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A review on manufacturing and application of open-cell metal foam

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Abstract

The present paper introduces the manufacturing process and industrial applications of Alantum metal foams having a complete open-pore structure. Wide spectrum of foam products, based on several distinguished properties of metal foams is described. Examples of Alantum foam products, transited to the industrial applications are provided with the roles of foams during their performances.

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Keywords: Open-cell structure; Emission control; Energy storage system; Environmental catalyst

1. Introduction

Alantum is a global company located in Korea (HQ), China, Germany and the U.S., which produces 4M m^2 of pure foams (Ni, Fe, Cu, etc.) and 0.5M m^2 of alloy foams annually. Alantum has successfully developed its patented manufacturing process to enable the application-optimized, economical production of a variety of alloy foams in different material systems.

Alantum's high-quality metal foams (certified to TS 16949 and ISO 9002) possess completely open-pores (Figure 1) with tailored and uniform structural and material properties. The flow of fluid media (gas or liquid) through such a 3-D tortuous path is well-characterized in terms of pressure drop and mixing behavior as shown by Walther et al. (2010) and Oh et al. (2011). By adapting various cell sizes (450, 580, 800, 1200 and 3000 μm) and the alloy compositions (e.g. NiFeCrAl, NiCrAl, NiAl, NiCu, Inconel 625, FeCrAl, STS 316L), the Alantum metal foams meet clients' requirements such as corrosion resistance and high temperature stability.

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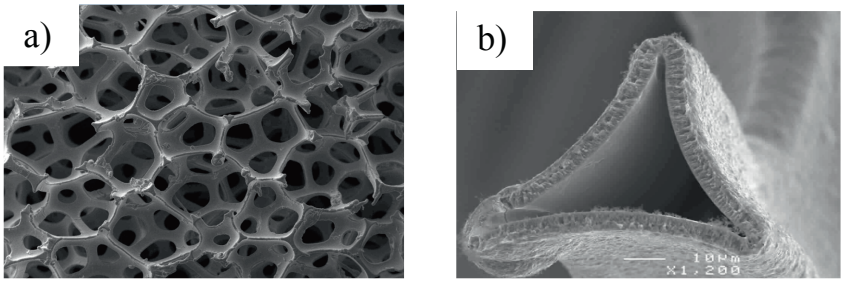

Fig. 1. SEM micrographs of a) open-pore structure of pure Ni foam and b) strut of Ni foam having unique hollow-structure inside.

Also, other properties including easy formability, light-weight and open-pore structure with design flexibility make the Alantum metal foams as a versatile material. These foams allow for an even temperature distribution in heated- or cooled-tools, optimum mixing of fluids or gases and effective filtering. Due to the above unique characteristics, the Alantum metal foams have been utilized in a wide range of applications such as catalyst supports, vehicle after-treatments, flame distributors, energy storage systems (ESS), etc.

2. Experimental

2.1. Manufacturing process of alloy foam

The manufacturing process of the Alantum alloy foams is schematically shown in Figure 2. The main features of the patented powder metallurgical process are the coating of the pure foam with an organic binder solution and afterwards with a high-alloyed powder using a spraying technique in a continuous process as demonstrated by Walther et al. (2010) and Oh et al. (2011). The amount of powder applied on the pure metal foam determines the powder-foam ratio (PFR), which is the percentage of powder with respect to the overall mass of the alloyed foam. Its optimum value depends on its respective applications and the pore size. The following heat-treatment includes de-bindering and sintering in a vacuum furnace, which allows the powder diffusion of transient liquid-phase ensures the homogeneity of the alloy composition throughout the alloy foam strut.

The SEM micrograph in Figure 3 reveals the bumpy surface of the Alantum alloy foam along the foam struts, resulting in much larger specific surface area. The combined characteristics of such high specific surface area and open-pore structure of the alloy foam manifest a variety of unique advantages such as outstanding mass transfer, high contact efficiency and good adhesion of catalytic coatings onto alloy foam in various industrial areas.

Also, for some specified applications demanding a thickness increase with mechanical strength, the foams can be stacked, compressed and sintered. This implies that the Alantum alloy foams can be effectively transformed into different shapes (Figure 4) which customers require due to their high flexibility and degree of freedom in designing products.

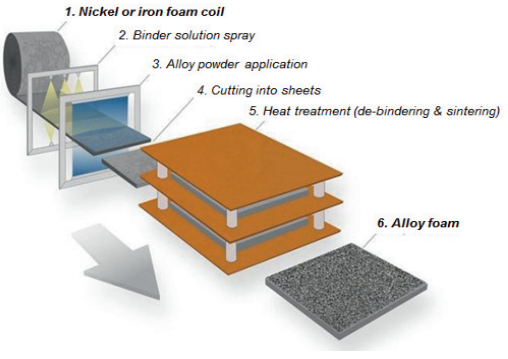

Fig. 2. Alantum's alloy foam production process

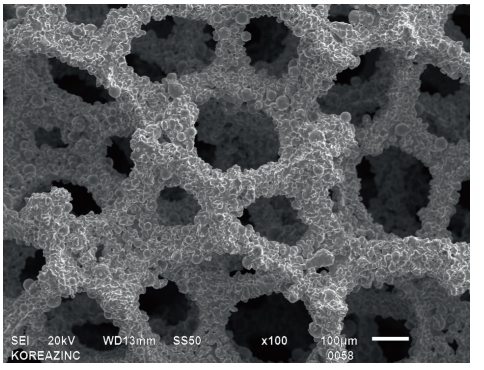

Fig. 3. SEM micrograph of Alantum alloy foam