Influence of the obtaining method on the compactness of AlMg10-SiCp ultralight composite

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Abstract. The research was carried out on composite materials based on AlMg10-SiCp. This metallic ultralight materials were obtained by two methods: butane bubbling method and the soluble salt method. We chose different amounts of SiCp (5, 10 and 15%), the particles size being about 120 micrometers. The A method involves a forceful agitation of the melt aluminium alloy and SiC mixture, combined with gas bubbling (we used CH₄ as the reactive gas). Method B involves the dissolution in water of the sodium chloride contained in the AlMg10-SiC composite after solidification of the metallic material. The occurrence of NaCl in the structure of the material is due to the introduction of sodium chloride and silicon carbide powders mixture in the molten material, which was very vigorously stirred. The A method leads to a cellular structure (small and medium size open and semi-open cells) of the composite and the B method to a porous one, like metal foams (semi-open cells). The increase of SiC percentage determinate the increase of the composite porosity, no matter of used method of achievement. The phenomenon can be explained by porosity increasing of those materials, equalization in cell size and tendency to uniform distribution of cells in the composite volume. As expected, the relative porosity of these composites increases with the silicon carbide percentage, reaching a maximum of 47% for AlMg10-15% SiC composite, obtained by the soluble salts method.

1. Introduction
As it is known from literature [1-7] there are a lot of methods to obtain lightweight porous materials, but used in industry are basically the following: using of a wax/polymer-foam precursor ceramic mold, metal vapor phase deposition/electrodeposition, consolidation a metallic material powder, consolidation by pressing of a metal powder-leachable powder mix, sintering, stirring a foaming agent-molten metallic alloy mixture, bubbling an inert gas through molten metallic alloys, hot isostatic pressing of inert gas into material pores, dissolution under pressure of hydrogen in a melted metallic material and so on.

The research was carried out on composite materials based on AlMg10-SiCp. These metallic ultralight materials were obtained by two methods: butane bubbling method and the soluble salt method [8-10]. We chose different amounts of SiCp (5, 10 and 15%), the particles size being about 120 micrometers.

The A method involves a forceful agitation of the melt aluminum alloy and SiC mixture, combined with gas bubbling (we used CH₄ as the reactive gas); the technological flow of this method is presented in figure 1.
Figure 1. Technological flow for obtaining ultralight cellular composites by gas bubbling.

Method B involves the dissolution in water of the sodium chloride contained in the AlMg10-SiC composite after solidification of the metallic material. The occurrence of NaCl in the structure of the material is due to the introduction of sodium chloride and silicon carbide powders mixture in the molten material, which was very vigorously stirred; the technological flow of this method is presented in figure 2.

Figure 2. Technological flow for obtaining ultralight cellular composites by soluble salt method.

The A method leads to a cellular structure (small and medium size open and semi-open cells) of the composite and the B method to a porous one, like metal foams (semi-open cells), figure 3.

The general appearance of the morphology of the cellular composite material obtained by A method is shown in figure 4. It was observed pores distribution in the whole volume of the material and also that they are interposed, between them being observed porous ligament bridges. The pores have dimensions of the order of more than 50μm, with many silicon carbides distributed mainly in the high porosity areas.
Figure 3. 15%SiC composite samples obtained by (a) A method and (b) B method [2].

Figure 4. Electron microscopy analysis SEM for highlighting the overall appearance of the composite obtained by A method, 60x.

Figure 5. Electron microscopy analysis SEM for highlighting the overall appearance of the composite obtained by B method, 100x.

The general appearance of the composite material morphology obtained by B method is shown in figure 5. We can observe the accentuated porous structure of the composite matrix, where the pores
reach average values between 1÷1.5 mm. The cellular structure of the material does not have a homogeneous distribution, the non-homogeneity being given also by the way the walls that limit the gaps are formed, because they contain numerous intersections of bridges between the formed cells.

The research carried out aimed to analyse whether the obtained cellular ultralight composite metal materials, based on AlMg10-SiC, have potential for use in applications where the compactness of the material is important (through its density and porosity): for structures, energy absorption and thermal management.

2. Experimental determination of relative density and porosity

Density determination was performed using a Kern EMB 200-3V device (figure 6). This is in fact a hydrostatic balance, which allows the accurate weighing of a sample in both air and water, the operating principle being based on the law of Archimedes, according to which the weight of a sample is equal to that of the volume of dislocated water.

![Figure 6. Image with Kern type EMB 200-3V hydrostatic balance, with which the density of the obtained ultralight cell composites was measured; 1-balance frame, 2-glass vessel, 3-sample tray, 4-control panel, 5-display [3].](image)

| %SiCp | SA-n | SB-n |
|-------|------|------|
| 5     | 2.35 | 1.85 |
| 10    | 2.31 | 1.60 |
| 15    | 2.26 | 1.45 |

![Figure 7. Density variation curves of AlMg10-SiC composites with the SiC percentage and the obtaining method of the ultralight composite material; SA-n - composite samples obtained by method A, SB-n - composite samples obtained by method B, n = 1, 2 or 3 (corresponding to 5, 10 or 15% SiC).](image)
Measurements results are presented in figure 7. In figure 8 is given the variation of the relative porosity of the samples from composite material, obtained by the two experimental methods. From the above figures it can be observed that, as the percentage of silicon carbide increases, the density of the composite materials decreases, regardless of the method used to obtain them (the average measured density of the AlMg10 alloy used in the experiments is 2.5554 g/cm³). The phenomenon can be explained by increasing the porosity of the respective materials and by uniformity of the distribution and size of the cells in the volume of the experienced composites. Of course, as expected, with the increases of the percentage of SiC the relative porosity of the composites is growing, the maximum value being 47% for 15% SiC composite, obtained by the B method.

3. Conclusions
The researches were carried out on ultralight metallic composite materials type AlMg10 with SiC particles in different amounts (5, 10 and 15%). These materials were obtained by two methods: butane bubbling method, which involves agitation of the melt aluminum alloy and SiC mixture, combined with CH₄ bubbling, and the soluble salt method which involves the dissolution in water of the NaCl contained in the solidified AlMg10-SiC composite. By the A method we obtained a cellular structure (small and medium size open and semi-open cells) and a porous one by the B method (semi-open cells).

It was observed that the density of the composite materials decreases as the percentage of silicon carbide increases (the minimum value is 1.45 g/cm³ for B composite with 15% SiC) and the porosity there of increases (the maximum value is 47% for the same previous composite), regardless of the method used to obtain them. It is observed that the most compact ultralight composite is the cellular one (obtained by the A method), the B method allowing the obtaining of less dense composite materials.
4. References
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