Effects of $Na_2B_4O_7$ $5H_2O$ on Foam Glass-Ceramics Prepared from High Titanium Blast Furnace Slag

Qingzhu SUN, Haibo WANG

School of Materials Engineering

Panzhihua University

Panzhihua, China

e-mail: haerbinsqz@163.com, jmsdxwhb@163.com

***Abstract*—Foam Glass-ceramics were prepared by one step method, the blast furnace slag and waste glass were used as main raw materials,$Na_2B_4O_7$ $5H_2O$ was added as flux .the Effects of $Na_2B_4O_7$ $5H_2O$ on the pore size distribution, the bulk density and compressive strength of foam glass-ceramics were studied. Experimental results show that with the increase of the content of $Na_2B_4O_7$ $5H_2O$, the pores of foam glass-ceramics became larger. When the addition amount of $Na_2B_4O_7$ $5H_2O$ was 8%, the foam glass-ceramics had the appropriate pore size, uniform distribution and good comprehensive performance, and its compressive strength was about 25MPa, the bulk density was 0.82g / cm^3.**

Keywords-blast furnace slag; foam glass-ceramics; waste glass; $Na_2B_4O_7$ $5H_2O$

I. INTRODUCTION

Foam glass-ceramics is a new multi-functional materials, its raw material are the mixture of industrial solid waste, such as blast furnace slag, waste glass, red mud, oil shale slag, fly ash , etc, and appropriate amount of additives, the mixture is broken, mixed and sintered to get microcrystalline foam glass.

Because of its unique internal structure and crystal interwoven, foam glass-ceramics have many excellent properties such as low density, low thermal conductivity, high surface area, good thermal shock resistance and high specific strength. Therefore, it is widely used in the building materials industry [1-3]. In recent years, with the continuous exploration on the raw material composition, preparation process and foaming and crystallization mechanism, more and more solid waste such as fly ash [4], waste glass [5-6], red mud [7] and blast furnace slag [8] have been used to produce foam glass-ceramics.

Water quenching high titanium blast furnace slag is the waste slag produced in ironmaking process in Panzhihua Iron and Steel Company, it has been stockpiling more than 6000 tons and with an annual increase rate of 300 tons [9]. The continuous accumulation of tailings not only pollutes the ecological environment, but also wastes titanium resources. There are a lot of oxides in the slag, which is the necessary component to form foam glass-ceramics. The content of titanium in the blast furnace slag is high, about 20% ~ 27%. High content of TiO_2 is an excellent nucleating agent in glass systems [10], the advantage of composition makes the high titanium blast furnace slag in Panxi area be the raw material for preparing microcrystalline foam glass.

In this paper, foam glass-ceramics was prepared by one-step process ,and water quenched blast furnace slag and waste glass were used as the main raw material, $CaCO_3$ as foaming agent, $Na_2B_4O_7$ $5H_2O$ as flux, $Na_3PO_4 \cdot 12H_2O$ as stabilizer. The effects of flux on pore structure, bulk density and compressive strength of glass foam glass were investigated.

II. EXPERIMENTAL MATERIALS AND PROCESSES

A Experimental Materials

The water quenched high titanium blast furnace slag was from Pangang Group, and its chemical composition is shown in Table I.

TABLE I. CHEMICAL COMPOSITION OF HIGH TITANIUM BLAST FURNACE SLAG IN PANZHIHUA IRON AND STEEL COMPANY

Composition	SiO_2	CaO	Al_2O_3	TiO_2	Fe_2O_3
Content (wt%)	24.72	28.39	13.64	21.40	0.66
Composition	*MgO*	MnO_2	*FeO*	V_2O_5	*others*
Content (wt%)	7.05	0.54	2.76	0.29	0.55

The content of SiO_2 in microcrystalline foam glass should be above 50% to form enough glass phase. But the content of SiO_2 in the high titanium blast furnace slag in Panxi area is lower, so the waste glass was added to adjust the content, the contents of waste glass is shown in Table II.

TABLE II. THE CONTENTS OF WASTE GLASS

Composition	SiO_2	*CaO*	Al_2O_3	Fe_2O_3
Content (wt%)	71	8.91	1.47	0.07
Composition	*MgO*	NaO_2	K_2O	*others*
Content (wt%)	3.55	13.1	0.83	1.07

B Experimental Process

The high titanium blast furnace slag and the waste glass were respectively milled for 2 hours and then screened through 200 meshes. The experimental raw material mainly consisted of high titanium blast furnace slag powder, waste glass powder and addition reagents, and the ratio between the three was 30: 70: 10. $Na_2B_4O_7 \cdot 5H_2O$ was added as a flux in the raw material, the amount added respectively was 6%, 7%, 8%, 9% and 10%.

The experimental materials were mixed on a ball mill and pressed into cylinders of Φ13 mm ·15 mm on a hydraulic press, then the cylinders were heated to 400 ℃ and hold for 20 min. In order to make the moisture in the experimental material fully volatile, but also for the mixture to heat evenly to form a uniform foam structure, and to prevent the foaming agent in the experimental material is not softened before the foam, the heating rate should be slower, it was set to 5 ℃ / min. Then, the material was heated at a heating rate of 10 ℃ / min to 900 ℃, after 30 min heat preservation, the foam glass was prepared.

III. Results And Analysis

A The Pore Structure of Microcrystalline Foam Glass

As can be seen from Figure 1, as the content of $Na_2B_4O_7 \cdot 5H_2O$ increases, the pores became larger. In Figure 1(C), the content of $Na_2B_4O_7 \cdot 5H_2O$ was 8%, the holes are more uniform and the communication holes are less, while in Figure .1(D) and Figure. 1(E) the holes are larger in size and the walls are thinner and have more communication holes. This is mainly because, with the increasing of flux content, the viscosity of the experimental material becomes larger, the produced gas is not easy to overflow, and the glass phase will wrap up the gas, as the increasing of holes, the chance of meeting between pores increases, which makes it easier to form communicating pores.

B The Properties of Microcrystalline Foam Glass

The change trends of bulk density and compressive strength of the sample with the increase of flux are shown as Figure 2, with the increase of flux content ,bulk density decrease first and then increase, when the flux content is 8%, the bulk density is minimum, about 0.82g/cm3. But with the increase of flux content, the compressive strength increases first, then decreases. When the flux content is 8%, compressive strength is maximum about 25MPa. When the flux is increased to 8%, the melt viscosity decreases, a large amount of gas overflows, that results in less gas remain in the hole and hole wall is thicker, so the strength becomes higher, when the flux is added too much, the viscosity of the melt becomes larger, and the pores are not easy to overflow, the glass phase wraps the pores, resulting in an increase in porosity, so the strength is low.

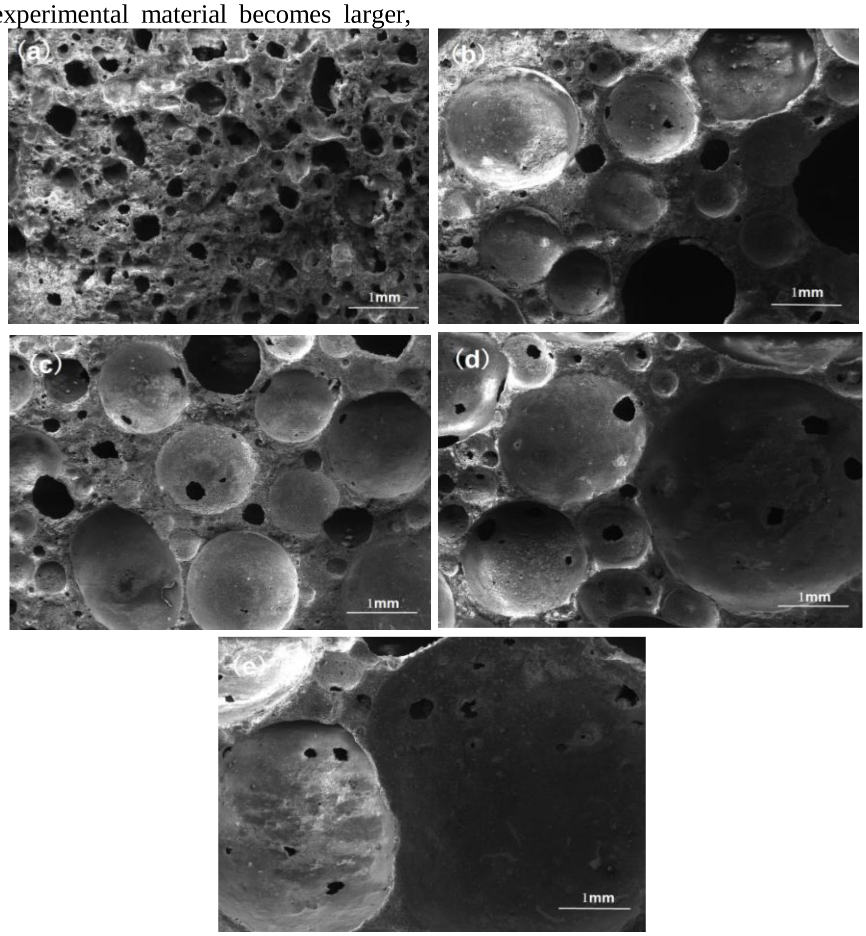

Figure 1. SEM images of the pores structure of foam glass ceramics : (a)this is the pores structure of foam glass ceramics added 6% of Na2B4O7 • 5H2O (b) this is the pores structure of foam glass ceramics 7% of Na2B4O7 • 5H2O(c)this is the pores structure of foam glass ceramics added 8% of Na2B4O7 • 5H2O(d)this is the pores structure of foam glass ceramics added 9% of Na2B4O7 • 5H2O (e), this is the pores structure of foam glass ceramics added 10% of Na2B4O7 • 5H2O.

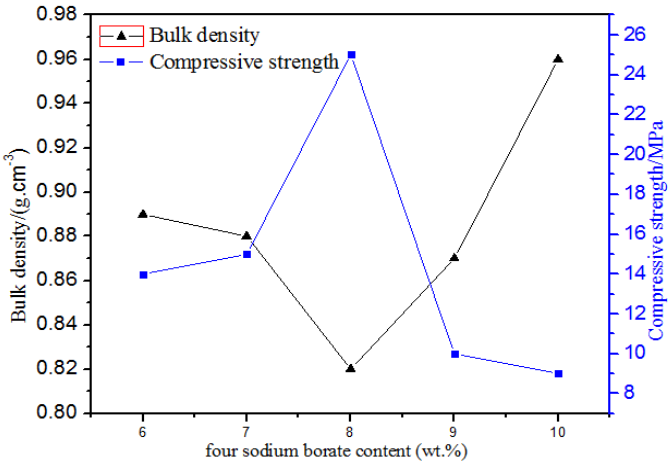

Figure 2. Figure 2 The change trends of bulk density and compressive strength of the sample with the increase of flux.

IV. Conclusion

As the content of $Na_2B_4O_7 \cdot 5H_2O$ increases, the pores of foam glass-ceramics became larger.

With the increase of the addition of $Na_2B_4O_7 \cdot 5H_2O$, the bulk density decreases first and then increases, but the compressive strength increases first and then decreases.

When the flux content is 8%, the properties of foam glass-ceramics are best, the pores of foam glass-ceramics are uniform and the communication holes are less , its compressive strength was about 25MPa, the bulk density was 0.82g / cm3.

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