Experimental Study on Acoustic Properties of Foam Ceramics

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Abstract. Foam ceramics have excellent properties such as high porosity, high temperature resistance, chemical corrosion resistance and good thermal stability, and are widely used as metal liquid filter, high temperature gas and ion exchange filter, catalyst carrier, environmental material, heat insulation material, sound absorption material, biological material and so on. In this paper, the preparation technology of porous ceramic materials is investigated firstly. Then the foam ceramic samples with different porosity of Al2O3 and SiC materials were manufactured, and their acoustic properties were tested, and the influence of material and porosity on sound absorption performance was analyzed.

1. Introduction

Foam ceramics is a new material with high specific area, high porosity, low density, low heat conduction coefficient, selective permeability to liquid and gas medium, and excellent properties such as energy absorption and damping characteristics. The porous channels are connected with each other in labyrinth type 3D mesh structure, which plays a significant role in molten metal, gas liquid filtration, purification and separation, chemical catalytic carrier, sound absorption and shock absorption, advanced insulation materials, biological materials, special wall materials and sensor materials, and is widely used in environmental protection, energy, chemical, biological and other fields.

Foam ceramics have a large number of pores with three-dimensional spatial network structure. After the sound wave is introduced into the porous body, the air in the pores is vibrated and the ceramic tendons are rubbed. Because of the viscous action, the sound wave changes to heat and disappears, thus achieving the effect of absorbing sound. With the aggravation of noise pollution and the enhancement of people's awareness of environmental protection, sound-absorbing materials will develop rapidly. Exploring and adopting new technology to broaden the sound-absorbing frequency band and improve the sound-absorbing performance of foam ceramics will still be a research hotspot. At the same time, researchers also need to strengthen the research on the application technology of sound-absorbing foam ceramics and improve its industrialization level.

In this paper, the preparation technology of porous ceramic materials is investigated firstly. Then the foam ceramic samples with different porosity of Al2O3 and SiC materials were manufactured, and their acoustic properties were tested, and the influence of material and porosity on sound absorption performance was analyzed.
2. Preparation Technology of Foam Ceramics

2.1. Adding pore-forming agent method
The method of adding pore-forming agent is to prepare foam ceramics by adding pore-forming agent to the ceramic ingredients, using the pore-forming agent to occupy a certain space in the blank body, and then through sintering, the pore-forming agent leaves the matrix and forms the pores. The shape and size of pore-forming agent particles determine the porosity and size of foam ceramic materials. Its molding methods mainly include moulding, extrusion, isostatic pressing, injection and powder pouring. This method can be used to produce foam ceramic products with complex shape, but the distribution uniformity of pores is poor. The pore-forming agent should be easily excluded during heating, and the type and amount of pore-forming agent is the key to this method.

2.2. Foaming method
Foaming method is the addition of organic or inorganic chemicals to ceramic components to produce volatile gases through chemical reactions and so on, to produce foam, and to make foam ceramics by drying and sintering. The advantage of this method is that foam ceramic products with complex shape can be prepared to meet the application of some special occasions. The disadvantage is that the foaming reaction process is more complex and difficult to control.

2.3. Organic foam impregnation method
Organic foam impregnation method was invented by Schwartzwalder in 1963. Using the special structure of the open-hole 3d reticular possessed by the organic foam body, the prepared slurry was uniformly coated on the organic foam mesh body, and the organic foam body was burned after drying to obtain a mesh porous ceramic. By controlling the slurry properties, optimizing the inorganic binder system and strictly controlling the slurry impregnation process, the high performance foam ceramic products can be prepared. but there is an obvious defect in the organic precursor impregnation process, that is, the pore structure of the product, especially the pore size, depends on the pore structure and pore size of the selected organic foam.

2.4. Sol-gel method
Sol-gel method is used to prepare foam materials by sol-gel technology. In the process of sol-gel transformation, the viscosity of the system increases rapidly, thus stabilizing the bubbles produced in the early stage and facilitating foaming. This method is mainly used to prepare microporous ceramic materials with uniform pore size and pore size distribution, and the foam ceramic materials with high flatness can be prepared by improvement.

3. Preparation of Foam Ceramic Samples
In this paper, two kinds of foam ceramics, Al2O3 material and SiC material, were prepared by adding pore-forming agent method, in which the pore density of Al2O3 material was 20 ppi, 40 ppi and 60 ppi, respectively, as shown in figure 1. the pore densities of SiC materials are 10 ppi, 20 ppi and 30 ppi, as shown in figure 2. all samples were cylindrical with thickness 4 cm, radius 5 cm.

Figure 1. The pore density from left to right is 20 ppi, 40 ppi and 60 ppi respectively (Al2O3 material).
Figure 2. The pore density from left to right is 10 ppi, 20 ppi and 30 ppi respectively (SiC material).

4. Acoustic Performance Test

In this paper, impedance tube is used to test the sound absorption performance of the prepared foam ceramic sample. The impedance tube test system is shown in Fig. 3.

![Figure 3. Test system for sound performance of impedance tube.](image)

First of all, the sound absorption coefficients of Al2O3 and SiC materials under the same hole density (20 ppi) were compared. The experimental results are shown in figure 4. We can see that the sound absorption performance of SiC material is slightly better than Al2O3 material in low frequency band (below 500 Hz), but in high frequency band (more than 1000 Hz), the Al2O3 material is superior to the SiC material.

![Figure 4. The sound absorption coefficients of Al2O3 and SiC materials under the same hole density (20 ppi) were compared.](image)
Figure 5. Comparison of sound absorption properties of Al2O3 foam ceramics with different pore densities

Figure 6. Comparison of sound absorption properties of SiC foam ceramics with different pore densities

The test results of Al2O3 foam ceramics at different pore densities are shown in figure 5, SiC foam ceramics are shown in figure 6. The following two conclusions can be drawn: (1) The low frequency effect of foam ceramics is better as a whole, and it is basically not affected by hole density and material; (2) At medium and high frequency, the larger the hole density is, the better the sound absorption performance is.

5. Conclusions

Two kinds of foam ceramics, Al2O3 material and SiC material, were prepared by pore-forming agent method. The acoustic properties of Al2O3 and SiC materials with different pore density were tested. It can be found that the sound absorption performance of foam ceramics with different materials is different, especially in the high frequency band; the low frequency effect of foam ceramics is better as a whole, and basically is not affected by the hole density and the material; the larger the hole density is, the better the sound absorption performance is. To explore and adopt new technology to widen the sound
absorption frequency band and improve the sound absorption performance of foam ceramics will still be the focus of future research.

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