Processing of Porous AC-AlSi11 Silumin Matrix Composites by Casting

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Abstract: The paper presents the application of the casting method to produce porous composites, called syntactic foams, of the casting alloy-solid particles type. Using this method, composites were produced based on Al alloys reinforced with clinoptilolite particles, a natural mineral from the zeolite group. Before the casting process, tests were carried out on the morphology, physicochemical properties and chemical composition of zeolite, which was obtained from a rock called zeolite tuff, mined in a quarry in Kucin (VSK PRO-ZEO s.r.o., Slovakia). Observations of the microstructure of the produced composites were also carried out using a scanning electron microscope, diffractometric studies of the zeolite rock as delivered for testing and the produced samples reinforced with zeolite particles. The suitability of the presented composite production method was assessed on the basis of structural tests, with particular emphasis on the distribution of particles in the alloy matrix.

Keywords: composite materials, syntactic foam, zeolite, aluminum alloy, foaming granules, matrix, microstructure, mechanical properties, porosity

1 Introduction

Porous metal materials are materials with a high degree of structural discontinuity. Their structure can be described as a geometrically disordered arrangement of pores in the metal matrix. They are mainly made of light metals or their alloys. One of the technologies for their production is adding a blowing agent directly to the molten metal in a liquid-solid state. Titanium hydride is used as a gas-forming agent, which decomposes into titanium and hydrogen gas [1].

An interesting method of generating the cellular structure are foams reinforced with particles by mixing liquid systems of aluminum alloy - ceramics. The presented work proposes an innovative method of producing metal foam using the method in which aluminum alloy was used as a matrix, and as foaming granules - clinoptilite, a natural mineral from the zeolite group [2]. Klinoptilites are microporous crystalline aluminosilicates, used as industrial adsorbents and catalysts containing a large amount of silicon, calcium, sodium, potassium and admixtures of various metals, such as: barium, strontium, potassium, magnesium, and manganese [3].

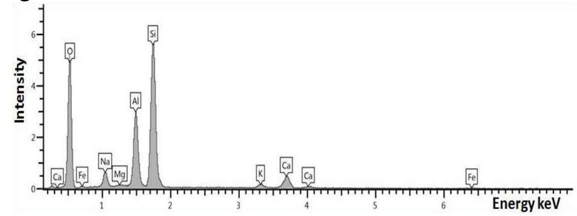
Aluminum alloy composites reinforced with zeolite particles give a material with good properties, lower density, higher strength, and a lower coefficient of thermal expansion compared to the solid material obtained by casting.

2 Experimental procedure

The innovative technology of casting metal foam with an aluminum alloy matrix, developed in the presented work, using clinoptilolite as foaming granules, can provide the ability to suppress sounds and vibrations [5].

The process of manufacturing a porous structure in the conducted experiment consisted in adding to the cast aluminum alloy AC-AlSi11 at a temperature of 790°C, zeolite granules with a grain size of 4-6 mm in the amount of 20% by weight. The foaming agent in the form of zeolite granules was mixed with the liquid metal while pouring the mold - die. After solidification and cooling down to room temperature, the ready foamed element with a porosity of about 55% was removed from the mold. Upon contact with metal at elevated temperatures, water vapor is released from the hydrated aluminosilicates, leading to the formation of pores in the liquid or solidifying metal. The zeolite grains that have not decomposed due to the intense evolution of water vapor are the syntactic part of the material. The melting process was carried out in a laboratory muffle furnace at 760°C for zeolite granulate and aluminum alloy. All processes were carried out without a protective atmosphere. Cylindrical samples with a diameter of φ29 were produced for further research.

Before the casting process, the physicochemical properties and chemical composition of the zeolite were tested using the JSM-7100f scanning electron microscope. The content of the elements was determined by x-ray microanalysis in the EDS analyzer by Oxford Instruments. The spectrum of x-rays taken from the surface of the zeolite particles and the content of individual elements are shown in figure 1.



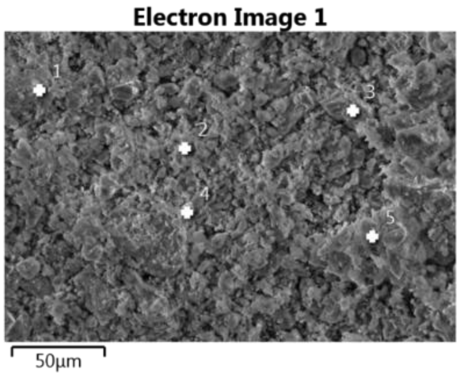


Fig.1. The energy spectrum for emitted X-rays for zeolite particles

Studies of the chemical composition of zeolite as delivered have shown that the main elements present in zeolite are aluminum, silicon, potassium, calcium and iron. This study confirmed that the tested rock is an aluminosilicate mineral.

Fig. 2. Photo of the manufactured composite

3 Conclusion

Optimal parameters of the sintered production technology were selected on the basis of previously conducted own research and it is satisfactory to repeatedly produce a porous structure in the experiment. As a result of the experiment, a casting with a density lower than that of a casting made in a solid mold was obtained. The highest porosity obtained for the composite was 58%. The results of the total porosity test for the produced foams made of aluminum alloy with zeolite allow for the conclusion that the introduction of zeolite particles increases the porosity of composites. The macrostructure of composites based on an aluminum alloy with the participation of zeolite particles are presented in figures 2.

As a result of the observations, no discontinuities were found at the interface between the matrix and zeolite particles. A very good combination of zeolite particles with an aluminum matrix was obtained, without the occurrence of voids, only the pores present in the composite are visible in the photomicrographs. The zeolite particles are clearly visible in the fractures in the form of irregular precipitations.

On the basis of the conducted research, it was assessed that the optimal parameters of the technology for the production of the porous structure on the matrix of the AC-AlSi11 aluminum alloy with the participation of zeolite particles were correctly selected and it is satisfactory to repeatedly obtain the above-mentioned porous structure in accordance with the proposed technology. Acoustic tests planned at a later date will confirm whether the produced porous composite can be used for elements intended to dampen sounds and vibrations.

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