

POROSITY CONTROL OF OPEN-CELL Al FOAMS PREPARED BY NEGATIVE PRESSURE INFILTRATION METHOD

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Abstract – In the present study, the possibility of infiltration process for the fabrication of open cell Al foams using a special kind of ceramic granules was examined. These granules provide burnable inner materials and insulating surface. After preheating, the granules became hollow and this eased their later removal from the solid composite. In this process, preheating temperature is the most important parameter. So the effect of preheating temperature was assessed to understand the formation of cellular structure. The relative density of open cell Al foams produced by the present method is in the range of 20~40%.

Keywords: open cell foams, infiltration, granule

1. INTRODUCTION

Metallic foams have found increasing applications in a wide range of structural and functional products, due to their exceptional mechanical, thermal, acoustic, electrical and chemical properties. Examples of their applications include lightweight panels, non-flammable ceiling, thermal and acoustic insulation, heat exchanger, filters and catalyst carriers.

Most of the open cell fabrication processes utilize open cell polymer foam as preform. The structures of these polymers can be changed by chemical vapor deposition or investment casting[1~2]. Metallic powder technologies, such as SDP(Sintering Dissolution Process)[3] and SRF(Slip Reaction Foam Sintering Process)[4], have also been introduced. These processes are, however, expensive and also the cell size cannot be controlled freely.

In this paper, a new open cell foams production method using a special kind of granules is introduced and the effect of preheating temperature on formation of cellular structure is examined as well. This process is believed to have a great potential for the production of commercial porous metals due to the lower cost and additional benefits, including the ease of controlling cell size.

2. EXPERIMENTAL PROCEDURE

The burnable primary particles were introduced into a chamber rotating at a constant velocity and angle. The insulating powder, and the Polyvinyl Alcohol(PVA) binder were sprayed at certain intervals. To obtain granules with various sizes, strength and surface, the rotating velocity and

angle of the chamber, binder and the spraying interval of powder and binder were rigorously controlled in the present study.

The granules were separated by sieving and packed into a steel mould with a size of 100×100×120mm³ by mechanical vibration. They were then preheated in an electric-furnace to obtain hollow granules. The molten Al was poured into the mould and was sucked to create the infiltration. The mould was cooled to room temperature. After solidification, the granules were harvested by pressurized water and cut into an appropriate size with a diamond saw. The images of samples were documented using an optical scope(Sometech.). The density of each specimen was calculated by weighing the specimen on a balance and measured its dimensions using a digital calliper.

3. EXPERIMENTAL RESULTS

Composition of the granules prepared by the present method is shown in Table. 1 and the picture of granules is shown in Fig.1.

Table 1. The composition of the granules

Composition	Primary particle	Powder	PVA	Moisture
Wt%	33.3	50	0.3	16.3

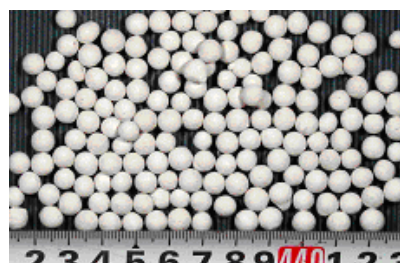


Fig.1. Photographs of granules

The representative picture of the Al foams produced by the present method is shown in Fig. 2.

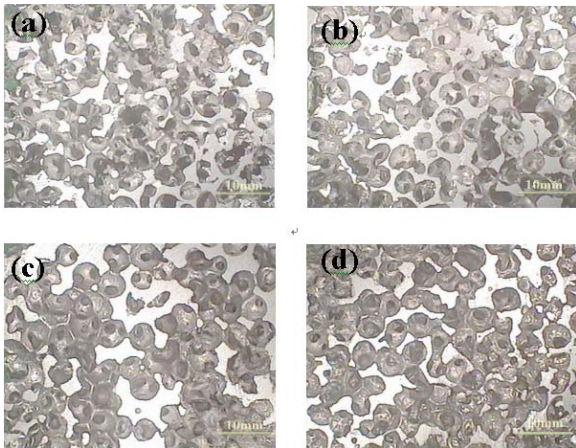


Fig.2. The representative picture of the Aluminum foams made at the preheating temperature of 300°C (b) 400 °C (c)500 °C (d) 600 °C.

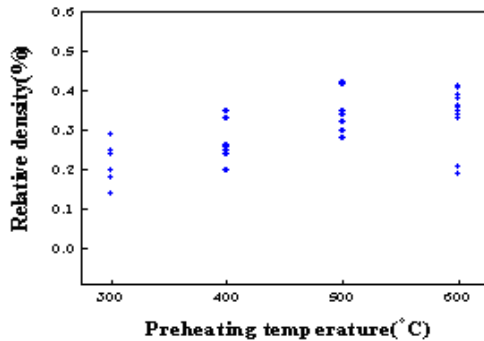


Fig. 3. The effect of preheating temperature on the relative density of Al foams

The present study suggests that preheating temperature has a strong influence on the formation of cellular structure. Fig. 3 shows the relationship between preheating temperature and relative density of Al foams. Relative density is slightly increasing with preheating temperature. The average relative densities of foams at the preheating temperature of 300°C, 400 °C, 500 °C and 600 °C are 0.21, 0.28, 0.33 and 0.33, respectively. It maybe caused by the different pore and cell edge formations at the different preheating temperatures.

With the increasing temperature, the pore tended to distribute in smaller size area. At the preheating temperature of 300 °C, the pore sizes distributed mainly in 2.5~3.0mm; at 400°C, pore distribution in the area of 2.5~3.0mm is slightly decreased and that in 2.0~2.5mm is increased. At the 500°C, it is obvious that the pores are distributed mainly in 2.0~2.5; and at 600 °C, they decreased and more pores are in the area of 1.5~2.0mm. Representative shapes of pores made at the different preheating temperatures are shown in Fig.6. With the increasing temperature, the pore size is decreasing.

At 300°C, the cell edge is thinner and it's thickness mainly distributed in the area of 1.5~2.0mm. With the increasing temperature, the peak frequency is moving to larger size area and at 600°C, the cell edge thickness turned to 2.0~2.5mm. Representative shape of cell neck made at the different preheating temperatures was shown in Fig.7. The

cell neck angle is smoother at the low temperature, and it becomes shaper with the increasing temperature. It can be concluded that solid area is wider and the infiltration is more complete at the higher temperature.

It can be assumed that these phenomena caused by the heat exchange between granules and molten Al. It can be related as follows:

$$V_p \rho_p C_p (T_m - T_p) = (1 - V_p) \rho_m F H \quad (1)$$

Where T_m : temperature of molten metal; T_p : preheating temperature of mould; C_p : specific heat of granules; H : solidification latent heat of metal; ρ_m : density of metal; ρ_p : density of granules; F : solid fraction during solidification and V_p : volume fraction of perform.

The heat loss of molten Al caused changes of viscosity and surface tension and as a result, it affected the formation of cell structures.

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