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Novel applications of waste ceramics on the fabrication of foamed materials for exterior building walls insulation

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HIGHLIGHTS

- Effect of clay and foam onthe properties of insulation materials was studied.
- The performance of specimens didn't vary linearly with the amount of foam.
- Clay promoted the densification and improved the strength of specimens.
- Thermal conductivities of specimens varied linearly with foam and clay content.
- The 10 wt% clay and foam content had good effect onthe properties of specimens.

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ABSTRACT

In this paper, a novel fabrication method has been proposed by using waste ceramic and other polishing materials as main raw materials to prepare foam ceramic for the potential applications in thermal insulation of exterior building walls. In particular, the content of Al_2O_3 and SiO_2 was almost 90% in this kind of materials. The polishing materials result from grinding polished tiles into powder and the ceramic foam was foamed slurry produced by self-configure foaming solution after mechanical stirring. Effects of content of foam and clay on the specimens' properties such as compressive strength, apparent porosity, bulk density, water absorption and thermal conductivity were investigated. Based on results, when the content of clay was 10 wt%, the amount of foam was 10 wt%, apparent porosity of specimens sintered at 1000 °C was 50.6%, linear change was 7.2%, bulk density was 0.70 g/cm^3, compressive strength was 8.0 MPa, and thermal conductivity was 0.137 W/(m·K) at 200 °C. Microstructures of specimens were also detected and compared, and the exceptional mean pore size was 39.7 μm which was measured by using "Micro-image Analysis and Process System" (MIAPS) software. Due to the difference in bulk density, the internal pore structure and performance of the sample are different. Comprehensive properties of specimens can be optimized by adjusting the amount of foam and clay. The proposed method for obtaining insulation foamed materials using ceramics' waste and other polishing materials was feasible, whilst saving resources and energy.

1. Introduction

At present, "low-carbon economy" has become the background of the times, building energy efficiency has also become a research hot. Wall insulation, especially exterior insulation was a key factor in building energy efficiency [1,2]. The market for building insulation has been almost dominated by organic materials nowadays [3]. The study found that foam insulation board belonging to inorganic material products [4,5] had the advantages of stable performance, fire retardant [6], anti-aging and eco-friendly. What's more, the product has excellent fireproof performance, which could overcome the fatal weakness of organic materials for fearing of open flame and easy aging, so it could be used as an ideal material for building insulation. However, the existing foamed ceramic plates mostly used the over-priced ores and fine ceramics as the main raw materials, which led to the disadvantages of high product cost and limiting the application of it.

Foamed ceramics are the third generation of porous ceramics that have been developed after ordinary porous ceramics and

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Table 1
Chemical composition of raw materials (wt%).

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	IL
Ceramic waste	78.62	10.56	1.00	0.99	0.97	1.48	3.37	2.36
Clay	49.21	31.91	1.45	0.16	0.22	0.15	0.01	13.60
Cement	27.75	12.71		46.41	4.6	0.56	0.09	5.99
Flux	70.14	18.29	0.37	0.58	0.07	3.37	4.12	2.76

Table 2
Batch compositions (wt%).

Foam	30	20	10	7.5
Clay				
0	A1	B1	C1	D1
5	A2	B2	C2	D2
10	A3	B3	C3	D3
15	A4	B4	C4	D4

honeycomb porous ceramics. In addition to the high temperature resistance, corrosion resistance and other excellent performances that traditional ceramics had, the foam ceramics were very attractive due to their unique characteristics, such as low density, high porosity [7], large surface area [8], high thermal stability and chemical inertness etc. A wide variety of porous materials have been prepared by using several raw materials such as ceramics [9], cements [10,11], fluxes and clays [12–14]. The fluxes mentioned here were sintering aids to promote sintering densification.

In this paper, ceramic wastes were used as a cheap raw material for the preparation of foam ceramics in order to take advantage of SiO_2 and Al_2O_3 component effectively and the potential applications in thermal insulation of exterior building wall. Some technical properties of the ceramic wastes such as line rate of change, strength at room temperature, apparent porosity, bulk density, water absorption and thermal conductivity were investigated.

2. Experimental procedures

2.1. Raw materials

The particle size of all starting materials such as waste ceramic and other polishing materials (Wuxi, PR China), flux (Wuxi, PR China), cement (Wuhan, PR China) and clay (Fujian, PR China) were

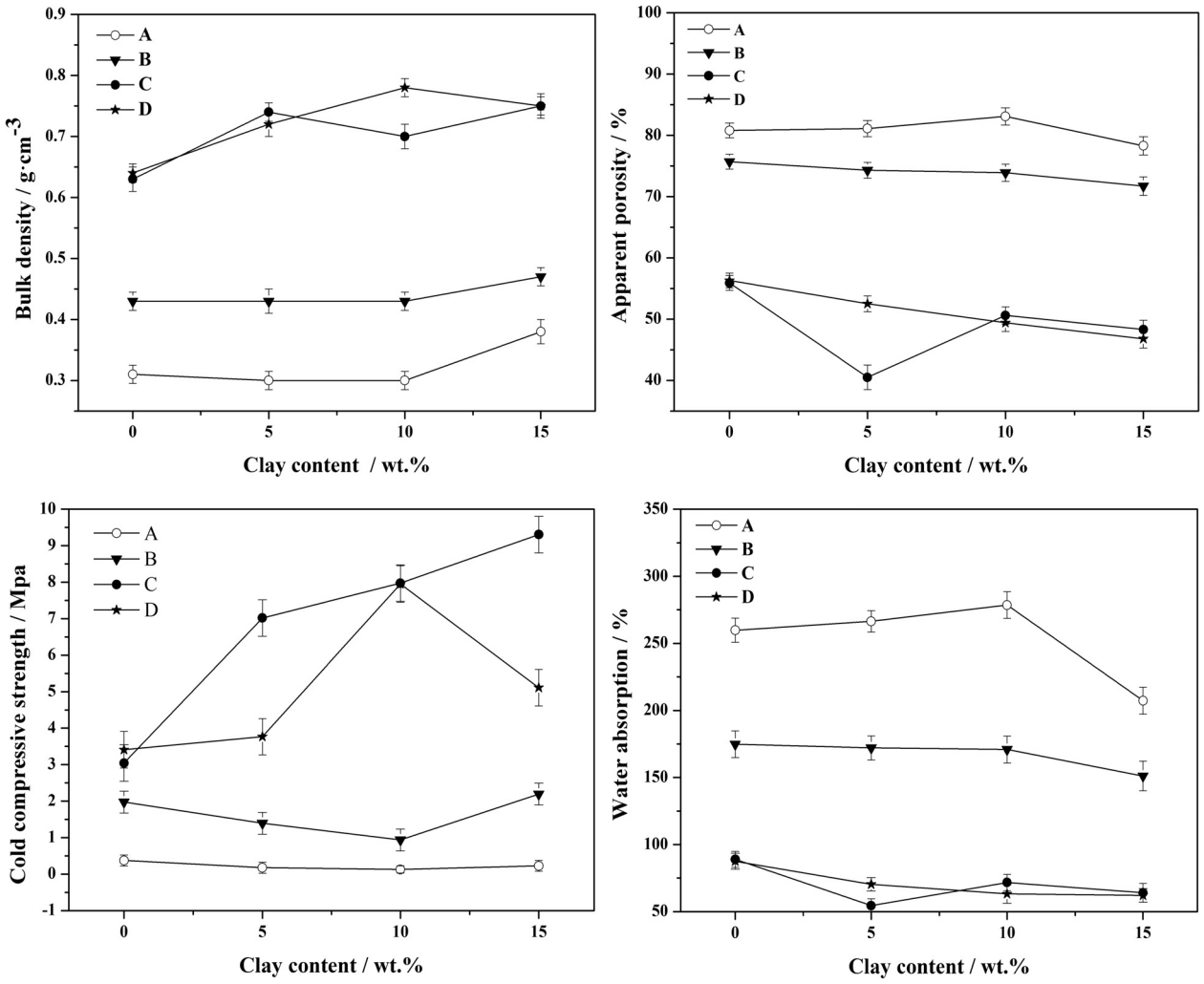

Fig. 1. Physical properties change of specimens as functions of the amount of clay and foam.