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HYBRID ALUMINUM MATRIX COMPOSITES OBTAINED THROUGH PROCESSING IN PASTY STATUS

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Abstract: *The paper presents the development of a hybrid metal matrix composite (MMCH) – AlSi7Mg0.3/10% $SiC_{(p)}$ + 3% $C_{Cu(p)}$ obtained by the inclusion of mixed SiC particles and graphite covered, by mechanical agitation (Vortex method able semi – solid) and bidirectional pressure.*
Key words: *metallic composite, reinforcement, hybrid*

1. INTRODUCTION

The material is designed for the transport industry (discs and rotor brake, rods, hangers) [1], having the great advantage of reduction the weight bodies brake with 50 – 60%.

The main problems occurring in developing hybrid metallic materials are given by the inoculation method in melt of the reinforcement elements.

For inoculation we choose a method that is not influenced by the specific weight of the reinforcement elements, the Vortex method at temperatures where the alloy is a semi – solid (is in the range of solidification).

2. EXPERIMENTAL PROCEDURE

The main elements used for reinforce matrix, have a different density that of aluminum matrix, so normally in melts occurs separation of the constituents, for that reason it is desirable that the processing of material to take place in a semi-solid state [2, 3].

For the AlSi7Mg0.3/10% vol. SiC + 3% vol. C_{Cu} composites, the particles are concentrated in eutectic mixture and Si crystals can germinate near the particles used for reinforcement matrix.

Composite materials have been developed in an electric furnace with resistors. Working temperature was chosen so that during the process the melt to be solidified within 650 – 600ºC.

The chose of this range was subject to there being an upper limit of viscosity to allow inclusion of SiC particles and graphite particles coated with copper, and a lower limits to allow both wetting of the reinforcement elements and a possible homogeneous distribution of their in matrix material [1, 4].

For experiments were tested two methods: the separately introduction of reinforcement elements, the simultaneous introduction of two types of reinforcement elements (preheated and mixed).

After choosing the working temperature for melting, treatment, keeping in liquid status for degassing and refining, development and preheating temperature of reinforcement elements, had chosen the best option for bringing SiC and C_{Cu}.

For development MMCH the introduction of SiC separately of the copper coated graphite were observed an elimination of the particles already embedded by the graphite particles – evidence obtained with a crumbly structure. This is due the difference of density between the aluminum alloy matrix (AlSi7Mg0.3 – 2.8 g/cm^3), silicon carbide (SiC – 3.22 g/cm^3) and graphite (C – 2.1÷2.3 g/cm^3).

MMCH samples obtained when the reinforcement elements were mixed before introduction into the matrix material are compact, with a robust and metallic structure.

Volume of these samples is much lower (at similar quantities of alloy and the reinforcement elements) compared with that of the samples obtained with the separately introduction of reinforcement elements, which led to the choice of two methods for metallic composites with tribologic properties.

Hybrid metallic material composites obtained (AlSi7Mg0.3/10% vol. SiC + 3% vol. C_{Cu}) were subjected to an operation of hot compaction (pressing).

3. COMPOSITES CHARACTERIZATION

Materials obtained were characterized to determine physico – mechanical and tribologic properties, to assess the possibility of replacing conventional materials used in braking systems with this new type of material [5].

- Structural caracterization by optical microscopy

In terms of fine structure are presented diffraction pattern of analysis sample, with identify the diffraction lines of the constituent elements of material characterized (figure 1).

Relativ uniform distribution of reinforcement particles (SiC) and graphite particles (solid lubricant) covered with copper (figure 2). It is also noted, the Al-Si eutectic modify with strontium, to limit of the grains (figure 3). The elongation of particles after pressing as the grains is observed.

Electronic microscopy EDAX and SEM analysis have highlighted the particular aspects of molded composite samples, specific characteristics are presented in Figure 4, where stands a good embed of carbide particles and a relativ homogeneous distribution of their in the matrix.

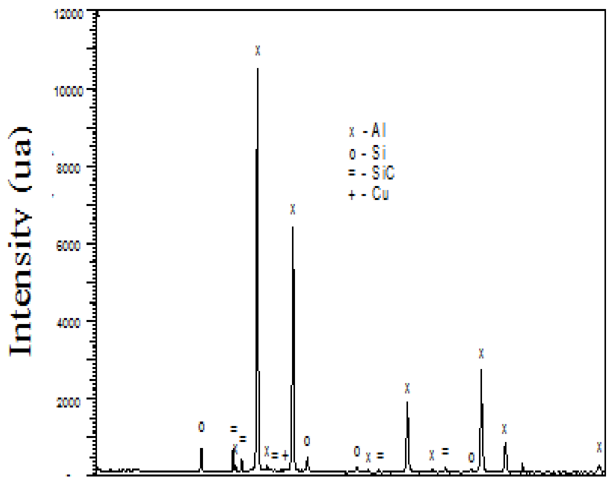

Fig. 1. Diffraction spectrum of sample

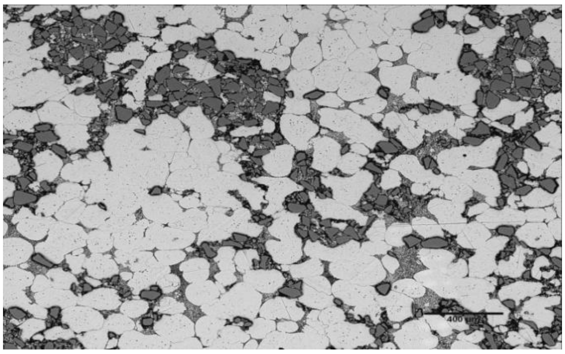

Fig. 2. Optical microstructure of MMCH developed

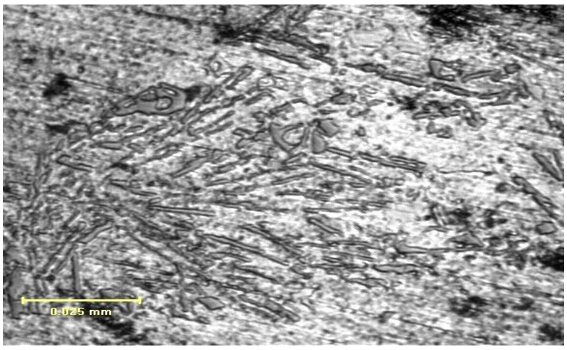

Fig. 3. Optical microstructure of MMCH developed

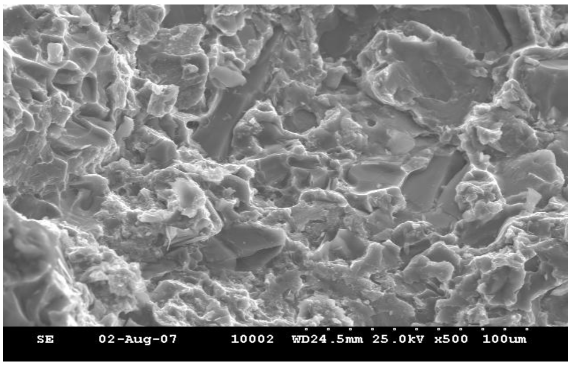

Fig. 4. SEM image of the composite, X500

Average size of crystallite for the Al, Si and SiC phases (tab. 2.) calculated with Debye – Scherrer formula, depending on the direction of crystallization identified by Miller indices (h k l).

	Phase	(hkl)	D (nm)
Average size of crystallite for the Al, Si and SiC phases	Al cubic system, the major phase	(111)	64.3
		(200)	61.0
		(220)	38.6
		(311)	41.0
	Si cubic system, the minority phase	(111)	76.0
		(220)	49.3
		(311)	34.8
	SiC Hexagonal system, the minority phase	(101)	84.9
		(006)	174.0

Tab. 2. Average size of crystallite

Given the working conditions of the materials used in braking systems, the materials obtained were tested to determine the thermo-physical, tribologic and physico – mechanical properties. The results are presented below:

- Thermal conductivity - 183.2 W/mK
- Liniar expansion coefficient – CTE

AlSi7Mg0.3/10% $SiC_{(p)}$ + 3% $C_{Cu(p)}$ – CTE (ppm/K)		
On direction X: 17.5	On direction Y: 17.5	On direction Z: 17.5

Tab. 1. Values of the linear expansion coefficient – CTE, for the hybrid metallic composite

- Heat capacity, C_p – 1.04 J/KgK
- Coefficient of friction, μ – 0.38
- Vickers Micro hardness for the reinforcement elements – 2803.8 HV0.1/10 (figure 5)
- Brinell Hardness – 71.30 HB (750daN/15s/5mm)
- Hydrostatic density - ρ = 2.685 g/cm^3

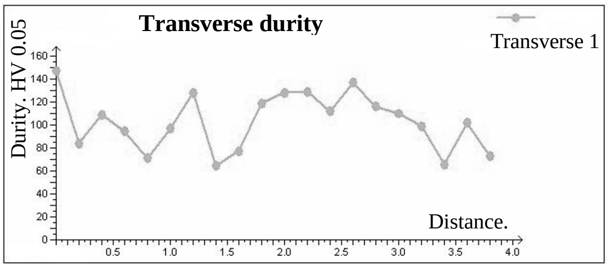

Fig. 5. Graph of hardness in the transverse direction

	File	a	b	c
Elementary cell parameters for phases of Al, Si and SiC	Al	4.057	4.057	4.057
	File 04-0787	4.049	4.049	4.049
	Si	5.445	5.445	5.445
	File 27-1402	5.431	5.431	5.431
	SiC	3.086	3.086	15.136
	File 74-1302	3.082	3.082	15.118

Tab. 2. Elementary cell parameters for phases of Al, Si and SiC identified by X – ray diffraction, determined by compared with the values of device files

4. CONCLUSIONS

From the results obtained, the following may be concluded:

For a better compactness to hybrid material composite obtained should be used the second option, where the reinforcement elements are introduced together, mixed.

Making optimum temperature of the material composite AlSi7Mg 0.3/10% $SiC_{(p)}$ + 3% $C_{Cu(p)}$ system is in the range 650 – 600ºC, range where the melt viscosity is optimal, allowing a better embed the reinforcement elements and a very good dispersion of their in matrix material.

Results obtained encourage us to continue research to optimize properties.

5. REFERENCES

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