CASTING METHODS OF PRODUCTION OF METALLIC FOAM WITH IRREGULAR INNER STRUCTURE

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Abstract

Metallic foams are materials with the broad applicability in many different areas of human activity (e.g. automotive industry, building industry, medicine, design, etc.). These metallic materials contain artificially created pores in their structure. These pores give them specific properties such as large rigidity at low density, high thermal conductivity, capability to absorb energy, etc.

The paper deals with an optimization of procedure for production of cast metallic foams with use of casting technology (infiltration method), which ensures rapid and economically feasible method for production of shaped components. In the experimental part conditions of casting of metallic foams with irregular inner structure and open pores made of ferrous and non-ferrous alloys by use of various types of filler material (precursors) were studied.

Keywords: Metallic foam, casting, precursor, infiltration method

1. INTRODUCTION

Metallic foams and porous metals are materials which contains in their structure artificially created pores. These pores give them specific properties such as: large rigidity maintaining low density, high temperature conductivity, capability to absorb energy etc.

The first mentions of metal foams come already from the beginning of the 20th century when these porous metal materials started to be used for engineering purposes. In the twenties of the last century there began to be produced and commercially used the foams produced by sintering of metal powders that were used for manufacture of filters, batteries and self-lubricating bearings. In the French patent from the year 1925 we can find the mention of metal foams made by material foaming, thirty years later in the United States their commercial use begun. But the extensive research and development activities started in the nineties and it continues up to now [1].

At VSB - Technical University of Ostrava (Department of Metallurgy and Foundry Engineering) the research dealing with optimization of manufacture of this unique material by a foundry way is currently underway.

2. PROPERTIES AND APPLICATION OF METALLIC FOAMS

The properties of metallic foams greatly depend on the characteristics of the pores distributed throughout them. These characteristics, which include the type, shape, size, number, uniformity and surface area of the pores, may be quite different in metallic foams produced by different processes [2].

This material offers the particularly the following most important properties:

- **Reduction of mass**: porous metals are very light and it is possible to achieve very high strength by application of ribbing.
- **Absorption (damping) of energy**: it uses ability of this type of material to get deformed under pressure and absorb in comparatively small volume big amounts of energy. This property can be used in transport industry for deformation zones of vehicles.

- **Absorption (damping) of sound and vibrations**: replacement of organic foam material in environment with extreme thermal and mechanical loads.
- **Thermal insulation**: metallic porous materials preserve high mechanical properties even at high-temperatures.
- **Exchange of heat or electricity**: metallic porous materials with open structure have large specific surface, which gives them better abilities of heat exchange [3].

3. MANUFACTURING OF METALLIC FOAMS

Since the discovery of porous metallic materials numerous methods of production have been developed. Some technologies are similar to those for polymer foaming, others are developed with regard to the characteristic properties of metallic materials, such as their ability to sintering or the fact that they can be deposited electrolytically [4].

According to the state, in which the metal is processed, the manufacturing processes can be divided into four groups (see **Fig. 1**). Cellular metals can be made from metal vapour, liquid metal, powdered metal or metal ions [5, 6].

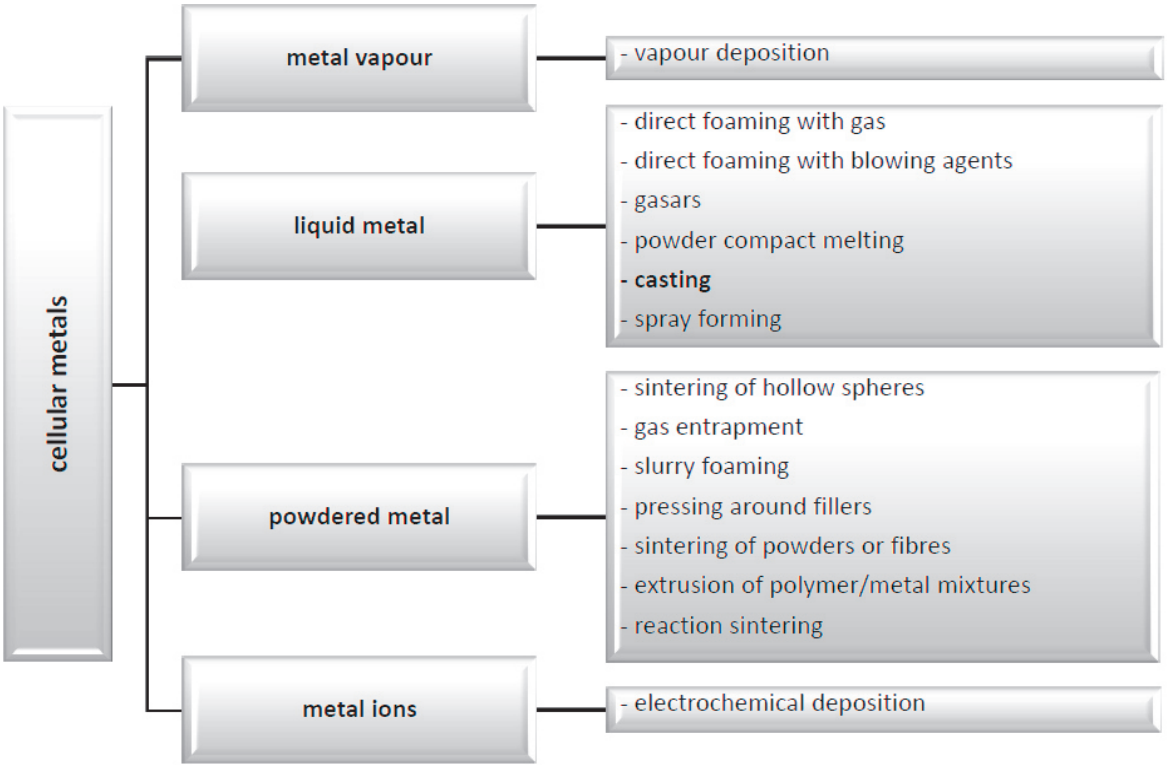

Fig. 1 Metallic foam production

4. EXPERIMENTAL

The experimental part deals with an optimization of procedure for production of cast metallic foams with use of casting technology (infiltration method), which ensures rapid and economically feasible method for production of shaped components.

4.1. Infiltration of molten metal into mould filled with precursors

The principle of this technology is pouring of liquid metal into the mould filled with inorganic or organic particles (precursors). The irregular structure of pores, we are dealing with, can be achieved by use of various types of precursors, which fill the mould cavity.

Precursors must be made of material, which preserves its shape at impact of the molten metal (sufficient strength, low abrasion, refractoriness) and they must allow also good disintegration after casting.

In the experiment we made castings with irregular cell structure with use of particles based on conventional moulding mixtures (organic types).

The possibility to control of the cellular structure produced (pore size, porosity, etc.), is the very important advantage of the use of a foundry technique to manufacture metallic foams, however the precursors are made.

4.2. Precursors (Croning process)

Core particles (precursors) were then manufactured from moulding mixture (respectively from reject cores made by Croning process). Final globular shape of core precursors was achieved by splitting into small pieces (10 - 30 mm) and followed by tumbling. The precursors so produced were inserted in a mould cavity. Mould was made from commonly used green sand (ie. bentonite bonded moulding mixture) - see **Fig. 2 - 4**.

Porosity of produced castings amounted to 60%. Precursors allow good disintegration after casting. The disadvantage of these precursors is their irregular shape, which is determined by uneven tumbling of the cullet due to non-uniform hardening of the default core mixture. Therefore, new technology of precursors manufacturing has been proposed - use of moulding mixture bonded by furan resin. This way of manufacturing of precursors should ensure the achievement of the same size, shape and the resulting characteristics of precursors.

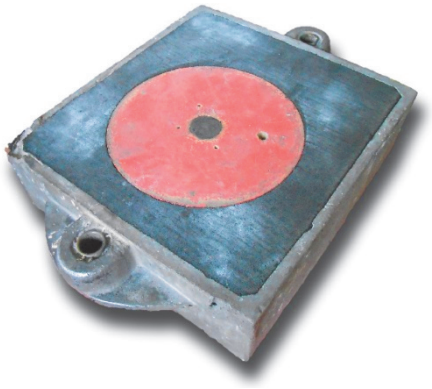

Fig. 2 Mould made from commonly used green sand

Fig. 3 Mould filled with precursors

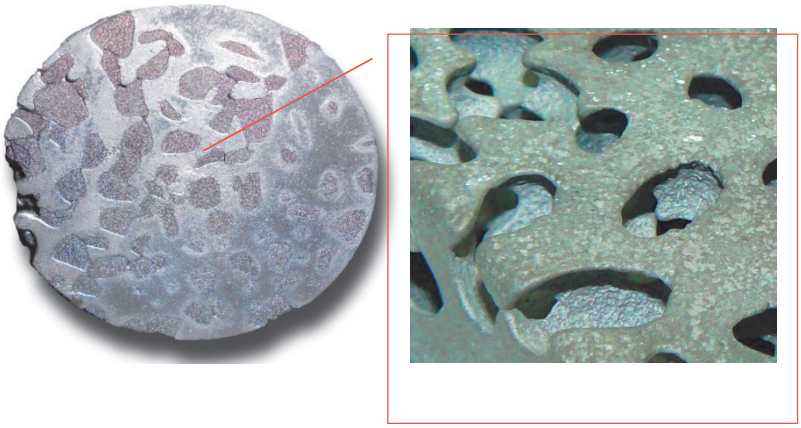

Fig. 4 Final casting and detail of its structure

4.3. Precursors (Furan moulding mixture)

To create these precursors were used as core box plastic grille (**Fig. 5**). By using this core box cubes of a side of 25 mm were created. These cubes were followed by tumbling. The proposed technology ensures the production of precursors of the same size, shape and properties.

Materials used fore casting were cast iron with lamellar graphite (EN GJL-200), AlSi10MgMn and CuSn10.There were two types of castings - a cuboid (A) and a cylinder (B) - see **Figs. 6, 7**.

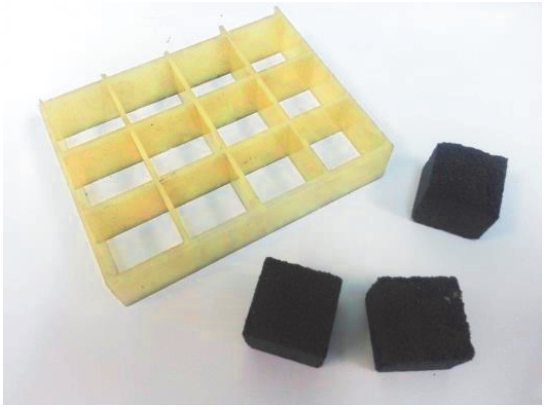

Fig. 5 Core box and created cubes

Fig. 6 Casting (cast iron with lamellar graphite) - type A

Fig. 7 Casting (cast iron with lamellar graphite) - type B

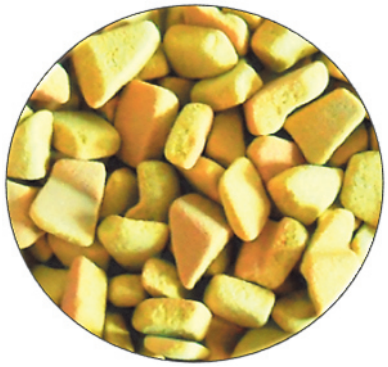

Fig. 8 Precursors - Croning process (irregular shape and size)

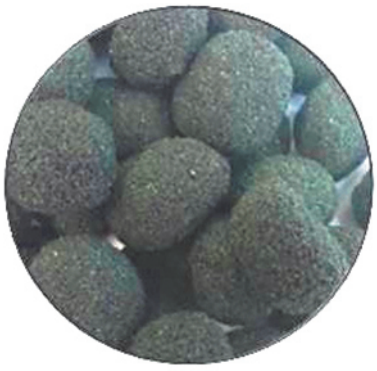

Fig. 9 Precursors - Furan moulding mixture (regular shape and size)

Porosity of produced castings amounted to 63 %. Precursors allow good disintegration after casting.

On the **Figs. 8** and **9** we can see a comparison of the two types of precursors.

5. CONCLUSION

Metal foams are progressive materials with continuously expanding use. Mastering of production of metallic foams with defined structure and properties using gravity casting into sand or metallic foundry moulds will contribute to an expansion of the assortment produced in foundries by completely new type of material, which has unique service properties thanks to its structure, and which fulfils the current demanding ecological requirements. Manufacture of foams with the aid of gravity casting in conventional foundry moulds is a cost advantage process which can be industrially used in foundries without high investment demands.

The principle of the above-mentioned technology is the infiltration of liquid metal into the mould cavity filled with precursors. This technology enables the production of shaped castings - metallic foams with irregular cell structure. In the production of precursors can be moreover assumed using of the material, which would be in other cases waste - reject cores or excess moulding mixture.

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