Bottom Electrode Refractories for ABB-type Direct Current Electrical Furnace

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Abstract

Bottom electrode refractories are one of the essential products for ABB-type direct current electrical furnace. In this report, we would like to introduce our products and our customer's actual operational results.

1. Introduction

An electrical furnace utilizing a three-phase alternating current (AC) has three artificial graphite electrodes and discharges an arc between the electrodes and iron scrap / molten steel. A direct current (DC) electric furnace has one electrode at the lid and another electrode at the bottom (bottom electrode). It discharges an arc between them via iron scrap and / or molten steel in the furnace. A lid electrode is cathode and bottom electrode is an anode. Some engineering companies have developed different types of bottom electrodes. They are categorized into three types as shown in Fig.1.

In the CLECIM-IRSID and MAN-GHH, the bottom electrodes are assembled with steel rods / billets and refractories. In the CLECIM-IRSID the bottom electrode is composed of some round billets with water-cooling copper jackets. Sleeve bricks and refractories (stamping mix) are installed outside of the electrodes. The MAN-GHH bottom electrode is assembled with a number of steel rods called contact pins and refractories on a conductive plate. On the other hand, the ABB bottom electrode is an assembly of only refractories with electrical conductivity. Fig.2 shows the installation of an ABB bottom electrode. The electrode refractories are often stacked parallel without joint material at the center of the furnace bottom. Refractories (Stamping mix) are installed outside of the electrode.

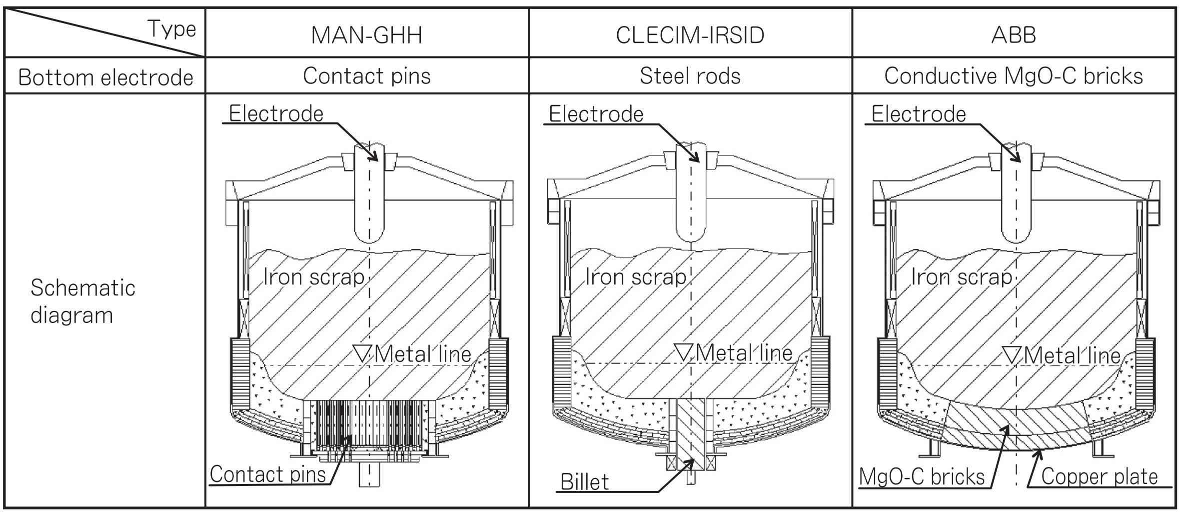

Fig. 1 Typical designs of DC arc furnaces.

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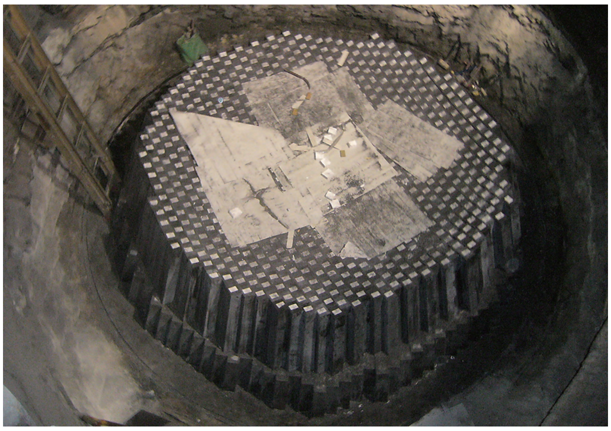

Fig. 2 Installation of bottom electrode.

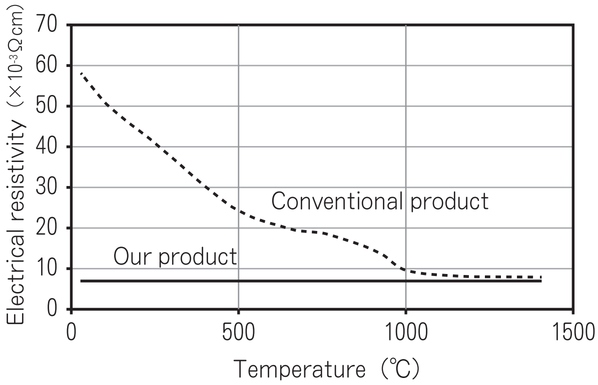

Fig. 3 Comparison of electrical resistivity between our product and conventional product (after heating at 1,500℃).

This report presents magnesia carbon refractories for the ABB bottom electrode with constant high electrical conductivity and a long service life.

2. Required Characteristics of ABB Bottom Electrode

We require ABB bottom electrode refractories to be constant and have as low specific electric resistivity as possible. We have often observed that steel infiltrates into the refractories joints when dismantling the bottom electrode. Steel skull and refractories integrated in large conglomerates. Once the skull was removed from them, the working area of the refractories also peeled away easily. The thermal history (heating and cooling cycle) during operation is considered to cause refractory joint opening, resulting in steel infiltration. Volume stability is the most important element in preventing joint opening and avoiding refractory damage. Some refractory characteristics such as low thermal expansion and positive after-expansion (expansion after heat-treatment) contribute to good volume stability. Moreover, the working surface becomes very high temperature because of arcing although it does not have so much chance to contact slug. Good corrosion resistance is also required.

It is very important to select magnesia carbon refractories that match the electric furnace design and actual operation of our customers.

3. Beneficial Features of Our Product

Electrode refractories are required to have constant and high electrical conductivity as described above. Fig.3 shows the relationship between the specific electric resistivity and temperature for our products and conventional products. The specific electric resistivity of the conventional products increases largely in the range of under 1,000 degrees Celsius. That of ours has a very constant and low specific resistivity all over the temperature range.

Table 1 Typical properties of magnesia carbon bricks for bottom electrode

Brand	MGT-3BR2
Chemical composition (mass %)	
MgO	85
C	13
Physical properties	
Apparent porosity (%)	10.5
Bulk density ($g \cdot cm^{-3}$)	2.85
Cold crushing strength (MPa)	30
Electrical resistivity ($\times 10^{-3}\Omega cm$)	
Product	7
After heating	
At 1000℃	7
At 1500℃	7
Beneficial features	Good corrosion resistance Positive after-expansion

Improvement of the grain size distribution in our materials and heat-treatment for refractories during the manufacturing process realized low thermal expansion and positive after-expansion characteristics for our products. It contributes to good volume stability in order to prevent joint openings. Table 1 shows the typical properties of magnesia carbon material for the ABB bottom

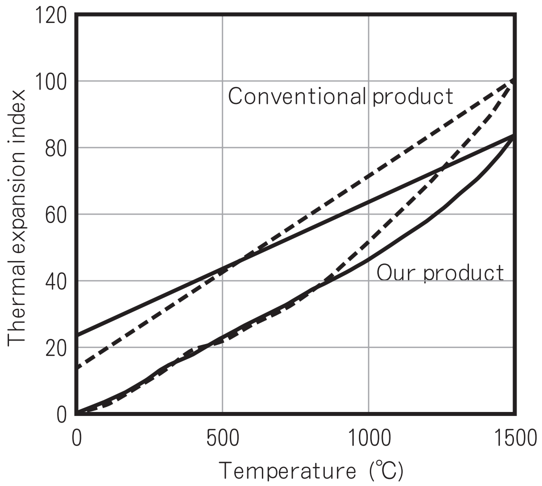

Fig. 4 Comparison of thermal expansion and after-expansion between our product and conventional product.

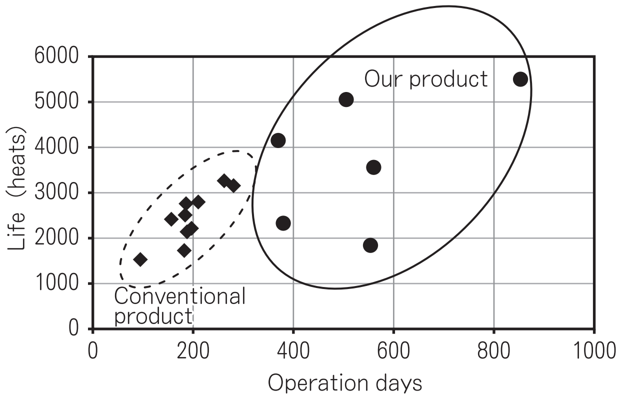

Fig. 5 Relationship between service life and number of operating days.

electrode. Fig.4 shows the thermal expansion curves of our materials and conventional materials. Our material has 20% lower thermal expansion at 1,500 degrees Celsius and two times larger after-expansion comparing to the conventional material.

4. Actual Operating Results

The superior characteristics of our bottom electrode refractories lead to stable operation and a longer service life.

Fig.5 shows the relationship between service life and number of operating days from a customer of ours. Our products had a much longer service life than the conventional ones. Even in severe operating conditions such as frequent intermittent use and long idling time, our products performed better than the conventional ones. We observed that electrode had less steel infiltration into refractory joints when we dismantled the electrode.

At another customer's factory, the service life of the conventional products was 9,000 heats, and our products reached 18,000 heats in the first trial. It should be the world record for ABB bottom electrode service life.

5. Summary

We developed magnesia carbon refractories with superior characteristics for the ABB bottom electrode. Our products have achieved a longer service life and realized stable operation. We will continue to study and develop new products that match the electric furnace design and actual operating conditions of our customers in order to give better performance.