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SOME ASPECTS OF THE TECHNOLOGY FOR OBTAINING THE SAMPLES FROM COMPOSITE MATERIAL WITH PARTICLE REINFORCEMENT

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ABSTRACT

The aim of the paper is to establish the main steps of technologies to obtain the sample of composite material with particles reinforcement and to present some experimental results. The methodology and techniques that will be used for obtaining the composite materials with particles reinforcement consist in running the following principal phases: introduction the Si-C particles into the aluminum liquid matrix; mixed all the mixture using one palette with driving belt; heating the all mixture; cooling the mixture down to the crystallization temperature; solidification; the extraction of composite material obtained. The main results of the paper will be focus in structure analyzing of the composite material obtained and traction testing researches.

KEYWORDS: composite material, particle, reinforcement, sample.

1. INTRODUCTION

The composite materials with particles reinforcement are made from base material (matrix) with particles inside, from one or more materials. The particles could be metallic or non-metallic like matrix metallic or non-metallic. In this case there are the following types of composite materials:
-metallic particles inside of non-metallic matrix, such as the rocket solid fuel, made from aluminum powder and oxides, with flexible link, [1];
-non-metallic particles with non-metallic matrix, is the material from sand particles and stone mixture of water and cement, [2, 4];
-metallic particles inside of metallic matrix, composite material is obtained from particles inside of metallic matrix without “dissolve”, [2, 4]. The slug particles are currently used inside of copper and steel alloy;
-non-metallic particles inside of metallic matrix, the non-metallic particles (such as ceramics particles) could be included inside of metallic matrix. The composite material obtained is called *cermets.* The choosing of reinforcement composite material with particles base on real conditions, such as main condition the request of beneficiary, the produce possibilities and characteristics of half finish material [3], complexity degree of technology which could be used.

The general requests for a product consists of: dimensions and form, weight and volume, finishing degree, cost, requisition, performance, accessibility, functioning, quality, maintenance level and ecological problems.

The manufacturing possibilities take into account the following: manufacturing area, equipments, facilities, labor force, design possibilities, testing and analyze and quality control.

Take into account the increasing of metallic composite material applications was developed also the manufacturing methods, the special accent was put over the processes without high investitions such as forging methods [6].

2. DESCRIPTION OF THE TECHNOLOGY USED

The methodology and techniques that will be used for obtaining the composite materials with particles reinforcement consist in running the following principal phases (Fig. 1):
-introduction the Si-C particles into the aluminum liquid matrix;
-mixed all the mixture using one palette with driving belt;
-heating the all mixture;
-cooling of all mixture into the crystallization;
-solidification;
-the extraction of composite material reinforcement.

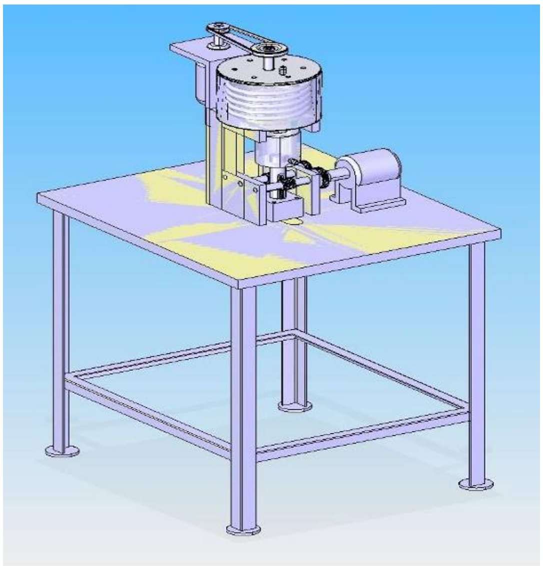


Fig.1. The general view of equipment for obtaining composite materials with particles reinforcement

3. RESEARCH METHODOLOGY

The general research methodology used followed the Taguchi steps. The proposed method tries to satisfy some criterions such as: acquisition facility; minimizing of research numbers thus the price also; obtaining the best possible precision.

Taguchi was made an original method which allowed, beginning from some standard tables, solving almost industrial problems from experimental plans point of view. The Taguchi method originality consist in put into practice the strategies, thus result an standard under-assembly, enough for currently practice.

The beginning of parameters determination presents three original aspects:

-reducing the effects with unchanged of impossible reduced cause;

-the main quality criterion of any process is the relative dispersion of performances;

-Taguchi made the linear graphics which are graphics representation of factors affectation on the orthogonal columns. This entire graphics have like simplified factor out into practice of these orthogonal arrangements.

The new knowledge acquisition for increasing of products and processes quality, are based on the progressive process with the experimentation base on.

The experimental plans consist of optimization method of new knowledge learning process and the Taguchi intervention simplified the procedure of fractional plan. The Taguchi procedure was made for performances increasing of process under the influences of more factors.

The main advantage of Taguchi method are: is achieving a real plan of experimentation functioning; reducing the number of researches; the research study could be include a high of factors with interactions establishing between them; obtaining the results with high accuracy and interpretation without errors of results; obtaining a mathematical model of system studied.

Easier to be studied is the Viger and Sisson [5] model, the matricial system model of “i” factors: F_1, F_2, …F_i each factor has n_i levels:

$$Z_t = M + \lfloor E_{F_1^1} E_{F_1^2} \ldots E_{F_1^{n1}} \rfloor \cdot [F_1] + \lfloor E_{F_2^1} E_{F_2^2} \ldots E_{F_2^{n2}} \rfloor \cdot [F_2] + \ldots + \lfloor E_{F_i^1} E_{F_i^2} \ldots E_{F_i^{ni}} \rfloor \cdot [F_i] + \quad (1)$$

$$+^t [F_1] \cdot \begin{vmatrix} I_{F_1^1 F_2^1} & I_{F_1^1 F_2^2} & \cdots & I_{F_1^1 F_2^{n2}} \\ I_{F_1^2 F_2^1} & I_{F_1^2 F_2^2} & \cdots & I_{F_1^2 F_2^{n2}} \\ \cdots & \cdots & \cdots & \cdots \\ I_{F_1^{n1} F_2^1} & I_{F_1^{n1} F_2^2} & \cdots & I_{F_1^{n1} F_2^{n2}} \end{vmatrix} \cdot [F_2] +^t [F_1] \begin{vmatrix} I_{F_1^1 F_3^1} & I_{F_1^1 F_3^2} & \cdots & I_{F_1^1 F_3^{n3}} \\ I_{F_1^2 F_3^1} & I_{F_1^2 F_3^2} & \cdots & I_{F_1^2 F_i^{n3}} \\ \cdots & \cdots & \cdots & \cdots \\ I_{F_1^{n1} F_3^1} & I_{F_1^{n1} F_3^2} & \cdots & I_{F_1^{n1} F_i^{n3}} \end{vmatrix} \cdot [F_3] + \ldots$$

$$\ldots +^t [F_1] \cdot \begin{vmatrix} I_{F_1^1 F_i^1} & I_{F_1^1 F_i^2} & \cdots & I_{F_1^1 F_i^{ni}} \\ I_{F_1^2 F_i^1} & I_{F_1^2 F_i^2} & \cdots & I_{F_1^2 F_i^{ni}} \\ \cdots & \cdots & \cdots & \cdots \\ I_{F_1^{n1} F_i^1} & I_{F_1^{n1} F_i^2} & \cdots & I_{F_1^{n1} F_i^{ni}} \end{vmatrix} \cdot [F_i] + \ldots +^t [F_{i-1}] \cdot \begin{vmatrix} I_{F_{i-1}^1 F_i^1} & I_{F_{i-1}^1 F_i^2} & \cdots & I_{F_{i-1}^1 F_i^{ni}} \\ I_{F_{i-1}^2 F_i^1} & I_{F_{i-1}^2 F_i^2} & \cdots & I_{F_{i-1}^2 F_i^{ni}} \\ \cdots & \cdots & \cdots & \cdots \\ I_{F_{i-1}^{n_i-1} F_i^1} & I_{F_{i-1}^{n_i-1} F_i^2} & \cdots & I_{F_{i-1}^{n_i-1} F_i^{ni}} \end{vmatrix} \cdot [F_i]$$

where: Z_t is the system theoretical answer; M is the general average of answers and could be calculate like ratio between sum of answers values and experimentation numbers; $[F_i]$ is the vector which indicate the F_i factor level, is the column matrix with zero elements at least one equal with 1 situated in ”i” line corresponding the level factor took into consideration; $E_{F_i^j}$ is the medium effect of system answer for F_i factor situated at j level and could be calculate come down from system answers average the general average M; $\lfloor I_{F_i^j F_k^t} \rfloor$ are the interactions between F_i and F_k factors and could be calculate come down from system answer average (when the F_I factors are at j level and F_k factors at t level) the general average (M) - $E_{F_i^j}$.

Each experimentation was made by three times, so three processes reported at the same referring surface. The machine tools wear influence was neglected for each probe.

Will be applied the matriceal modeling using the Taguchi method and model writing after Viger and Sisson. Also will be following the coefficient determination of model such as (2) type:

$$Z_t = M + G_r + A + P + T_{emp} + T_{imp} + V_a + G_r \cdot A + G_r \cdot P + G_r \cdot T_{emp} + G_r \cdot T_{imp} + A \cdot P \quad (2)$$

where: M is the general average; G_r is the particles druses, [μm]; T_{emp} is the forging temperature, [^oC]; T_{imp} is the time, [min]; A the allow type; P is the mass percent of particles, [%]; V_a the mixture speed of alloy with particles, [rot/min].

It’s compulsory to take into consideration that each input parameter has two levels, so result 6(2-1)=6 degree of freedom for each individual parameters and 6(2-1)(2-1)=6 degree of freedom for interactions between parameters. The number of degree of freedom could be calculating using the following relation:

$$N_{n,m} = n_g l_n \cdot n_g l_m = (n_i v_n - 1)(n_i v_m - 1) \quad (3)$$

where $n_g l_n$ and $n_g l_m$ are the number of degree of freedom for n and m factors. The $n_i v_n$ and $n_i v_m$ are the numbers of levels for above factors. So for presented model the number of degree of freedom is the sum between the degree of freedom of input factors and interactions between them. To this sum will be add one degree of freedom for the effect of average M, so it will result 1+6+6=13 degree of freedom.

The levels variation of input parameters is presented in the table 1.

Table 1 The levels of input parameters

Input Param. / Levels	Gr μm	T °C	Time min	Alloy type, (European Standard)	P %	V, rot/min
Level 1	40	650	1	ENACAlSi5 Cu3Mg	2	250
Level 2	60	750	3	ENACAlSi7 Cu2Mg	6	720

A compulsory condition for calculation of independent factor effects is the orthogonality one. Analyzing this condition result that the small orthogonal program which could be realized is the plan with 8 experimental researches, [5].

The second condition consists in verification of number of freedom degree. The number of freedom degree indicates the values number necessary to be calculating to know the model coefficients. Is necessary at least the same experimentations with freedom degree number of the model. Take into account all above considerations will be 13 freedom degree for the model, so it's necessary at least 13 experimental researches.

The next step consists in presentation the Taguchi graph (Fig. 2) and realization of model graph presented on the Fig. 3. Take into account the aspects between both graphs results the columns level for each individual factors at 16 experimental researches.

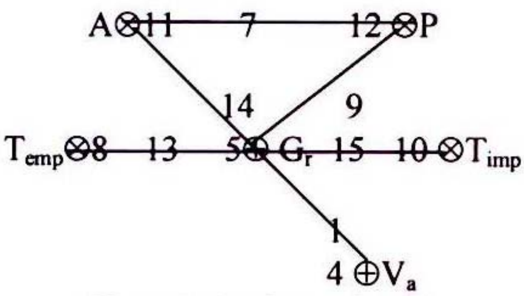


Fig.2. Standard graph, [5]

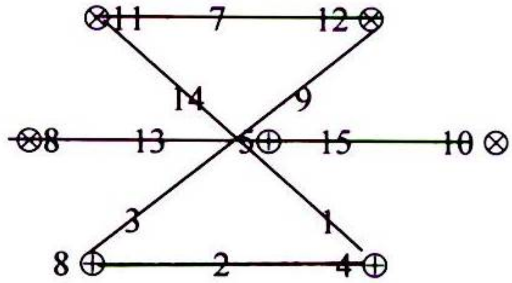


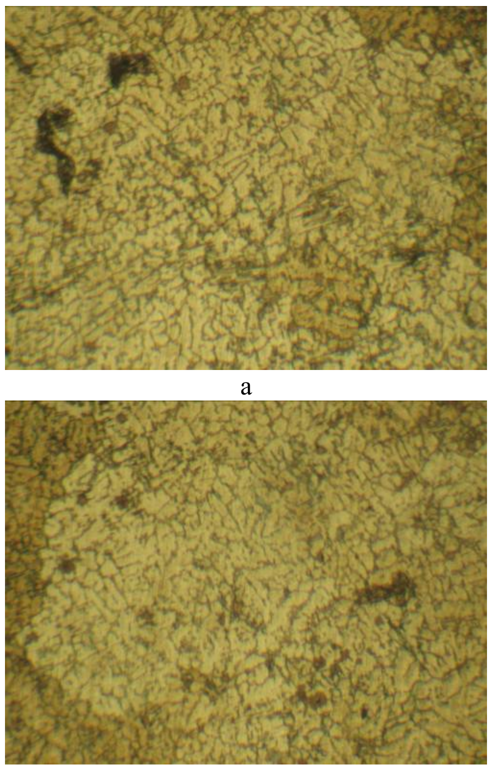
Fig.3. The model graph

4. EXPERIMENTAL RESULTS

The main results made until now are the traction researches and structure analyzing. In this paper will be present the results only for the 3 experimental research.

Thus the Fig. 4 presents the optical microphotographies at different enlargement power.

From this optical microphotography's could be observe, at the top position, small globular porosity, one-way dendrites with secondary dendrites by small dimensions, solids; intermetalics compounds with needle morphology / chinese letters or more compact beside the others (possible secondary dendrites alpha phase). On the bottom position is the fine dendrites structure with constituents by aproximative globular-polygonal form or splints type by gray open color with big dimensions, interdendrites compounds

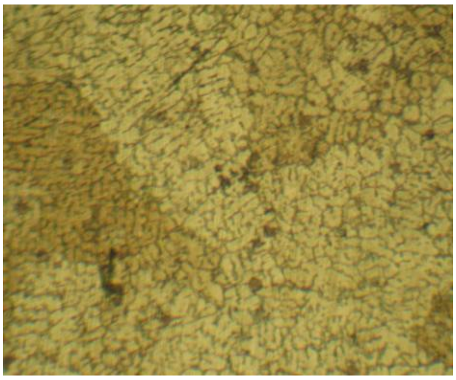


a

b

Fig. 4. Optical microphotographies

intemetallics with globular- dendrites morphology by small dimensions, dendrites branches by small dimensions.



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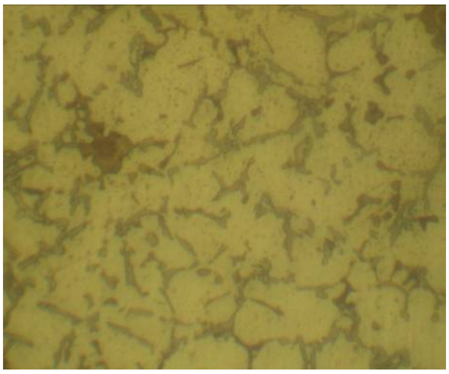

d

Fig.4. Optical microphotographies

Fig.5. INSTRON 3382 machine tools

The traction experimental research was made take into account the European standard EN 10002-1, using INSTRON 3382 (SUA) machine tools, Fig. 5, with software Bluehill Series IX^{TM}.

a. Characteristics: nominal load 100kN; minimum speed – 0,005mm/min; maximum speed – 500mm/min; resolution of displacement measurement – 0,0598μm; precision of load cell ±0,5%; precision of displacement distributor ±0,5%.

b. Parameters

- Speed of traverse advancement v_d = 1, 0 mm/min;
- Deformation temperature $23^o \pm 0, 5°C$ (laboratory with air-conditioning)

Characteristics curve

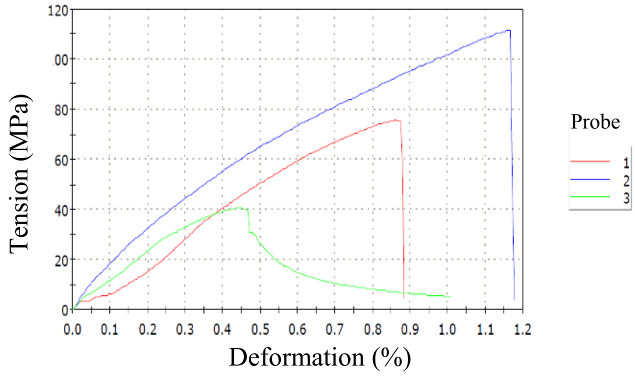

Fig.6. Characteristics curves of traction testing

Technical parameters vales used are as follow:

1) Probe 3_1: Maximum Load (N) = 948, 28; Modulus (E-modulus) (MPa) = 12583, 40; Tensile stress at Tensile Strength, (MPa) = 75,462; Tensile strain at Break (Standard), (%) =0, 88; Tensile stress at Yield (Offset 0, 2%) (MPa)= 75,040; Tensile strain at Yield (Offset 0, 2%), (%) =0, 87;

2) Probe 3_2: Maximum Load (N) = 1401, 92; Modulus (E-modulus) (MPa) =13982, 20; Tensile stress at Tensile Strength, (MPa) =111,561; Tensile strain at Break (Standard), (%) =1, 17; Tensile stress at Yield (Offset 0, 2%) (MPa)= 88,019; Tensile strain at Yield (Offset 0, 2%), (%) =0, 80;

3) Probe 3_3: Maximum Load (N) = 508, 33; Modulus (E-modulus) (MPa) = 11877, 18; Tensile stress at Tensile Strength, (MPa) = 40,452; Tensile strain at Break (Standard), (%) =0, 47; Tensile stress at Yield (Offset 0, 2%) (MPa)= 31,637; Tensile strain at Yield (Offset 0, 2%), (%) =0, 41.

The values of the traction test (Fig. 6) will be improved with the increasing of the SiC percentage introduced into the alloy.

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