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ALUMINUM FOAMS WITH CLOSED PORES OBTAINED BY CASTING TECHNIQUES

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ABSTRACT

Techniques for the preparation of metallic foams, including casting, powder metallurgy and metallic deposition, have been reviewed. There is a present interest in the development of materials capable of plastic deforming to absorb the effects of shock and impact. Solid foams form an important class of lightweight, cellular engineering materials to meet these threats. The foam materials themselves may be divided into two classes according to their morphology. The first group is open cell structured foams containing pores that are connected to each other and form an interconnected network. The second class does not have interconnected pores and is termed as closed cell foams. The paper presents some experimental data for obtaining aluminum foams with hollow pores by casting techniques. The specific equipment used for experiments is also described.

KEYWORDS: aluminum, foam, pore, casting technique, equipment, cell

1. Introduction

Porous materials are known to have a high stiffness combined with a very low specific weight. The fact that even metals and metallic alloys can be produced as cellular solids or metal foams is not as well known as the possibility to foam more traditional engineering materials such as polymers, ceramics or glass.

Metallic foams offer interesting perspectives due to the combination of properties which are related to the metallic character on the one hand and to the porous structure on the other hand.

In the past 40 years many attempts have been undertaken to foam metals or to produce porous metallic structures.

There is no clear-cut and generally accepted definition for the term “foam“. First of all, one has to distinguish between liquid and solid foams. A liquid foam is a fine dispersion of gas bubbles in a liquid. Cooling down a liquid foam beneath the melting point of the respective material yields a frozen liquid foam which is then clearly a solid foam. What is generally meant in the context of metallic foams are in general solid metallic foams.

One could restrict the usage of the word “solid foam“ to materials which originally were in the liquid state. However, customarily other porous structures such as sintered metal powders are often also called “foams“ although they were never in a liquid state. So one often extends the usage of the word “foam“ to porous metal structures which are no actually foams, but resemble foams regarding their high porosity, the inter-connectivity of the solid material and their irregular structure.

2. Foams made from metallic melts

A first group of foam making processes starts from the molten metal that is processed to a porous material by either foaming it directly, by using an indirect method via a polymer foam or by casting the liquid metal around solid filler materials which reserve space for the pores or which remain in the foam.

Metallic melts can be foamed directly under certain circumstances by injecting gases into the liquid. Normally, the gas bubbles which are then formed in the metallic melt will tend to rise to its surface quickly due to the high buoyancy forces in the high-density liquid but this rise can be impeded by increasing the viscosity of the molten metal. This can be done by adding fine ceramic powders or alloying elements which form particles in the melt.

It should be noted that numerous attempts to foam liquid metals have been undertaken in the 60s and 70s [1], but apparently the processes then invented could not be sufficiently optimised to yield foams of a satisfactory quality and cost. In the past ten years, however, a number of new developments have taken place so that nowadays better production routes are available.

The second way for foaming melts directly is to add a foaming agent to the melt instead of blowing gas into it [1, 2]. The foaming agent decomposes under the influence of heat and releases gas which then propels the foaming process. Calcium is used to stabilise the melt (probably forming an Al_4Ca intermetallic) and titanium hydride TiH_2 serves as the foaming agent releasing hydrogen gas when it is heated. Typical densities are 0.25 to 0.33 g/cm^3.

The projections of the future fuel crisis, the requirements of achieving high fuel efficiency along with higher passenger safety in the automobile industry, and the needs of creating light weight construction materials have attracted tremendous consideration for ultra light weight metallic foams.

In general, metallic foams possess a range of thermo-mechanical properties that suggest their application in areas demanding impact/blast amelioration, heat dissipation, acoustic isolation and heat exchange [3, 4].

The projected applications of metallic foams have already been recognised and a detailed description of the requirements of various industrial sectors can be seen elsewhere [1, 3, 4].

Recently, National Physical Laboratory (UK) made a survey both in industries and in research institutions to have an idea of potential expectations from metallic foams.

The survey indicated that the major applications of metallic foams, around 32%, in the near future would be directed towards automotive and aerospace industries (Fig. 1).

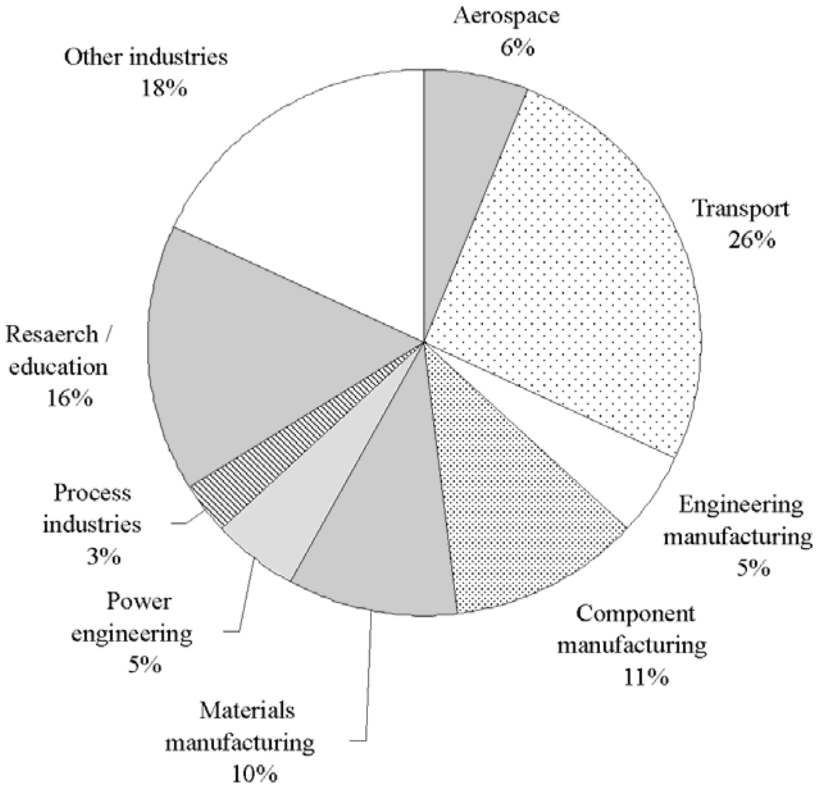


Fig. 1. *The implementation of metallic foams*

3. Experimental results

Metal alloys can be foamed by mixing into them a foaming agent that releases gas when heated. The widely used foaming agent titanium hydride (TiH_2) begins to decompose into Ti and gaseous H_2 when heated above about 465°C. By adding titanium hydride particles to aluminum melt, large volumes of hydrogen gas are rapidly produced, creating bubbles that can lead to closed-cell foam, provided foam drainage is sufficiently slow, which requires a high melt viscosity [5, 6]. The process begins by melting aluminum and stabilizing the melt temperature between 670 and 690°C. Its viscosity is then raised by adding 1–2% of calcium which rapidly oxidizes and forms fine dispersed CaO and $CaAl_2O_4$ particles. The melt is then aggressively stirred and 1–2% of TiH_2 is added in the form of 5–20μm diameter particles. As soon as these are dispersed in the melt, the stirring system is withdrawn, and a foam is allowed to form above the melt. Control of the process is achieved by adjusting the over pressure, temperature and time. It takes, typically, about ten minutes to totally decompose the titanium hydride. When foaming is complete the melt is cooled to solidify the foam before the hydrogen escapes and the bubbles coalesce or collapse. The volume fraction of calcium and titanium hydride added to the melt ultimately determines the relative density and, in combination with cooling conditions, the cell size. The cell size can be varied from 0.5 to 5mm by changing the TiH_2 content, and the foaming and cooling conditions. In figures 2 and 3 are given some results of the foam obtained from aluminum alloy ATSi5Cu1 in the Casting Laboratory from Materials Science & Engineering Faculty - Transilvania University of Brasov.

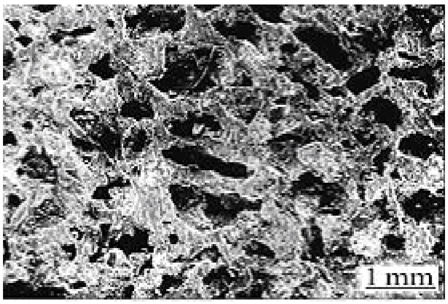


Fig. 2. *Micrography of ATSi5Cu1 – aluminium alloy with 1.5mm average size of pores*

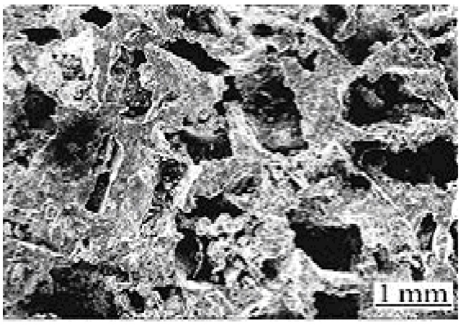
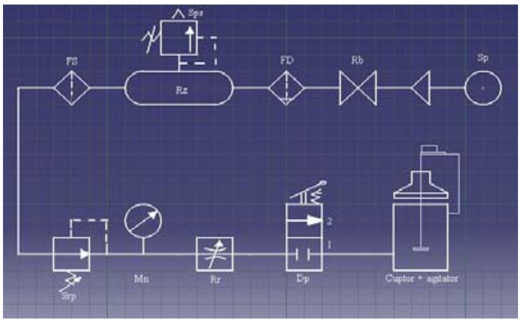


Fig. 3. *Micrography of ATSi5Cu1 – aluminium alloy with 2mm average size of pores*

a).



b).

Fig. 4. *Experimental equipment: a). view, b). scheme*

All the experimental results are made in a specially equipment designed by authors – seen in Figure 4.

3. Concluding remarks

Recent technological advances in the field of metallic foams have led to the development of a wide range of processing techniques for the open, as well as closed cell morphologies.

The processing route has to be decided on the basis of the cost of production, materials properties, and the intended applications of the final product. However, as the cost of production of a good quality metallic foam is still high, continual innovations are underway so as to draw maximum benefit by opening new avenues for a wide range of industrial applications.

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