Preparation, structure control and acoustic properties of porous aluminium with open cells

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Abstract

Porous aluminium having spherical and multi-angular pores was manufactured by negative melt infiltration method. It was found via experiment that the degree of pore opening (DPO) decreases with the increase of infiltration pressure, the maximum sound absorption coefficients of the porous aluminium within the frequency range of 125~4000Hz were over 0.9, and their acoustic properties as a function of frequency were influenced by pore size, porosity and the air cavity depth behind the samples.

1 Introduction

Pressure infiltration for making porous metals has advantages over other commonly used methods, such as foaming method, in the following aspects: a. the size and the shape of the pores can easily be controlled by choosing fillers properly; b. the pores obtained are 3-dimentional interconnecting. So pressure infiltration can be used to make porous metals needed for sound absorption, filtration and heat exchanging usage. In the present paper, porous aluminium was made with negative pressure infiltration method, the influence of infiltration pressure on pore structure was researched, and their sound absorption properties as a function of frequency were tested.

2 Preparation and structure control of porous aluminium

Porous aluminium was produced by first infiltrating liquid aluminium around the voids of water-soluble particles packed in a mould to form an aluminium/particle composite and then dissolving the particles with water to get porous aluminium having 3-dimentional inter-connecting pores. For overcoming the surface tension of liquid aluminium, a vacuum pressure was applied to the mold during infiltration process to let the melt flow into the interstices in the present experiment. Assuming that an infiltration element in which two rigid balls having a diameter of d contact at point O and liquid aluminium tries to enter the interstices of the balls under negative pressure, see Fig. 1. Because the melt could not penetrate to the point O under limited pressure, thus a passage connecting the neighboring pores after the removal of particles existed. Assuming that the diameter of the passage is δ, thus δ/d is defined as the degree of pore opening (DPO) which is the key factor determining the permeability and thus its closely related properties of sound absorption [1] , heat exchanging [2] and filtration of porous metals. It is obviously that DPO depends on infiltration pressure ΔP. To investigate the influence of pressure on DPO, a serial of experiments were made by infiltrating liquid aluminium under different vacuum pressures into packed spherical particles having different diameters. After the removal of the particles, the samples were sectioned, the diameters of pore-opening of the pores (see Fig.2) were measured with an optical testing apparatus having a precision of 0.01mm, and the DPO was calculated. Experimental results showed that the higher the vacuum pressures, the smaller the DPO, see the solid points in Fig. 3(a), (b).

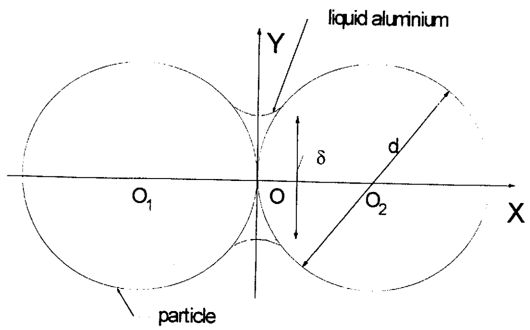

Fig. 1: Scheme of an infiltration element

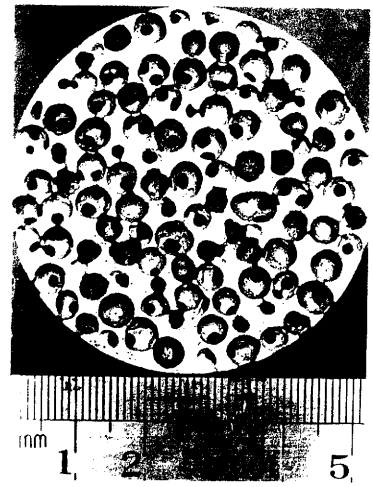

Fig 2: Section of a porous specimen having spherical pores and pore-opening

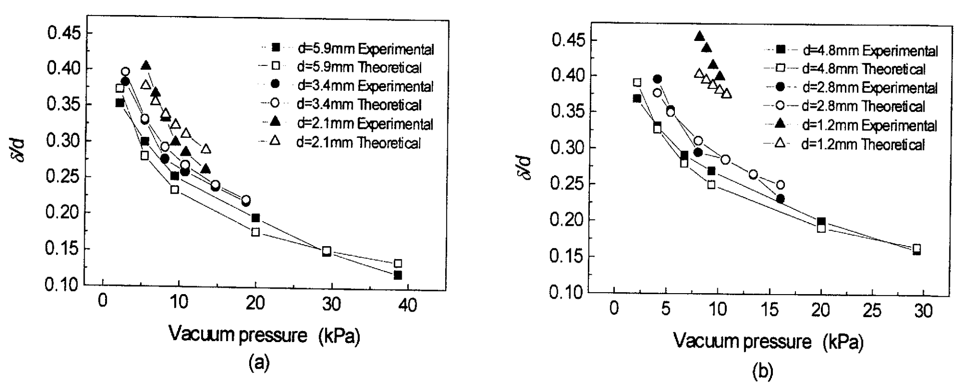

Fig. 3: Theoretical and experimental relation between DPO and infiltration pressure

For the simplified infiltration element shown in Fig. 1, a theoretical model predicting DPO was established [3]. It was found that DPO depends on the following parameters: infiltration pressure ΔP, particle diameter d, surface tension of liquid aluminium σ, the wetting angle θ between liquid aluminium and particle. In the present experiment conditions, σ_{Al}=0.914N/m, θ=152°, and the theoretical relationship between DPO and pressure coincided well with the experimental results of Fig. 3(a) and (b).

Normally, the particles used were not spherical, but multi-angular, thus the passage connecting neighboring pores was irregular (see Fig. 4). Although measuring the DPO of irregular pores is difficulty, it may be estimated that the relation between its average DPO and pressure will be similar to that shown in Fig. 3.

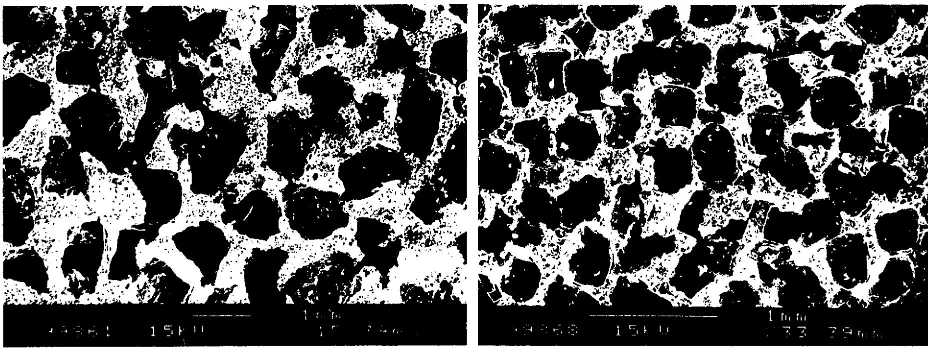

Fig. 4: Photos of porous aluminium with multi-angular pores having the average pore sizes of 1.43mm (left) and 0.38mm (right)

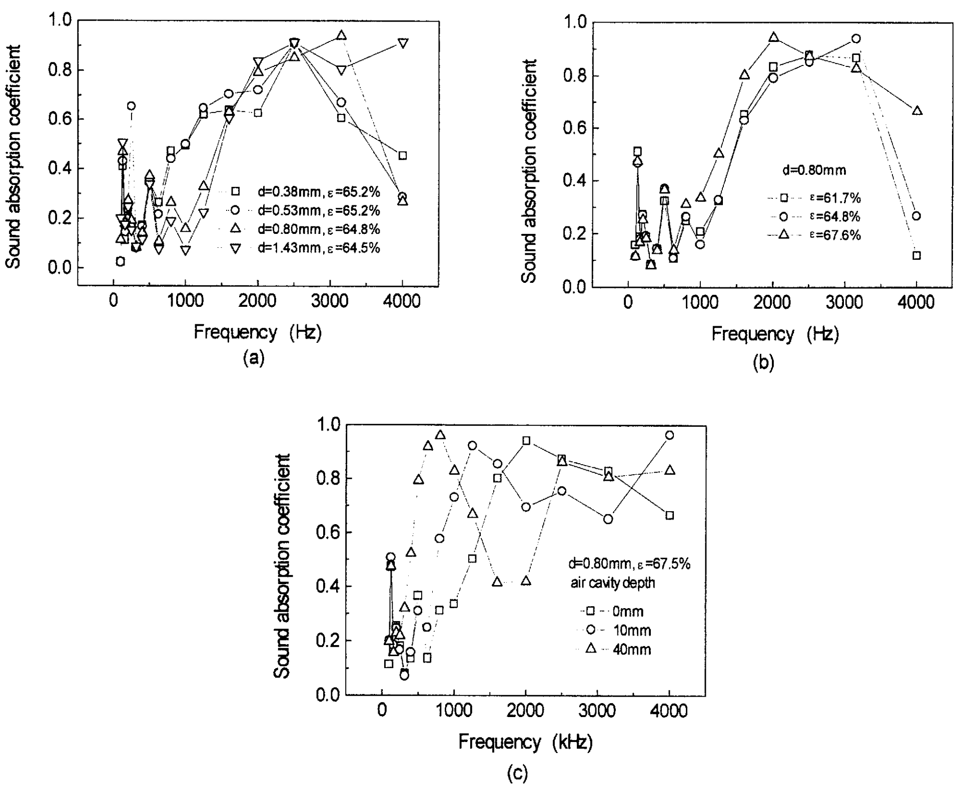

Fig. 5 Sound absorption coefficient of porous aluminium having (a) different average pore size; (b) different porosity; (c) different air cavity depth behind the sample

3 Acoustic properties

Porous samples having multi-angular pores were made (see Fig 4) and cut to the size of 93mm in diameter and 20mm in thickness, and their sound absorption coefficients backed by a rigid wall were measured in an impedance tube within the frequency range of 125～4000Hz. It was found that the sound absorption coefficients of the samples having similar porosity (ε =64.5～65.2%) and different average pore sizes (d=0.38, 0.53, 0.80 and 1.43mm) were smaller within lower frequency range, see Fig. 5(a). With the increase of frequency, their coefficients increased rapidly reaching a peak value of about 0.9, and then dropped again. On the whole, the samples with smaller pore sizes had better sound absorption properties at the lower end of the frequency range. It was also found that higher porosity gave better sound absorption properties, see Fig. 5(b).

When the samples were backed by an air layer, the peaks of their sound absorption were shifted to lower frequencies, thus their sound absorption properties within lower frequency range could be improved, see Fig.5(c).

4 Conclusion

Porous aluminium having 3-dimentional interconnecting pores was successfully manufactured by negative melt infiltration method. It was found via experiment that the degree of pore opening (DPO) decreases with the increase of infiltration pressure. The maximum sound absorption coefficients of the porous aluminium within the frequency range of 125~4000Hz was over 0.9, and their acoustic properties as a function of frequency were influenced by pore size, porosity and the air cavity depth behind the samples.

Acknowledgment

The authors are thankful to the National Natural Science Foundation of China and Hwa-Ying Culture and Education Foundation for the financial support for the present work.

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