

# PRODUCTION OF CAST POROUS METAL

## IZDELAVA POROZNIH KOVINSKIH ULITKOV

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The article deals with the foundry methods of manufacturing porous metal; it is focused on the materials with a regular arrangement of internal cells. Currently, there are many fields dealing with the problem of porous metals by either optimizing the already known technologies, developing new ones or using porous metals. The production of a porous metal with a regular structure of cells and the possibility of its functional usage are the main subjects of this article. Due to their shapes, sizes and distribution of internal pores, cast porous metals exhibit various properties including reduced weight, sufficient strength, an ability to absorb impact energy, a possibility to conduct heat, etc., that allow a wide range of applications in the areas such as construction, transport or power engineering.

Keywords: porous metal, energy absorption, lost foam, deformation work

Članek opisuje livarske metode izdelave poroznih kovin. Osredotoča se na materiale s pravilno urejenostjo notranjih celic. Trenutno se na mnogih področjih ukvarjajo s problemi poroznih kovin, bodisi z optimizacijo že znanih tehnologij, razvojem novih, ali njihovo uporabo. Glavni predmet članka je izdelava poroznih kovin s pravilno strukturo celic in možnostjo njihove uporabe. Porozni ulitki imajo zaradi svoje značilne oblike, velikosti in porazdelitve por različne specifične lastnosti, vključno z manjšo maso, zadovoljivo trdnostjo, sposobnostjo absorpcije udarne energije, prevajanja toplote itd. Vse to omogoča njihovo uporabo na različnih področjih, kot so konstrukcije, transport, inženiring prenosa energije in moči.

Ključne besede: porozne kovine, absorpcijska energija, ulivanje z izparljivimi modeli, deformacija

## 1 INTRODUCTION

The term of porous metal refers to a light, porous material with a cellular structure but with good mechanical properties. The porosity of these materials, i.e., the ratio of the vacant space to the total volume, ranges from 75 % to 95 %. Cavities can be connected with open pores; in this case, the material is a porous metal with open cells. Cavities can also be mutually separated and then the material is a porous metal with closed cells.<sup>1,2</sup>

### 1.1 Use of porous metals

Metal foams find many applications in many industrial sectors (transport, aviation, defence, marine industry, power engineering and architecture). Foams are used as multifunctional materials for high-performance applications for civil, mechanical, chemical and biomedical engineering.<sup>3</sup> Due to their low weight, high strength and the ability to absorb energy, porous-metal materials are suitable for the use, for example, in the deformation zones of conveying devices.<sup>4,5</sup>

### 1.2 Method of production

A variety of methods and techniques for the production of porous-metal materials can be found in

practice. The production involving conventional casting processes used in foundries ensures an economic manufacture without the need to acquire expensive equipment. For the production of porous materials, the method of pouring a solid filler material with a liquid metal can be used as an example. After removing the filler material, the pores become structured. The size and shape of these castings are defined on the basis of the properties, at given process repeatability and in compliance with the process and production conditions.<sup>6</sup> The defined properties of these modern materials are crucial for the other applications.<sup>7</sup>

## 2 EXPERIMENTAL PART

The experiment was focused on the production of metal foams with a regular structure and the testing of their mechanical properties. For the production of samples, the lost-foam method, i.e., the investment casting process was used. This is a widely used method for the manufacture of precision castings. For the manufacture of the pattern, expanded polystyrene (EPS) was used as a material suitable for the lost-foam method and also as a material fairly flexible for the manual manufacture of the pattern. The dimensions of the grids were (52 × 52 × 6) mm and the overall dimensions of the pattern were (52 × 52 × 42) mm. The pattern consisted of

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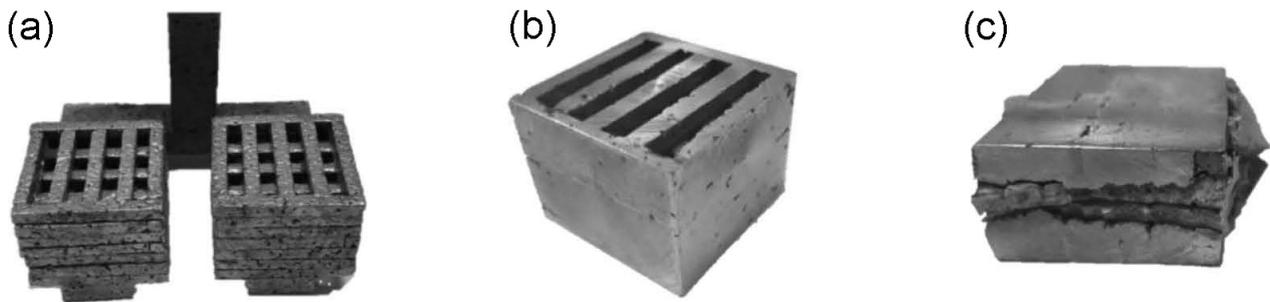


Figure 1: a) casting, b) machined sample, c) compressed sample

seven floors/grids that were glued together and equipped with a grating system.

The pattern together with the grating system was dipped in a fireproof coating of the FOUNDRYLAC ZBM/365 type. The cast material was aluminium alloy AISi11, which is suitable for the production of thin-walled and shape-complicated castings. The alloy was molten in an electric resistance furnace (LAC 80/13). For a better alloy fluidity, higher casting temperatures were chosen, e.g., 750 °C. The molten metal was poured directly on the pattern, which was placed in a flask and filled with dry quartz-based sand without a binder and compacted with vibration. The casting of the porous metal with the grating system is shown in **Figure 1a**.

### 3 RESULTS

All the samples with the dimensions of (52 × 52 × 42) mm were subjected to a pressure test. A total of 20 porous-metal samples with a regular structure were tested. The tests were carried out at company VÍTKOVICE TESTING CENTER s.r.o. (Ltd.), a member of the VÍTKOVICE MACHINERY GROUP. Pressure tests were carried out on a Zwick Z600 machine with an advancing speed of 10 mm/min. A sample before and after the pressure test is shown in **Figures 1b** and **1c**.

The castings manufactured with the lost-foam method were tested to investigate the material performance at constant loading and different deformation curves were determined. Several dozens of samples were measured. Selected values obtained with the pressure tests are given in **Table 1**. Using the calculations of

triangles and cuboids for the potential, deformation curves (the area under a curve) and the values of the strain energy, i.e., deformation work (J) were calculated.

### 4 DISCUSSION

It is clear from the results of the pressure tests that Sample no. 8 reached the highest compression strength (354 kN) and, at the same time, it exhibited the highest deformation (31.7 mm). The highest values of deformation were found for sample no. 13 (3872 J); its compression strength was slightly above the average of all the samples. The average of the maximum compression-strength values for the tested samples was 272.50 kN. Deformation curves for different samples showed a similar trend and for this reason, only the

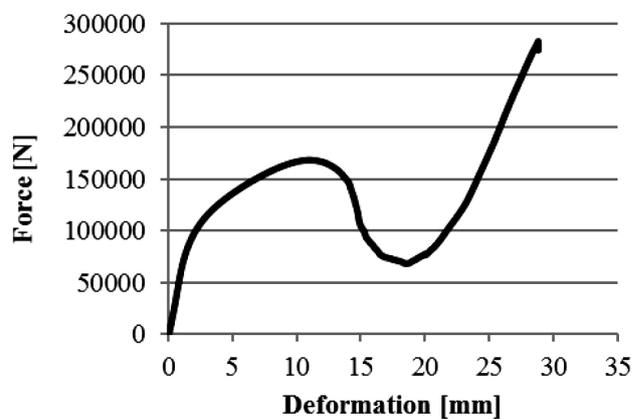


Figure 2: Force vs. stress curve

Table 1: Results of the pressure tests of individual samples

Sample number	Casting temperature (°C)	Real dimensions after machining (mm)	Max. compression strength (kN)	Max. deformation (mm)	Deformation work (J)
1	793	49.7 × 49.3 × 38.3	254	29.1	2962
5	792	49.3 × 49.6 × 38.3	276	28.9	3027
7	807	49.8 × 49.0 × 38.0	277	30.6	2831
8	807	49.7 × 48.8 × 38.4	354	31.7	3340
9	795	48.8 × 48.0 × 38.4	268	29.1	3010
13	807	48.0 × 48.8 × 38.4	283	28.8	3872
16	807	49.4 × 48.3 × 38.6	325	29.9	3486
19	808	48.5 × 49.5 × 38.2	270	27.7	3205

graph for sample no. 13 is shown as a representative example, **Figure 2**.

## 5 CONCLUSIONS

The dimensions of (52 × 52 × 42) mm were chosen for the polystyrene pattern. These samples were pressure tested. The average value of the maximum compression strength was 272.50 kN. Individual values of the strain energy were calculated for the total areas under individual deformation curves. The average value of the strain energy was 3150 J. Due to the obtained values of the strain energy, this porous metal can be recommended for further development with respect to applications in transportation deformation zones. The potential of this modern material to absorb a large amount of impact energy is obvious from the obtained results, but it is still difficult to find the right shape for a specific application.

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