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Contributions in the Preparation and Processing of Composite Material Type Silumin 3 - Reinforced Matrix with S235JR Steel Mesh

In the paper are presented concrete data on developing technological batches of metal composite material (MCM) type Silumin 3-reinforced matrix with steel mesh S235JR, with the indicating of the parameter and of the distinct stages of work. The samples from prepared batches were cut along and across by water jet abrasive process and were subjected to a destructive testing program and microstructural examination, obtaining results in concordance with the desired quality. The abrasive material used for cut was GMA granite with the average mesh of 80, the particle size ranging between 150-300 μm , density 2300 kg/m^3 and melting point 1240°C.

Keywords: composite materials, destructive testing program, microstructural examinations

1. Introduction

Replacing the conventional materials with composite materials is increasingly used in the most varied fields such as: mobile industry, sports equipment, automotive, various types of pipes etc. Characteristics of a composite material are determined by the constituents: matrix, inserts and the interface between them [1]. Generally, the matrix has the property to hold together the inserts made by different materials, the mechanical and thermal properties having an influence on the performance of composite materials especially in the case of metal matrix composite materials (MCM), because incorporation of a different material from that of the matrix, sometimes requires specific thermal processing which can leads to changes in the microstructure and mechanical properties [2-7]. Because of their low density and mechanical properties in a wide range due to their high plasticity, extensive machining possibilities, high weldability, high corrosion resistance, are used as matrix alloys: Al-Cu-Mg, Al-Zn-Mg-Cu and Al-Li.

Any of those alloys generally used as matrix contains more than 92% Al. To produce MCM with Al alloy matrix can use regular processing techniques in liquid or solid state. Many of them allow in-situ incorporation of the inserts. In the paper is presented the technology of SIL3-S235JR laminate from centrifugally cast sleeves.

2. Materials

Matrix material (Silumin 3) was prepared in a low frequency induction furnace. Chemical composition of the matrix is: 87% Al; 9÷10% Si; 0.3÷0.6%Mn; 0.2÷0.5% Mg; 0,6% Fe; 0,15% Ti; 0,1% Zn and 0,05% Cu. It is recommended that the Fe percentage to be low for an appropriate structure and high mechanical strength (Mn + Fe = max. 1.1%) [1-2].

Technological characteristics:

- Casting temperature: 710-730°C;
- Heat processing temperature: 350-450°C;
- Annealing temperature: 370-400°C;
- Beginning of recrystallization temperature: 150°C;
- Casting shrinkage: 1.7%;
- Deformation admitted: 75-95%;

Mechanical characteristics:

- Tensile strength: $R_m = 230 \text{ N/mm}^2$;
- Hardness: $HB = 85$;
- Density: $\rho = 2.65 \text{ kg/dm}^3$;
- Longitudinal modulus: $E = 7,60.105 \text{ daN/cm}^2$.

The insert material is a steel mesh type S235JR (according to EN 10025:2004) with the following chemical composition: 99.32÷98.73% Fe; 0.13÷0.22% C; 0.3÷0.6% Mn; 0.15÷0.35% Si; 0,045% P and 0,055% S.

Mechanical characteristics:

- Tensile strength: $R_m = 410 \text{ N/mm}^2$;
- Hardness: $HB = 160$;
- Density: $\rho = 7.80 \text{ kg/dm}^3$;
- Longitudinal modulus: $E = 2,06.106 \text{ daN/cm}^2$.

In parallel with the development of the matrix material was also prepared the fibre matrix material purchased as mesh wire with the diameter $d = 0.2 \text{ mm}$ and square mesh of 0.5 mm . This were mechanically cleaned by impurities, degreased in trichloroethylene and dried in a stream of warm air. Bushes of MCM Silumin 3 of non-alloy steel wire mesh were carried away by centrifugal casting foundry with horizontal axis designed and built at UCMR S.A. Romania which can achieve speed range: 800, 1000, 1200 and 1460 rot/min. Machine geometry and the maximum speed and maximum dimensions of the cast bushes are:

- External diameter: $D_e = \text{max. } 180 \text{ mm}$;
- Interior diameter: $D_i = 50 \text{ mm min}$;
- Moulded sleeve length: $L = \text{max } 250 \text{ mm}$;
- Bush wall thickness $s = 10 \text{ mm min}$.

3. MCM'S rolling cast

Samples of MCM-S235JR SIL3 had a thickness of 4 mm and the wire mesh insert was placed in the middle of the sample. Lamination was accomplished by multiple passes ultimately resulting plate thicknesses of 0.3-0.5-1-2.5-3 mm, corresponding to values of absolute reduction of 3.7 to 3.5-3-1.5-1 mm and relative reductions of 92.5 - 87.5 - 75 to 37.5 -25% (examples in Figure 1, b, c, d).

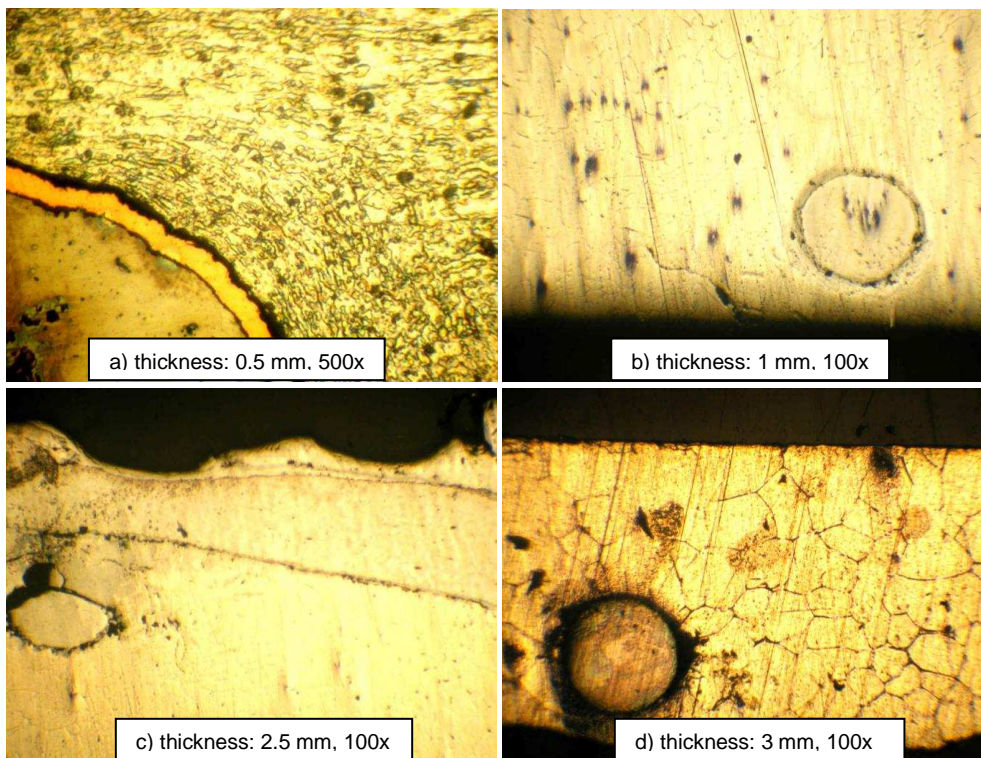


Figure 1. Examples of microstructures of sheets from MCM Si3-S235JR

Before rolling, the pieces were cleaned mechanically to remove surface inclusions avoiding destruction and/or dislocation of the fibres. Cold rolling was performed in a reversing mill with the following characteristics:

- cylinder diameter: 60mm;
- tab length: 1100 mm;

- distance between the pressure screws: 140 mm;
- motor power drive track roller and drive motor cylinder: 2.5 kW;
- speed: 1500 rot/min;
- maximum width of the sheet metal: 100 mm.

4. Water jet cutting equipment

Technical characteristics of the equipment:

- Maximum movement speed of the portal: 6000 mm/min;
- Cutting Table size: 950 x 650 mm;
- Maximum height of the work piece: 100 mm;
- Maximum system pressure (pressure water cutting): 4200 bar.

Abrasive material used was granite type GMA with the average grain size of 80 mesh with a particle size in the range from 150 to 300 μm , density of 2300 kg/m³ and melting point 1240°C. The cutting parameters are presented in Table 1.

Table 1. Cutting parameters

Pressure [bar]	Cutting speed [mm/min]	Abrasive flow [g/min]
1400	100	100

Workstation used for cutting the samples is shown in Figure 2, and is composed of the following elements: 1 - Cutting head; 2 - Abrasive dispenser with adjustable flow rate: 50 to 600 g/min; 3 - Cutting head with water jet and abrasive; 4 - Carriage longitudinal feed; 5 - Cross stroller advance; 6 - Abrasive hopper; 7 - Portal cutting (cross-beam); 8 - Grill cut; 9 - Tank with stop and dispersion of abrasive water jet.



Figure 2. Water jet cutting equipment

5. Microhardness tests

There were made Vickers microhardness on all the samples, using PMT 3 device with the load of 100 g. The average hardness values in the matrix material are shown in Table 4. In previous research, the authors have conducted research on the welding by pressure points [10] and ultrasound [11] of metallic composite materials MCM SiI3-S235JR coated with copper [6-9].

Table 4 Average hardness values in the matrix material

No sample	HV0.1 hardness		
1.	35.4	36.6	37.6
2.	33	34.1	34.3
3.	36.5	35.8	35.2
4.	37	33.8	36.5
5.	34.2	34.5	35.7
6.	35.4	39.1	38.6
7.	34.8	38	35.4

6. Conclusions

- There are given general information about composite applications in industry and the main issues arising in their implementation;
- It is presented the technology of SIL3-S235JR laminate from centrifugally cast sleeves with Silumin 3 matrix and fibre with the diameter of 0.2 mm and composites examination after it were cut by water and abrasive jet cutting system;
- Microscopic analysis of the materials and the results obtained from testing the hardness values recommends using these types of composite materials in various applications.

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