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Studies on Metal Matrix Composite Based On AlMg Alloys

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ABSTRACT: Composite materials are the most advanced class of materials invented and produced by humans in modern times as well as a challenge for the future in the field of scientific and technological performance. They are made up of at least two phases of different nature which are so combined to form a new material with a superior combination of properties. They are generally materials with unusual performances on the relationship between properties and specific gravity. Composites are multiphase materials with distinct and well-defined interface between the constituent phases ensuring a transfer of property but can lead to obtaining a product with exceptional performance from the starting material. In this paper we have focused research on Al-Mg alloys with magnesium and silicon carbide (SiC). To obtain these materials has been chosen different gas blowing method (N_2, SO_2 and C_4H_{10}). It was observed that the best results in terms of pore volume gave blowing with C_4H_{10}. The samples obtained were analyzed by electron microscopy.
Keywords- cellular materials, manufacture metal foams, porous metals, stabilized aluminium foams (SAF).

I. INTRODUCTION

Aluminum foams are a new class of materials with low densities, large specific surface and novel physical and mechanical properties. Their applications are extremely varied: for light weight structural components, for filters and electrodes and for shock or sound absorbing products. Recently, interesting foaming technology developments have proposed metallic foams as a valid commercial chance; foam manufacturing techniques include solid, liquid or vapor state methods. The foams presented in this study are produced by Melt Gas Injection (MGI) process starting from melt aluminum [1,2].

Solid metallic foams are known to have many interesting combinations of physical and mechanical properties such as high stiffness in conjunction with very low specific weight or high gas permeability combined with high strength. For this reason, the past ten years have seen an increase in interest for these materials. In the literature and in practical use there is some confusion concerning the term "metallic foam". The term is mostly used in a quite general way although the materials described are often not foams in the strictest sense. One has to distinguish between:

- *cellular metals*: the most general term, refers to a metallic body with any kind of gaseous voids dispersed in it,
- *porous metals*: general term but restricted to a special type of voids: pores are usually round and isolated from each other,
- *(solid) metal foams*: a special class of cellular metals with a special history (originating from a liquid metal foam),
- *metal sponges:* refers to a special morphology of a cellular metal with usually interconnected voids. [2,3].

II. PROPRETIES OF STABILISED ALUMINUM FOAMS

The properties of the metal foams belong to a group of materials called cellular solids which are defined as having porosity >up to 0.7 [4]. Natural foams are produced by plants and animals such as cork or bone. Man made foams can be manufactured from a variety of materials such as ceramics, polymers and metals. There are two categories of foams: open - and closed- cells. Here, it is presented a brief overview of the main properties of closed-cell Al-alloy foams obtained by the PM method.

Metal foams combine properties of cellular materials with those of metals. For this reason, metal foams are advantageous for lightweight constructions due to their high strength-to weight ratio, in combination with structural and functional properties like crash energy absorption, sound and heat management [5,6]. Many metals and their alloys can be foamed. Among the metal foams, the Al-alloy ones are commercially the most exploited due to their low density, high ductility, high thermal conductivity, and metal competitive cost.

1.1. Structural properties

There are several structural parameters of these foams, such as number, size-pore distribution, average size, shape and geometry of the pores, thickness, intersections and defects in the cell-walls and thickness, defects and cracks of the external dense surface for describing the cellular architecture of the foams. The properties of these foams are influenced by these morphological features [4,7,8].

Progress has been made in understanding the relationship between properties and morphology. Although this exact interrelationship is not yet sufficiently known, one usually assumes that the properties are improved when all the individual cells of a foam have similar size and a spherical shape. This has not really been verified experimentally. There is no doubt that the density of a metal foam and the matrix alloy properties influence the modulus and strength of the foam. All studies indicate that the real properties are inferior than the theoretically expected due to structural defects. This demands a better pore control and reduction in structural defects. Density variation and imperfections yield a large scatter of measured properties, which is detrimental for the metal foams reliability [7]. Wiggled or missing cell-walls reduce strength, and in turn, result in a reduced deformation energy absorbed under compression [8,9]. Mechanical studies demonstrate that selective deformation of the weakest region of the foam structure leads to crush-band formation [10]. Cell morphology and interconnection could also affect thermal and acoustic properties [11]. It is widely accepted that foams with a uniform pore distribution and defects free, are desirable. This would make the properties more predictable. Only then, metal foams will be considered reliable materials for engineering purposes and will be able to compete with classical materials. Despite their quality improvement in the last 10 years the resulting metal foams still suffer from non-uniformities. Scientists aim to produce more regular structures with fewer defects in a more reproducible way which is the crucial challenge of the research in this field.

1.2. Mechanical properties

Many literature studies have been undertaken on the mechanical properties of metal foams. A broad survey of the understanding of the mechanical behavior of a wide range of cellular solids is provided by Gibson and Ashby [5]. Others have carried out experiments to investigate the behavior of metallic foams under different loading conditions, particularly the properties of metal foams under impact loading. The possibility of controlling the load-displacement behavior by an appropriate selection of matrix material, cellular geometry and relative density makes foams an ideal material for energy absorbing structures. Among the several mechanical testing methods available, uniaxial compressive mechanical tests are commonly used to evaluate the compressive behaviour and the energy absorbed of these foams [12,13].

III. PRELIMINARY EXPERIMENTS AND RESULTS

The experimental equipment consists of an electric resistance furnace (maximum heating temperature 800ºC), which was adapted for insufflation gas (SO_2, N_2, inert gas, etc.) It is also equipped with a wide agitator and a trough acquisition of foam formed.

Has been obtained metal foam by mixing the alloy melt AlMg10 with 15% SiC powder 120 μm size, at a temperature of 710ºC and with C_4H_{10} injection at 1.2 atm pressure.

The study of samples was performed using scanning electron microscope equipped with cannon QUANTA INSPECT F field emission electron - FEG (field emission gun) with a resolution of 1,2 nm and dispersive X-ray spectrometer energy (provenance EDAX) with a resolution of 130 eV at MnK.

Below we present the characterization of morphology and dimensional tests of samples from cell-based composite type aluminum alloy reinforced with silicon carbide particles. Analysis was performed by scanning electron microscopy (SEM) and the electron diffraction analysis (EDX).

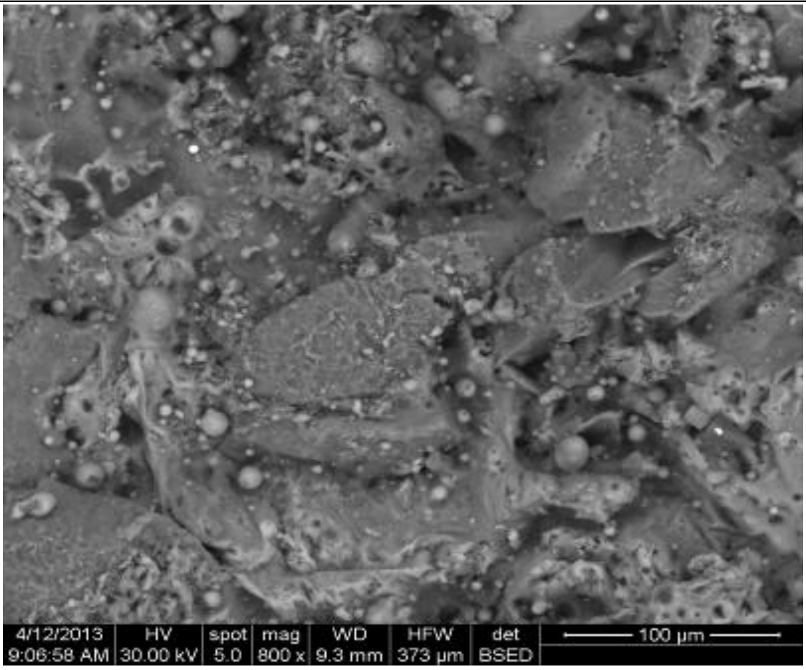

Figure 1. Analysis by scanning electron microscopy SEM to highlight the overall appearance of the overall composition and the morphology of the constituents and distribution of the pores in the matrix of the composite. X 800.

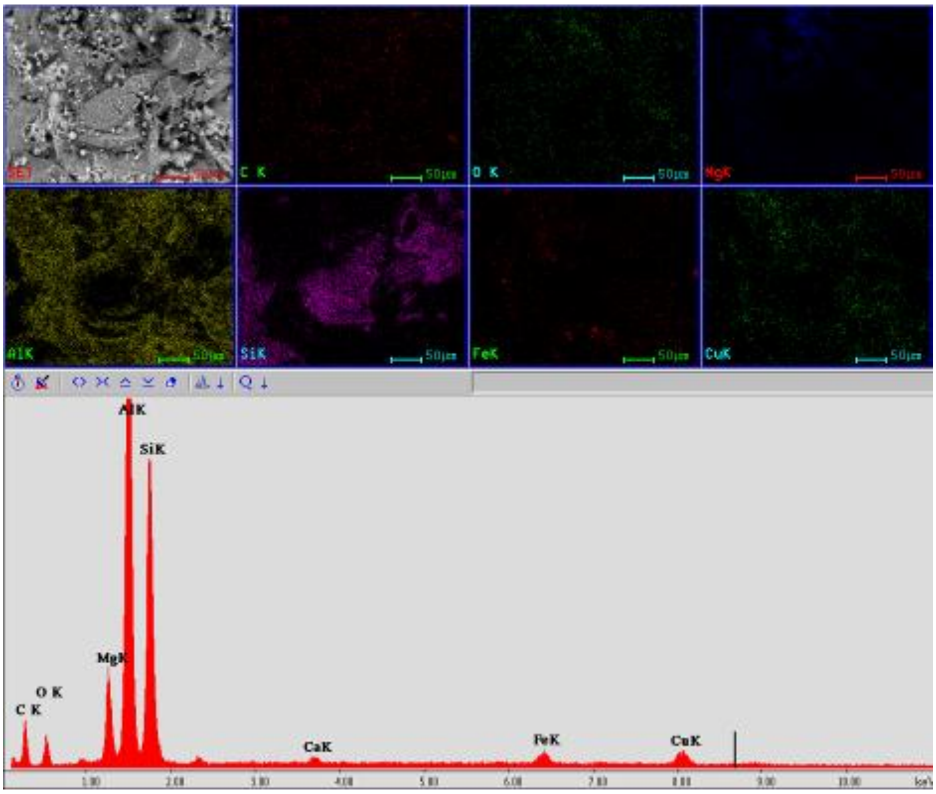

Figure 2. Electron diffraction analyzer EDAX analysis of previously highlighted area SDEM. Is distinguished the distribution maps for the main constituents of the composite. The colors chosen for call distribution to be able to differentiate the constituents on the basis of:Al, Si, Fe, Cu, Mg, C şi O.

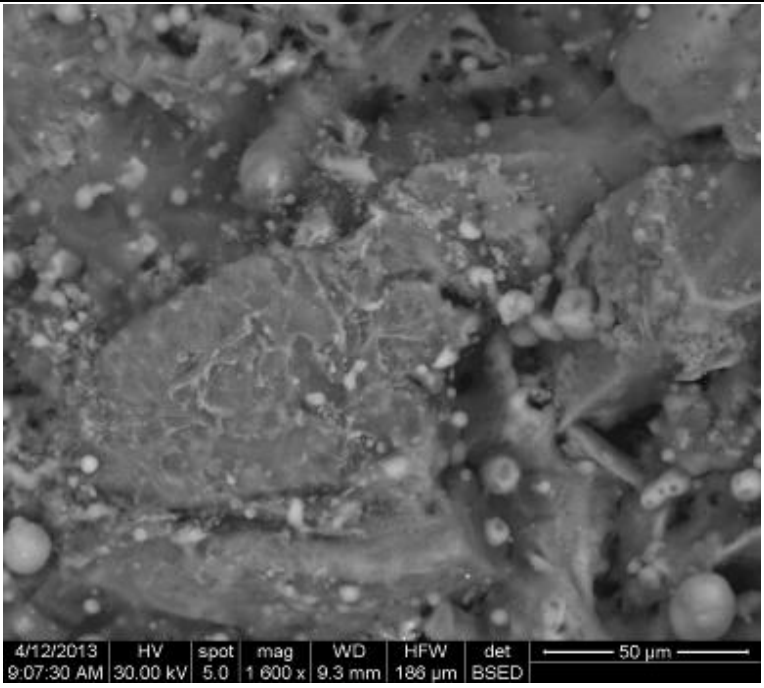

Figure 3. SEM image showing how embedding silicon carbide particles that are found in the center image. It can be seen that adjacent areas of silicon carbide particles are found showing Intercan porous areas of communication networks by forming aluminum alloy matrix (areas that appear black in the micrograph). In these areas are found spherulites similar to sample 1, but in much larger numbers. X 1600.

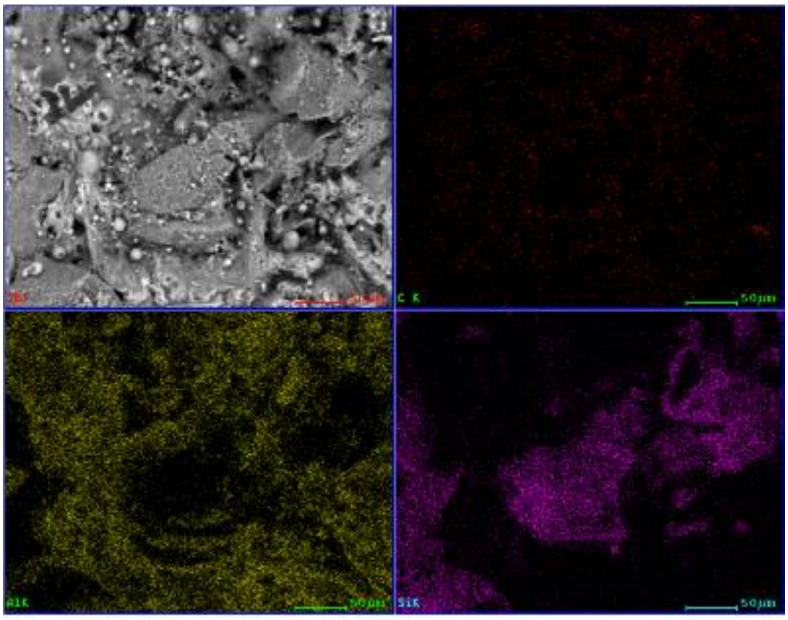

Figure 4. EDX qualitative analysis to highlight the distribution map of aluminum, carbon and silicon. It can identify that the spherulites that are found distributed in the matrix of the composite are based on aluminum oxide.

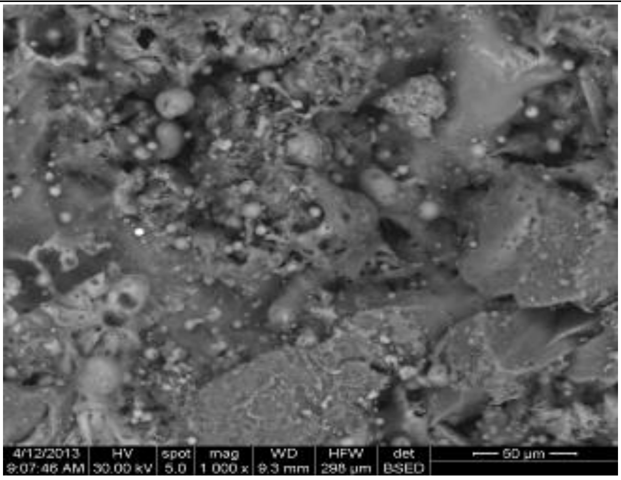

Figure 5. SEM image illustrating the manner of embedding the silicon carbide particles wich are contained in the matrix alloy. It can be seen that adjacent areas of silicon carbide particles are found showing Intercan porous areas of communication networks by forming aluminum alloy matrix and the matrix surface has a plurality of micropores (black areas appearing micrograph). X 1000.

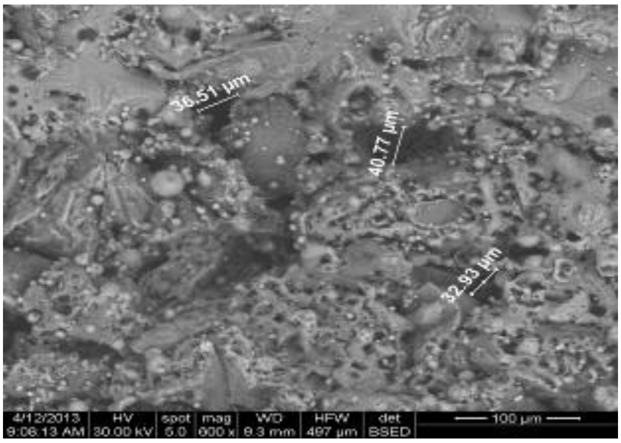

Figure 6. SEM image highlighting the distribution and morphology of porosity that are formed in the structure of composite. It can easily seen a multitude of micro-porous globular structure as well as pores which have dimensions of the order of 30-40 µm distributed throughout the mass of the composite. As in Sample 1 there is a plurality of microspheres of aluminum oxide as the pores distributed in the body of the composite. X 400.

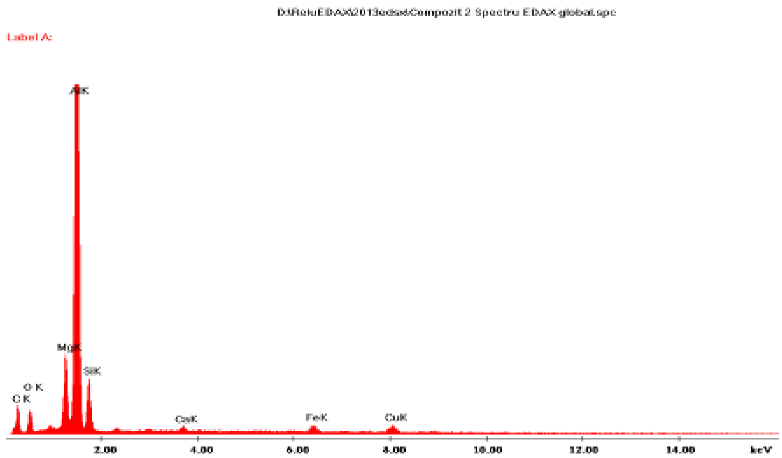

Figure 7. EDX qualitative analysis to identify components of the composite matrix.

IV. CONCLUSION

Experiments have shown the viability of the foams obtaining method and that the foam stability was achieved by depositing of some particles (Al_2O_3, and SiC) on pores walls.

The spherulites distribution and their size substantially influence the increase of cellular composite material porosity.

Another reason for applying stabilized aluminum foams achieving are the uniform pore distribution over the entire area and relatively low production costs.

There are a lot of applications of metallic foams, but most of them are in the automotive, aircraft and building industries, in which the SAF manufacturers have the objective to achieve a market penetration that will bring stabilized aluminum foam to where magnesium is today.

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REFERENCES

[1] J. T. Wood, Production and applications of continuously cast, foamed aluminium, Proceedings of Fraunhofer USA Metal Foam Symposium, Verlag MIT Publishing, 1997, 31-35.

[2] P. Asholt, Aluminium foam produced by the melt foaming route process, properties and applications, Proceedings of Int. Conf. on Metal Foam and Porous Metal Structures, MIT Publishing, 1999, 133-140.

[3] J. Banhart, Metallic foams: challenges and opportunities, Eurofoam2000, Editors: P. Zitha, J. Banhart, G. Verbist (MIT-Verlag Bremen), 2000, 13-20.

[4] L.J. Gibson & M.F. Ashby, Cellular solids – Structure and properties, Second Edition, Cambridge University Press, ISBN 0-521-49911-9, Cambridge, United Kindgom, 1997.

[5] M.F. Ashby, A. Evans, N.A. Fleck, L.J. Gibson, J.W. Hutchinson, & Wadley, Metal foams — a design guide, Butterworth-Heinemann, ISBN 0-7506-7219-6, London, England, 2000.

[6] H.P. Degischer & B. Kriszt, (Ed(s).), Handbook of Cellular Metals, Wiley-VCH, ISBN 3-527-30339-1, Weinheim, 2002.

[7] U. Ramamurty & A. Paul, Variability in mechanical properties of a metal foam, Acta Materialia, Vol. 52, No. (4), ISSN 1359-6454, 2004, 869-876.

[8] F. Campana & D. Pilone, Effect of wall microstructure and morphometric parameters on the crush behaviour of Al-alloy foams, Materials Science & Engineering A, Vol. 479, No. (1-2), ISSN 0921-5093, 2008, 58-64.

[9] A.E. Markaki & T.W. Clyne, The effect of cell wall microstructure on the deformation and fracture of aluminum-based foams, Acta Materialia, Vol. 49, No 9, ISSN 1359-6454, 2001, 1677-1686.

[10] I. Duarte, F. Teixeira-Dias, A. Graça & Ferreira, Failure Modes and Influence of the Quasi-static Deformation Rate on the Mechanical Behavior of Sandwich Panels with Aluminum Foam Cores, Mechanics of Advanced Materials and Structures, Vol.17, No. (5), ISSN 1537-6494, 2010, 335-342.

[11] M. Kolluri, M. Mukherjee, F. Garcia-Moreno, J. Banhart & U. Ramamurty, Fatigue of a laterally constrained closed cell aluminum foam, Acta Materialia, Vol. 56, ISSN 1359-6454, 2008, pp. 1114.

[12] Y. Sugimura, J. Meyer, M.Y. He, H. Bart-Smith, J. Grenstedt & A.G. Evans, On the mechanical performance of closed cell Al alloy foams, *Acta Materialia*, Vol. 45, No. (12), ISSN 1359-6454, 1997, 5245-5259.

[13] J. Banhart, & J. Baumeister, Deformation characteristics of metal foams. *Journal of Materials Science*, Vol. 33, ISSN: 0022-2461, 1998, 1431–1440.