Characteristics and Performance of Basic Bricks for Cement Kilns

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Abstract

In cement kilns in Japan, service condition of refractory lining is becoming more severe, which causes increased wear of the lining. The magnesia-spinel bricks for cement kilns which we produce have shown superior performance in severe conditions, and contribute to achieving economical and stable operation. This report introduces the characteristics and performance of bricks for each application zone.

1. Introduction

Recently, the cement rotary kiln (hereafter referred to as cement kiln) plays an important role not only in producing cement, but also in treating the wastes and by-products from other industries. The unit consumption of wastes and by-products in the production of cement in Japan continues to increase year by year. Moreover, it is expected to increase more in the future. In addition, oil coke or waste plastics are widely utilized as fuel for cement kilns, because the price of coal recently hovers at a high level.The kiln lining is being exposed to more severe service conditions due to the unstable coating and change of gas composition in the kiln. We have improved the kiln refractories in order to cope with the service conditions and had a good reputation in many kilns. Our product lineup of basic bricks for the cement kiln is introduced in this report.

2. Lining of Cement Kiln

Fig. 1 shows the typical lining of the cement kiln. High alumina bricks or fireclay bricks are generally used in the relatively low temperature calcining zone. In the burning zone, where the thermo-chemical load is the highest, the magnesia-chrome bricks, which are superior in erosion resistance and coating stability, had been widely used in previously. However, magnesia-chrome bricks disappeared in most domestic cement kilns because of increased environmental consciousness. Recently, mainly magnesia-spinel bricks are used in the cooling zone, burning zone and transition zone.

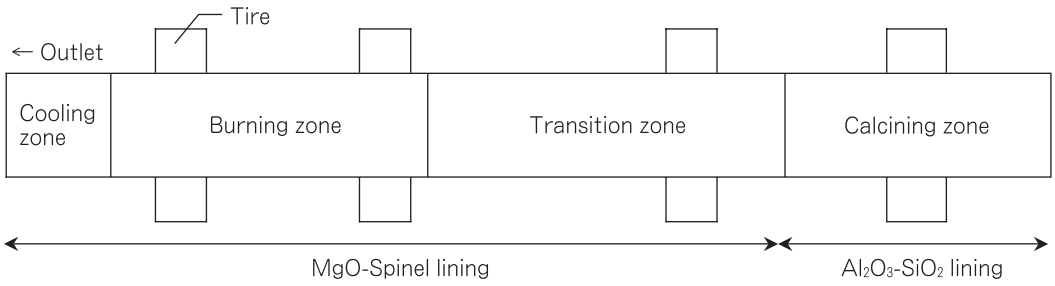

Fig. 1 Typical refractory lining of cement rotary kilns.

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3. Quality and Performance of Basic Bricks for Cement Kilns

Table 1 shows the properties and characteristics of bricks for cement kilns. ECOLOK (abbreviation : ELK) is a series of chrome-free bricks for the burning zone and SPILOK (abbreviation : SP) is a series of magnesia-spinel bricks for the cooling zone and transition zone, both of which require bricks to suitable for different operating conditions by adjusting thermal-physical properties. We introduce the characteristics and performance of the bricks for each zone.

3. 1 Bricks for the cooling zone

In the cooling zone, an important wear factor is hot abrasion by cement clinker because the operating temperature is comparative high (about 1300℃), and the brick surface is not protected by a coating. In addition, the kiln shell of the cooling zone is apt to deform to a trumpet shape by heating during a long term operation. Shell deformation causes loosening of the lining, often resulting in slipping and the consequent crushing damage of the bricks.

We have improved the abrasion resistance and thermal shock resistance of the bricks for the cooling zone. SP-8DC contains a small amount of impurities to improve coating stability. SP-8D is made with high-purity materials.

Fig. 2 shows a view of the cooling zone lined with SP-8DC. The left picture shows bricks damaged by hot abrasion, the right picture shows bricks crushed by stress. These pictures show different wear mechanism, however, SP-8DC has shown better performance than other conventional bricks in both cases.

Table 1 Typical properties of MgO-Spinel bricks for cement kilns

Zone		Cooling zone		Burning zone			Transition zone		
Brand		SP-8DC	SP-8D	ELK-11CW	ELK-12CXR	ELK-12CX-1	SP-8L	SP-8LS	SP-8LDF
Apparent porosity / % Bulk density /g•cm^{-3}		15.5 3.05	15.3 3.05	14.0 3.06	15.7 3.02	14.5 3.04	15.5 2.95	14.8 3.00	15.1 3.00
Cold crushing strength /MPa		57	54	60	54	56	48	54	50
Hot modulus of rupture at 1250℃ /MPa		8.0	7.0	8.0	9.0	9.0	7.0	8.0	7.0
Chemical composition /mass%	MgO Al_2O_3 Fe_2O_3	79.5 17.6 1.5	81.0 17.6 —	85.8 10.8 1.2	83.2 12.2 1.4	84.6 12.2 1.0	81.0 17.7 —	81.4 17.4 —	81.0 17.6 —

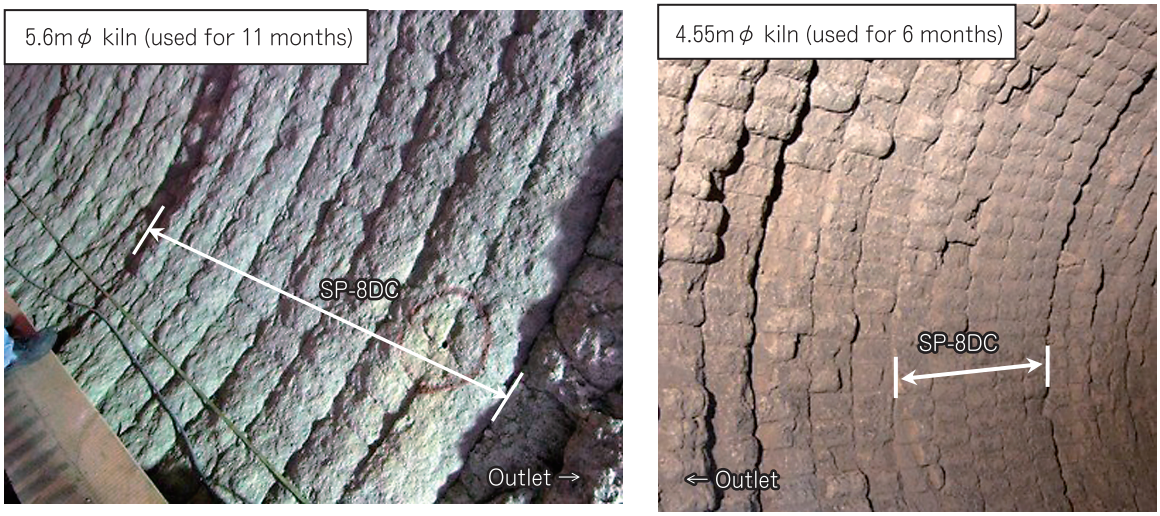

Fig. 2 Appearances of SP-8DC zone.

3. 2 Chrome-free bricks for burning zone

The operating temperature reaches 1450℃ in the burning zone, which is the highest in the cement kiln. Our magnesia-spinel bricks for the burning zone have the following common characteristics; optimized Al_2O_3 content which gives high erosion resistance and thermal shock resistance and special additives which improve erosion resistance and coating stability.

Fig. 3 shows the erosion rate of the burning zone bricks after the rotary drum erosion test (at 1700℃, for 5h, Erosion agent : Portland cement).

ELK-11CW, which shows the lowest erosion rate, is suitable for the "hot spot" which has an excessively high operating temperature. ELK-12CXR shows the second lowest erosion rate and is suitable for the zone where the kiln is supported by the tire and the bricks are subjected to mechanical stress from the tire. ELK-12CX-1 is superior in the balance of erosion resistance and coating stability and is suitable for almost all of the burning zone.

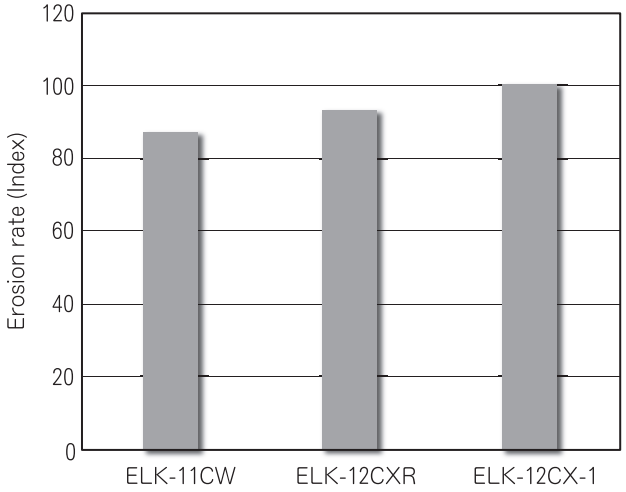

Fig. 3 Erosion rate index of bricks after rotary drum erosion test.

Fig. 4 shows a view of the burning zone lined with ELK-12CX-1. The location of the left picture is at the lower burning zone. The location of the right picture is at the upper burning zone. ELK-12CX-1 showed not only a lower wear rate, but also better coating formation than the other bricks, both of which contribute to stable operation at the burning zone.

3. 3 Bricks for transition zone

In many cement kilns, the furnace atmosphere in the transition zone has been changed by the increase in wastes and by-products consumption reducing the lifetime of the bricks. One of the important wear factors is a weakening of the brick structure caused by the penetration of alkali-sulphate ($K_3Na(SO_4)_2$, K_2SO_4) or alkali-chloride (KCl, NaCl)[1]. This degradation of the transition zone brick is known to be promoted by the reaction of impurities in bricks with vapor phase in the kiln gas[2]. Our bricks for the transition zone are commonly characterized by being in low impurities in order to suppress the above reaction. Among these, SP-8L is superior in sulfur resistance. SP-8LDF is superior in flexibility, and SP-8LS is superior in abrasion resistance due to a high hot modulus of rupture.

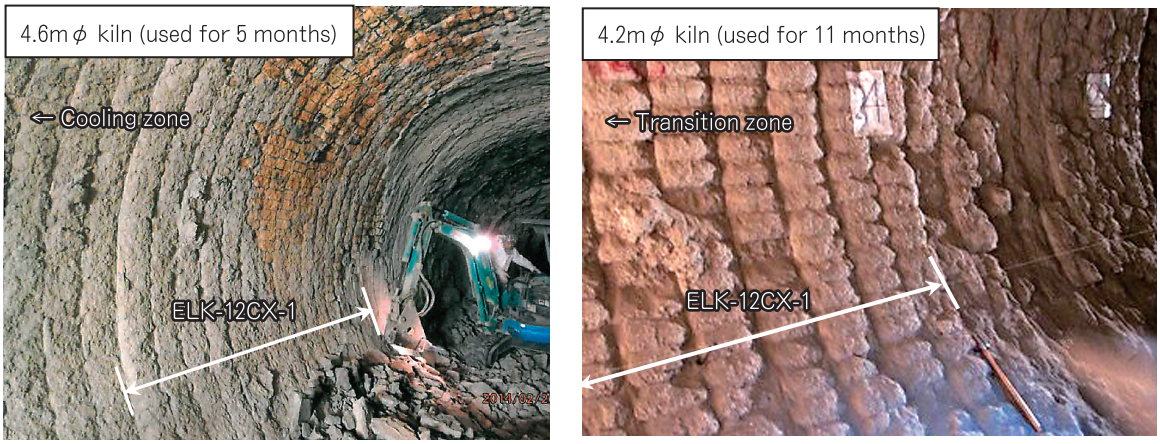

Fig. 4 Appearance of ELK-12CX-1 zone.

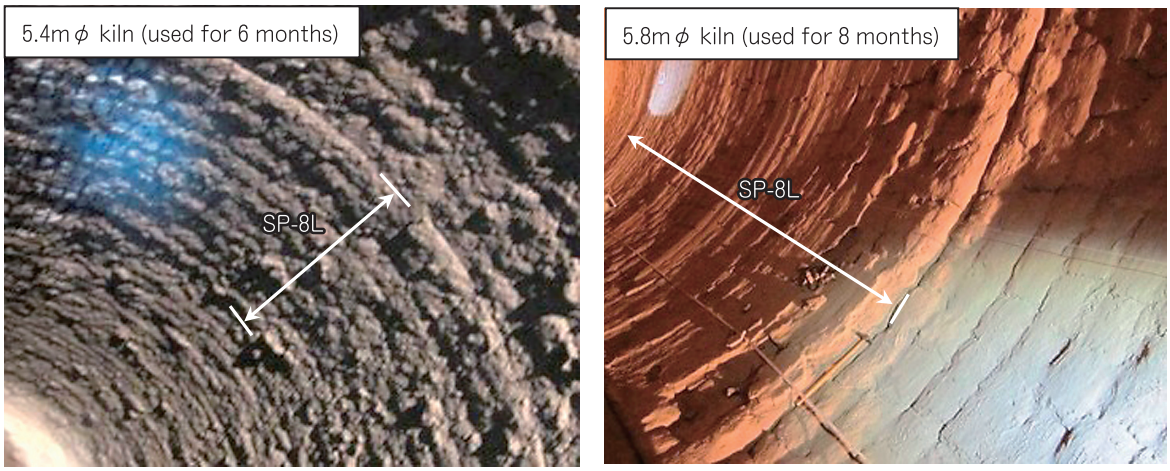

Fig. 5 Appearance of SP-8L zone.

Fig. 5 shows a view of the transition zone where SP-8L showed more residual thickness compared with the adjacent other company's brick. The used SP-8L showed a less weakened brick texture, which seems to have been the reason for the good performance.

4. Summary

The characteristics and performances of our magnesia-spinel bricks for cement kilns were introduced in this report. Although the number of cement kilns operating in Japan has decreased from the peak time, availability of the kilns has been kept at a high level because of the steady demand for cement recently. If the kiln operation is stopped in an emergency under a high availability, it has a significant impact on total service. Especially the performance of kiln bricks is becoming more important because of the trouble caused by the brick requires several days to reline the brick for restarting. The shinagawa bricks introduced in this report have been well received by many customers not only for reducing the risk of brick troubles but for cost merit through good performance.

References

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