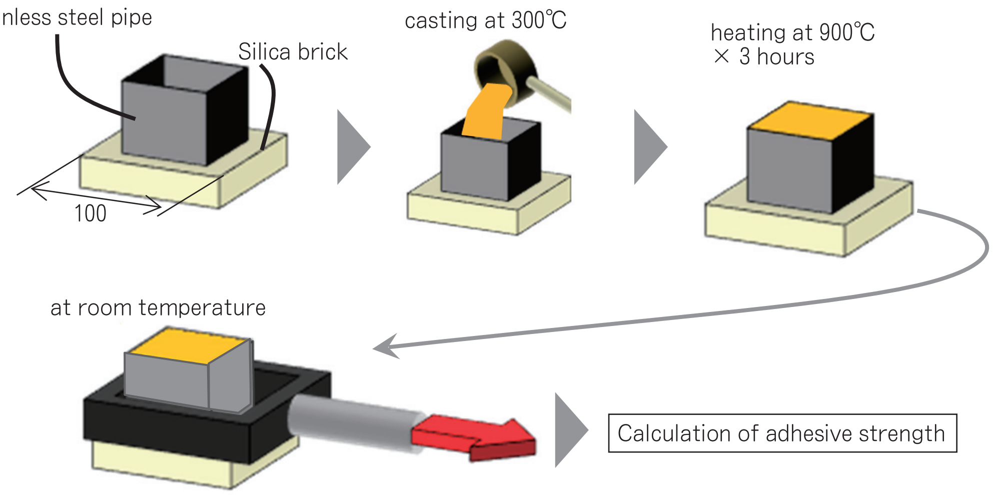


Fig.1 Schematic diagram of adhesion evaluation.

Table 1 Properties of sole repair material

Properties \ Brand name		FRX-K85-D1	SCOAT-A29
Chemical composition (mass%)	SiO_2 Al_2O_3	86 1.6	17 78
Adhesive strength at room temperature (MPa)	900℃-3h	1.0	Detached
Bulk density ($g \cdot cm^{-3}$)	900℃-3h	1.47	2.10
Cold crushing strength (MPa)	900℃-3h	44	6.4

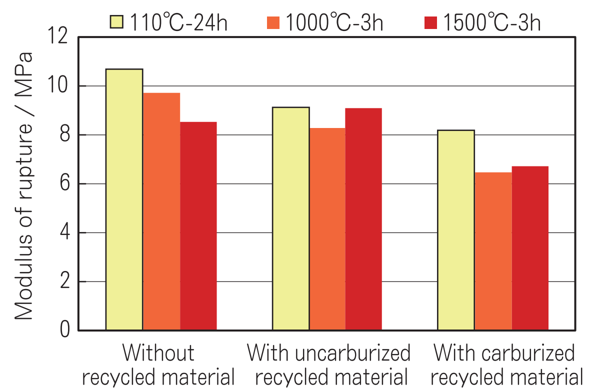


Fig.2 Modulus of ruptures of door block.

3. Recycling of Door Block

In recent years, environmental issues have attracted a lot of attention. Recycling of used refractories is one of the options from perspective of reducing the environmental load. It is estimated that the large door blocks attached to coke ovens generate about 100t of waste per coke oven annually. Thus, we pursued the effective utilization of the used door blocks and established a door block recycling technique.

Coal tar pitch gas generated in the coking process is used as a raw material for organic chemical industries. Meanwhile, some of the gas penetrates into the pores of the door block. Although some door blocks are not prone to carburization, almost all door blocks carburize severely. For that reason, it was expected that utilization of recycled material deteriorates the quality of the products. Whereas, according to a used door block investigation that confirmed a sound microstructure and chemistry except for coal tar pitch penetration[1], it was assumable

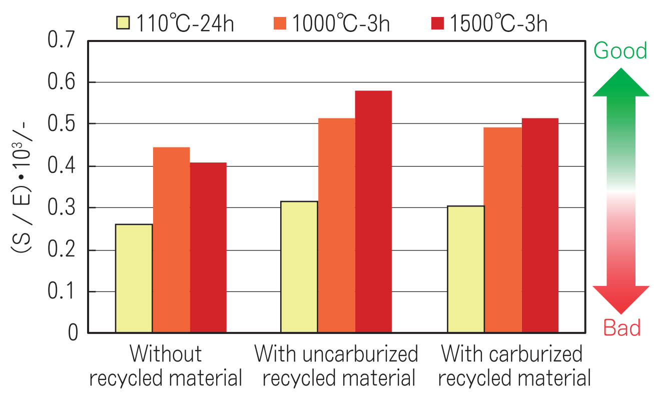
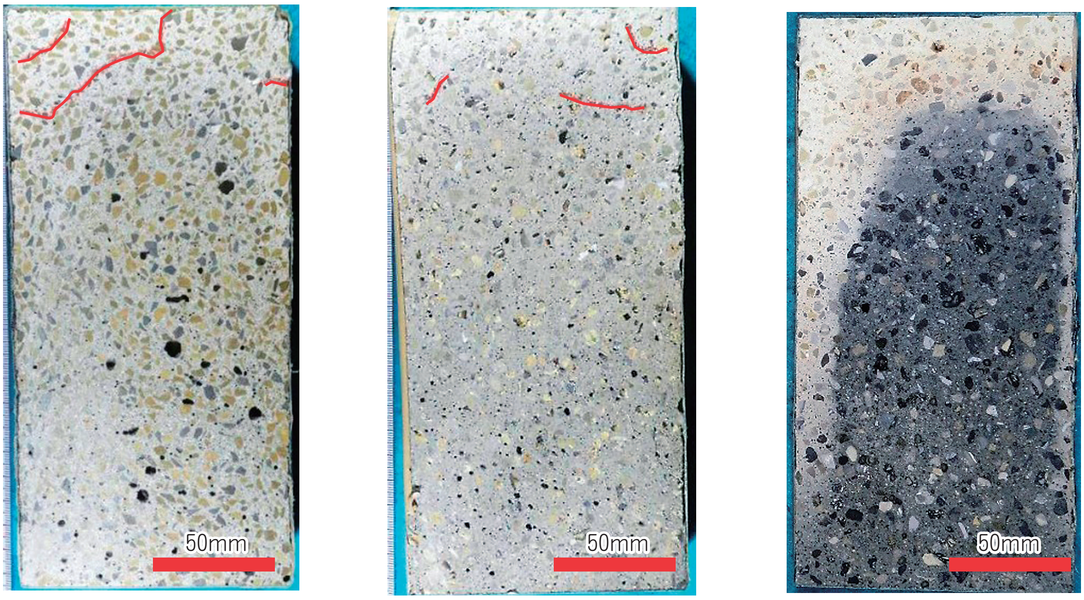


Fig.3 Modulus of rupture / dynamic elasticity ratios of door block.

that carburized door block can be recycled without serious deterioration in the quality of the products.

Hence, we evaluated the influences of the recycled materials on block quality deterioration experimentally by comparison of spalling resistance and general properties among the following three blocks; a block without



Without recycled material　　With uncarburized recycled material　　With carburized recycled material

Fig.4　Cross sections of specimen after spalling test.
(heating at 1200℃-30min ⇔ cooling in the air-30min /10cycles)

recycled material, a block with non-carburized recycled material and a block with carburized recycled material. Fig.2 and Fig.3 show the modulus of rupture (S) and ratio of modulus of rupture / dynamic modulus of elasticity (S/E) of each specimen, respectively. While two recycled material-including blocks exhibited slightly lower S, the S/E of them was higher. Fig.4 shows the result of the spalling test. There were few cracks in the blocks containing carburized and non-carburized recycled material and they showed superior thermal shock resistance compared to the block without recycled material.

Two years has passed since the two blocks which contains carburized and non-carburized recycled material each other installed on the coke oven. They are also still in service without any problems.

4. Conclusion

In this article, the developed product, which has an excellent adhesive property when used as a sole also referred to as hearth repair material, and recycling technology for the door block were introduced. The sole repair material has a thermal expansion close to that of silica bricks as well as high strength, resulting in peeling and abrasion resistance. The door block which contains recycled door block material has been in service without any problems. We will continue to contribute to solving problems by improving the development of materials and recycling.

Reference

1) H. Nishiguchi, K. Sakawa, K. Yamashita and M. Iida: Proc. of UNITECR 2015, No.65 (2015).