THE EFFECTS OF B_2O_3 CONTENT ON PROPERTIES OF ALUMINA-MAGNESIA DRY RAMMING MATERIALS

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ABSTRACT

This paper explored the effect of B_2O_3 content on the properties of alumina-magnesia dry ramming materials through analysis of its phases, morphology of the samples fired at a high temperature with different amounts of B_2O_3. Different sizes of corundum, α-Al_2O_3 powder and fused magnesia were used as raw materials, boron oxide as binding agent and a hand-ramming molding method to keep its shape. The test results of the samples fired at 1600 ℃ for 3h showed that the most appropriate amount of B_2O_3 addition was 1.5wt%, at this condition, the Al_2O_3 and MgO reacted with each other to generate a great amount of aluminum-magnesium spinel with the size ranging from 3μm to 15μm. Some of the alumina-magnesia spinel were closely combined together by reason of sintering and crystallization, and the ones of small size showed a more regular shape.

KEYWORDS

- Dry ramming materials
- Aluminum-magnesium spinel
- Hand-ramming molding method.

INTRODUCTION

Induction furnaces are widely used in casting and metallurgy industry due to their excellent performance, such as the advantages of electric efficiency, heating speed, easy operation. Induction furnaces fall into two types: induction furnaces and coreless induction furnaces[1-3]. Magnesia-alumina spinel refractories as a basic material has good corrosion resistance to basic slag, which were commonly used for furnace lining of induction furnace[4-6]. B_2O_3 is often added in materials as a binder, for which can translate into liquid phase and decrease the temperature of the formation of magnesium aluminate spinel[7]. But so far, the research focused on the effect of the amount of B_2O_3 is rare. In this paper, our current research focuses on the effect of the B_2O_3 to improve the characteristic of alumina-magnesia dry ramming materials. By this way, the appropriate quantity of B_2O_3 is confirmed to guide industrial production.

EXPERIMENTAL

5-3mm, 3-1mm, ≤1mm and ≤0.074mm sizes of white corundum and industrial-grade purity α-Al_2O_3 powder, boron oxide were used as starting materials in this experiment. The experiment formulas for preparing alumina-magnesia dry ramming materials was shown in Table 1. All chemicals were molded in a special mold by hand-ramming method after dry mixture evenly followed by heat treatment at 1600℃ for 3h. The expansion ratio, apparent porosity and cold crushing strength were tested by GB/T5988-2007, GB/T2997-2000 and GB/T5027-2008, respectively. The X-ray diffraction (XRD) using Cu-K α irradiation at a scan rate (2θ) of $0.02°\cdot s^{-1}$ were used to determine the identity of any phase present. The morphologies of specimens were observed by field emission scanning electron microscope(FEI, XL30TMP).

Tab.1 The experiment formulas with different contents of B_2O_3/wt%

No.	Corundum/mm				Magnesia/mm	α-Al_2O_3	B_2O_3
	5-3	3-1	≤1	≤0.074	≤0.088	powder	
G1	12.0	21.1	30.5	28.4	6	2	0
G2				27.9			0.5
G3				27.4			1
G4				26.9			1.5
G5				26.4			2
G6				25.9			2.5

RESULTS AND DISCUSSION

Fig.1 shows that the apparent porosity decreased at first and then increased after the lead, finally declined, while sample with an increasing amount of B_2O_3 fired at 1600℃; the cold crushing strength, the linear change and bulk density overall decreases at first and then increased and finally decreased. The bulk density of samples with 2wt% and 2.5wt% amount of B_2O_3 had little change. The sample with 1.5wt% amount of B_2O_3 had the maximum bulk density. The possible cause of changes in physical properties was the joint effect of that sintering and volume expansion. It was generally known that a better sintering could decrease the apparent porosity of the sample and the continued increased amount of B_2O_3 facilitated the generation of alumina-magnesia spinel with volume expansion. From the pictures, we can see that 1.5wt% addition of B_2O_3 maybe the most suitable amount of B_2O_3.

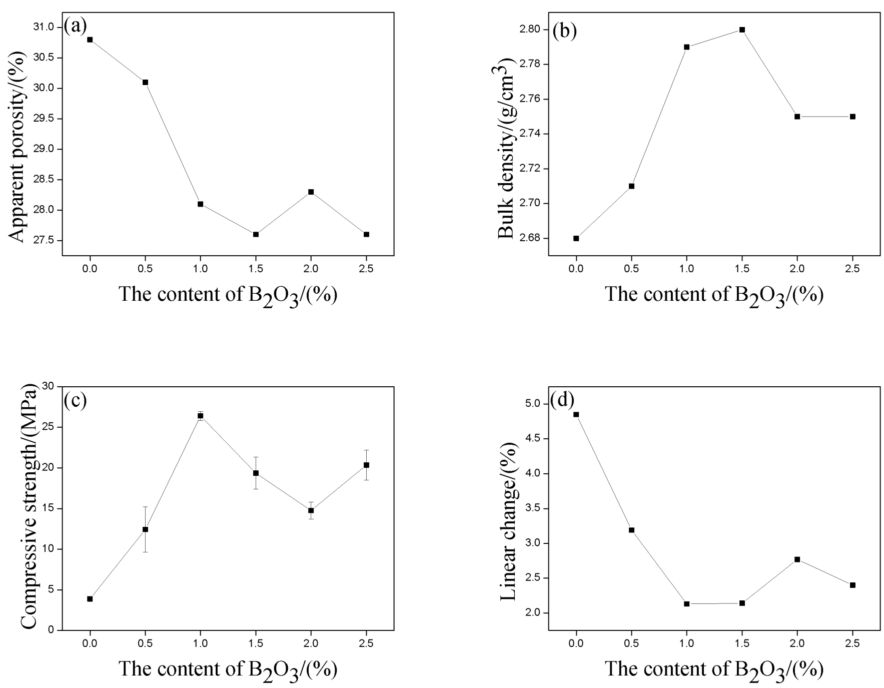

Fig.1 Physical properties of the samplesfired at 1600 ℃with different addition of B_2O_3

(a)Apparent porosity, (b)Bulk density, (c)Compression strength, (d)Linear change

Fig.2 showed that the main phases of the sample with 1.5wt% B_2O_3 fired at 1600℃ were Al_2O_3, $MgAl_2O_4$ and $Al_{18}B_4O_{33}$. That magnesium oxide diffraction peaks were not detected in the sample indicating that all of the magnesium oxide added had converted into aluminum-magnesium spinel.

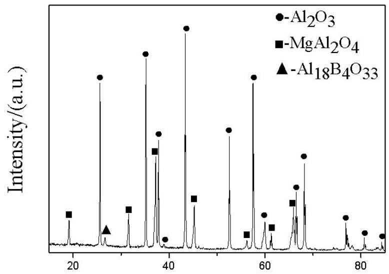

Fig.2 The XRD patterns of the sample with 1.5 wt% amount of B_2O_3 after firing at 1600 ℃

$Al_4B_2O_9$ was generated from the reaction of Al_2O_3 and B_2O_3 before heating up to 1000℃ and $Al_4B_2O_9$ began to decompose into $Al_{18}B_4O_{33}$ phase at about 1000℃. The reaction equations were as follows :

$$2Al_2O_3+B_2O_3=Al_4B_2O_9 \quad (1)$$

$$9Al_4B_2O_9=2Al_{18}B_4O_{33}+B_2O_3 \quad (2)$$

Fig.3 showed that alumina-magnesia spinel was generated at high temperature. The generated alumina-magnesia spinel was closely arranged together. The grain size was different. The smaller ones were about 3~5μm with regular octahedron shape and the larger ones were about 15μm without a definite or regular shape. Energy spectrum analysis confirmed that the biggest grain in the photograph was alumina-magnesia spinel, the size of which was about 15μm.

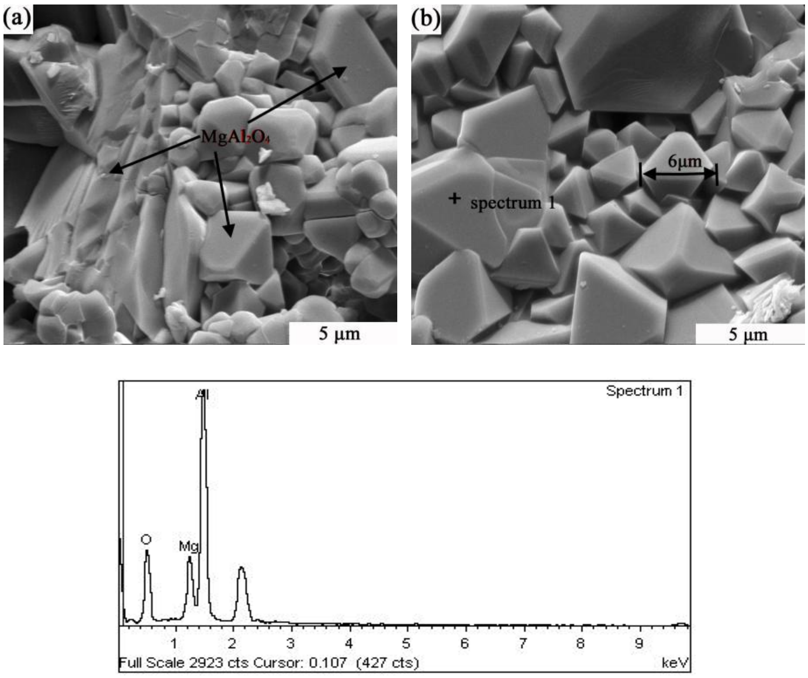

Fig. 3 SEM photographs and energy spectrum analysis of sample with 1.5wt% of B_2O_3 fired at 1600℃

CONCLUSIONS

The appropriate amount of B_2O_3 addition for alumina-magnesia dry ramming materials was 1.5wt%. The reaction at high temperature generated a great amount of alumina-magnesia spinel, the smaller ones were about 3~5μm with regular octahedron shape and the larger ones were about 15μm without a definite or regular shape.

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