Chapter 7
Production Techniques of Metallic Foams in Lightweight Materials

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ABSTRACT

Lightweight materials were needed in many different areas, especially in order to reduce the required energy in areas such as automotive and aerospace industries. Metallic foams attract attention in light-weight material applications due to their unique properties. The pores in its structure provide advantages in many applications, both structural and functional by promising both ultra-lightweight construction, energy absorption, and damping insulation. Production techniques of metallic foams can generally be classified as liquid, solid, gas, and ionic state production according to the physical state of the metal at the beginning of the process. The production technique should be chosen according to the usage area and desired properties of the metallic foam and the suitability in terms of cost and sustainability of production. For this reason, the details of the production techniques should be known and the products that can be obtained and their properties should be understood. In this respect, this chapter emphasizes the production methods from past to present.

INTRODUCTION

Metal foams are a class of engineering materials developed for light-weight material applications (Dukhan, 2013). Metallic foam consists of a rigid frame and air-containing internal and external pores, which gives the material different characteristics. Due to the porous structure, metallic foams provide significant

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advantages in terms of vibration resistance, energy, and thermal absorption as well as lightness. Metal foam structures have attracted attention due to their high stiffness-to-weight and strength-to-weight ratios. Metallic foams are becoming an interesting and important field of research in recent times. It can be used in many structural and functional applications in many fields such as aviation, railway, building, and biomedical industries and especially in the automotive industry (Yilong et al., 2016; Claar et al., 2000; Andure et al., 2012; Qin et al., 2016; Bisht et al., 2019). People encounter porous structures in many places in nature (wood, bone, corals, pumice, lava, etc.). The porous form observed in the structure of lightweight but strength materials in nature has attracted the attention of scientists and they have studied material production in these forms (Banhart, 2001; Bauer et al., 2013; Liu and Chen, 2014). Manmade porous materials that people encounter at many points in daily life can basically be polymeric, ceramic, and metallic. Porous plastics are found in many different applications such as foam cups, food packaging, and airbags. Polymer foams can't show rigidity under loading and are not resistant to high temperatures. Ceramic foam structures are often preferred in filtering applications. This material is limited in use because it is brittle under suddenly loading and is difficult to machining (Qin et al., 2016; Sivertsen, 2007; Yilong et al., 2016). For these reasons and owing to the unique characteristics of metallic ones have the potential for many applications. Since the pore structure can be controlled, the usage areas of metallic foams are varied (Garcia-Moreno, 2016). Basically, the pore structure of metallic foams is divided into two categories and usage areas are accordingly diversified. Pores are named according to whether they are connected or not: open (through) or closed (Qin et al., 2016). Foams with open porous structures are used in heat exchangers and absorbers, especially implants and filters, due to their thermal and permeability properties (Gülsoy and German, 2008). Closed porous metallic foams are preferred in structural applications due to their specific mechanical properties (Vendra et al., 2011). It is used in applications such as crash absorbers in vehicles and sound absorbers in machines with the increase in the thickness of the pore walls and the development of energy absorption properties compared to open pores structures (Vendra et al., 2011; Andure et al., 2012; Bauer et al., 2013; Yilong et al., 2016).

Metallic foam production technique should be selected by considering factors such as usage area, desired properties, cost and continuity. Therefore, all production techniques should be known in detail and the relationship between product-feature-structure should be understood. Studies on the production of metallic foams were first made by Sosnick in 1943. Benjamin Sosnick melted the mixture of aluminium and mercury in a high-pressure vessel. Then, due to the melting temperature of aluminium with the releasing of the pressure, mercury was evaporated and formed a foamy structure (Banhart and Weaire, 2002). Since then, many new methods have been discovered in metallic foam production. New techniques are explored for reasons such as cost of production, commercialization, being able to apply to different metals, and better quality of products. This chapter of the book, it is aimed to create an up-to-date source by dealing with production methods from past to present and focusing on developments.

Production Techniques

As a new type of material, metallic foams have attracted the attention of scientists. "Foam" is defined in the literature as the structures obtained by the distribution of the gas phase in a liquid or solid phase (Banhart, 2001). Metallic foam means in the solid phase, liquid metallic foam can only be during the production stage. In the literature, porous structures have been given different names according to different pore morphologies such as cellular, porous, sponge and foam (Banhart, 2016). In this chapter,

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