Structure and Properties of EN AC – AlSi12 Alloy Reinforced by Ceramic Fibre and Particles

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Abstract

The paper presents the possibilities of obtaining new composite materials based on sintered porous ceramics with particles and fibre of Al_2O_3 infiltrated by aluminum alloy. The EN AC - AlSi12 alloy features the matrix material, whereas the RF50AX-301 preform, of Saffil Automotive, was used as the reinforcement. Examinations of ceramics preforms permeability were made. Metallographic examination of composite materials made on light microscope and in scanning electron microscope show that aluminum alloys fill micropores in the matrix. New composite materials show twice higher value of hardness in comparison with matrix. Results indicate that it is possible to infiltrate porous ceramic with liquid aluminum alloy to obtain new composite materials were advantageous properties of each component are connected.

Keywords : Composites, ceramic preforms, infiltration, permeability

1. Introduction

Composite materials reinforced by fibres and particles, based on metal alloy matrices, are characterised by very good mechanical and application properties over a wide range of service temperatures. They are presently applied widely in aircraft production technologies, defence technology and there is observed growing interest in the car industry even in the bicycle industry [1].

Two main development directions of manufacturing technology of the metal composite materials are observed, powder metallurgy [2, 3] and casting methods, with specific modification of the pressure infiltration of the porous, ceramic preforms with liquid metals alloys. That method is used more and more often in manufacturing of the composite materials with metal matrix and has also become the subject of many research projects [4-7]. The usage of infiltration process as the high-profitable technology is a base of getting the wide range of composite materials and allows to obtain the many technological-organizational profits.

2. Experimental procedure

Material for experiments was made using the pressure infiltration of the ceramic preforms with the liquid aluminium alloy. The EN AC - AlSi12 alloy features the matrix material, whereas the RF50AX-301 Al_2O_3 preform, of Saffil Automotive, with the ceramic phase 20% volume fraction was used as the reinforcement. The reinforcement material consists of 75% fibres and 25% particles.

The permeability measurements of porous performs where made on especially designed device for pumping over the liquid through the porous materials. During the test, the flow time of 350ml water was measured, adequately under the pressure of 0.5; 1; 1.5 and 2 bars at room temperature.

Metallographic examinations of the composite materials with the EN AC - AlSi12 aluminium alloy matrix reinforced with the Al_2O_3 fibres and particles were made on the Zeiss Axiophot light microscope to investigate their structure and infiltration extent.

Fractographic examinations of composite materials were made on the OPTON DSM 940 scanning electron microscope.

Phase composition of the investigated material was determined using the DRON 2 diffractometer with the step data logging, employing the filtered Kα-X-ray radiation of the $\lambda = 1{,}79021$ nm wavelength obtained from a cobalt lamp powered with the 40 kV voltage at the 8 mA heater current. The measurements were made in the angle range 2θ from 40 to 105º.

Hardness tests of the fabricated composite materials and of the matrix material were made on Zwick / ZHR hardness tester at 98 N load for 30 sec.

3. Experimental results

A permeability meusurements of used ceramic preforms show high value of $1{,}66 \cdot 10^{-12}$ m^2. That means infiltration by liquid aluminum alloy is possible caused by the presence of open porosity.

Results of metallographic examinations of the porous ceramics based composite materials obtained with the EN

AC – AlSi12 alloy infiltration, carried out on the light microscope are presented in Fig. 1. Observations revealed the homogeneous distribution of particles and fibres of the reinforcing material in the metal matrix.

Examinations of fractures mande on (SEM) of the composite material obtained by infiltration of the porous ceramics reveal that the liquid aluminium alloy fills the micro-pores entirely around the Al_2O_3 particles and fibres, whereas the voids visible around the ceramic phase are the effect of the differences of the coefficients of expansion between aluminium and the aluminium oxide. The observed images are shown in Fig. 2

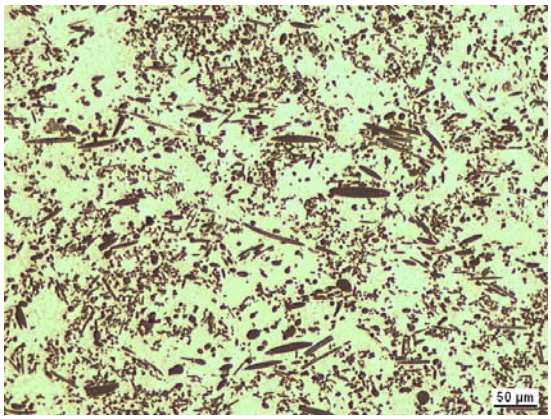

Fig. 1. Structure of the composite material with the aluminium alloy matrix reinforced with the Al_2O_3 ceramic particles and fibre (LM)

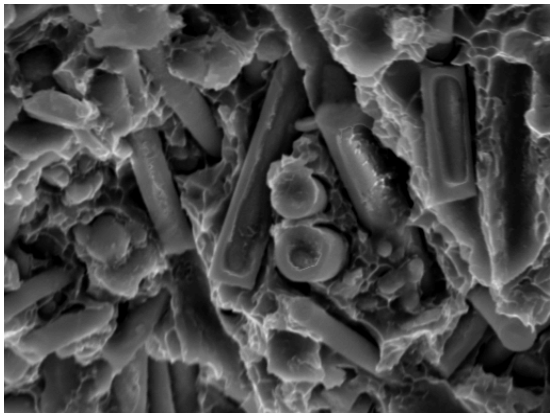

Fig. 2. Fracture of the obtained composite material (SEM)

Results of the quantitative micro-analisys made with X-ray dispersive radiation of composite materiale obteined by infiltration of ceramic performs show the presence of aluminum and Al_2O_3 phase (Fig. 3).

The composite material hardness it was found to be 2 times higher compared to the EN AC – AlSi12 matrix material. The average matrix hardness is 19.6 HRA; whereas hardness values of the composite material is 40,8 HRA.

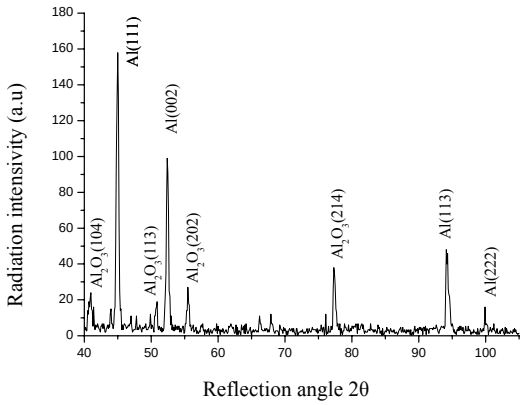

Fig. 3. X-Ray difraction pattern for obtained composite materials

3. Summary

It was found out that the developed technology of fabricating the composite material with the EN AC – AlSi12 alloy matrix reinforced with the Al_2O_3 particles and fibres, consisting in the infiltration of the RF50AX-301 ceramic preforms with the liquid aluminum alloy, ensures the required structure and hardness, increased about twice compared to the matrix, and – therefore – may find practical applications.

4. Aknowlements

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5. References

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