SOME EXPERIMENTAL ASPECTS CONCERNING THE STRATIFIED COMPOSITE MATERIALS WITH METALLIC MATRIX

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Abstract: The technical paper presents some experimental aspects concerning the stratified composite material obtained using the direct pressing process. Were used the glass fiber with 0,3mm thickness and 1,4mm of mesh. The main results which will presented inside of the paper are as follow: traction break resistance of base alloy used (90,12%Al, 3,46%Cu, 4,8%Si, 0,24%Mn, 0,22%Mg, 0,4%Fe) and stratified composite material obtained; SEM images with embedded fibers inside of metallic matrix; the elements repartition from matrix and fibers (EDX images): Al repartition inside of metallic matrix, Cu repartition inside of metallic matrix, O repartition inside of SiO_2 fibers, Si repartition inside of SiO_2 fibers and metallic matrix; content elements variation from metallic matrix and fibers along reference line.
Key words: stainless, stratified, composite, metallic, matrix, fiber.

1. INTRODUCTION

Laminated composites are composed of two or more layers of two larger than the third. A layer thickness is between (0,1 ...1)mm. In general, these composites consist of (4...40) layers. Fiber orientation may change from one layer to another. Each additional layer of composite material in the form of continuous fibers can be oriented unidirectional or bidirectional. If unidirecţional the composite materials have high strength and stiffness properties in the direction of alignment of the fibers, [Rohatgi, P., 1988].
Laminated composites can be obtained using and short staple fibers. Fibers may be arranged one-way or have a random distribution.
Discontinuous fiber composites are characterized by values of main mechanical properties, lower material with continuous fibers. However, random orientation of the complementary phase leads to improving these properties.
Laminated composites can be classified in, [Hall, BJ, 2003]:
-composite laminates, obtained using a single type of fiber;
-hybrid composites obtained from two types of fibers in the same array.

The best known of this group are composite materials with organic matrix and an additional phase consists of a mixture of carbon and glass fibers. These composites have improved mechanical properties due to the elasticity of carbon fibers.
The main advantages afforded by the composites consist of the following aspects [Noton, BR, 1987]: the combination can create many variations of matrix; may modulate the properties of all proportion by the choice of complementary material; are lightweight and their use leads to a significant decline in weight parts; rigid material can be made large and resistant to torsion; have a very good resistance to wearing by friction, a process equivalent to that of fracture or deformation.

1.1. Metallic composite materials (MCM)

Metal matrix composites "metal matrix composites" are compound materials, which have high strength and resistant to high temperatures, up to about 1500K, [Carcea, I., 2008].
These materials are composed of a base (matrix) metal (metal or metal alloy) and insertion components (reinforcement), metal, carbon fiber or ceramic fiber, the latest form of yarn or fibers (long, short or whiskers) and some cases the form of strips, flakes or powder. Their properties are presented in table 1, [Moldovan, P., 2008, Zhu, Z.A., 1988].

Table 1. Properties of MCM

Metal matrix	Resistance		Tension / Effort	
	Constituents	% Vol	Matrix unreinforced	Composite material
Strength of metal fiber				
Copper	Fibre de W	60	20	200 i)
Silver	Whiskers Al_2O_3	35	10 ii)	75 ii)
Aluminum	Al_2O_3	35	25 iii)	161 iii)
Nickel	B	8	70 iii)	384 iii)
Metals	Al_2O_3	36	40 iii)	237 iii)
Titan	Mo	20	80 iii)	96 iii)
Resistance metal by carbides sintered				
Cobalt	WC	90	E=30 iv)	E=85 iv)
Nickel	TiC	75	E=31 v)	E=55 v)

In the table 3 the following semnifications are: i) tensile strength of continuous fiber; ii) tensile strength at 350ºC; iii) tensile strength at room temperature; iv) modulus of elasticity is measured compressive (600000psi); v) modulus of elasticity is measured compressive.

Metallic composite materials are presented in various forms: semi (plates, sheets, wire, profiles) default configurations pieces (finished parts) with functionality specified combinations (eg radiators). To achieve the MCM, the main methods used in relation to the state matrix, are methods in solid phase, liquid phase methods, chemical deposition methods etc.

Solid phase methods for obtaining MCM shall [Skorokhod, VV, 2003]:

-hot-pressing;
-hot-rolling;
-sintering (after pressing, powder metallurgy techniques);
hot-drawing.

Liquid phase methods for obtaining MCM are:

-infiltration under pressure or vacuum;
-casting forging;
-casting mold;
-mixing in the liquid.

1.2. Laminated composite materials

Layered laminated composite material consisting of at least 2 layers of materials attached (tied together). It can thus combine the best properties of the material components, resulting in higher material that resistance, stiffness, density, aesthetics, corrosion and moisture resistance, thermal insulation, sound etc.. In this class are: bimetalele, metal protection, laminated glass, laminated materials, fibrous laminated.

-Bimetals: laminated composites are derived from two different metals with significantly different coefficients of thermal expansion. The change of temperature, bimetallic typically deforms and may be used as a means of measuring the temperature;
-Metals protection: cover made of metal with each other, resulting in composite materials with improved properties over some base metals;
-Laminated glass (or bottle securitul security): is a material composed of a layer of polyvinyl-butirol, placed between two layers of glass. Glass protects the plastic traces and gives rigidity, while a plastic is less brittle type;
-Layered materials: the materials are obtained which can be saturated with various plastic substances and then treated accordingly.

The layers of glass or asbestos can be impregnated with silicone to obtain composite materials resistant to high temperatures. Polyamide 6 Glass or structure may be laminated with various resins, resulting in a composite material with high resistance to shock;

Laminated fiber-composite materials: is a hybrid class of composite materials, fibrous materials and a technique involving the settlement of their layers. Usual name is layered laminated composite material reinforced with fibers. Layers of fiber-reinforced material so fibers are made of a layer are parallel and each layer is properly oriented to achieve the best possible strength and stiffness in certain directions. Fibrous composite materials are obtained by the integration in the basic materials - called matrix - of fibers of different forms, configurations and processes shown in Figure 1.

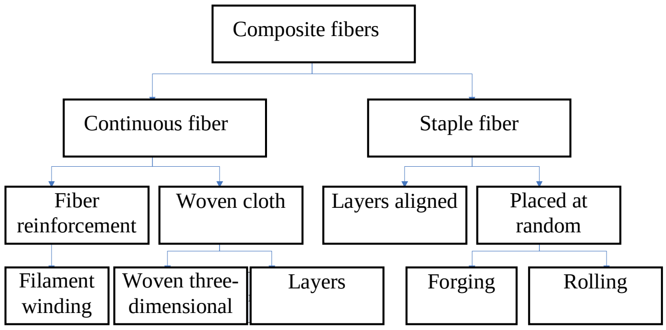


Fig. 1. Getting fiber composites

The layers through a process technology lead to the production of structural links between adjacent layers of matrices (pressing in closed dies at high temperature to eliminate excess gas and material). Examples of classification of laminated structures after geometry are presented in Table 1 and Figure 2, [Skorokhod, V.V, 2003, Misirli, C., 2010].

Of course not in all possible types of composite laminates. However, these examples show that the design of multilayered composites with a particular set of physical and mechanical properties, the choice of certain materials, is closely related to the possibilities of structural-geometric characteristics of control systems multristratificate, considered as a whole.

Table 2. The classification of laminated composites as structural geometric parameters

Regular structures		Irregular structures	Special Features
Type structure	Elements of symmetry		
"Sandwich", layers of parallel periodic	Layers in the direction normal	"Sandwich", with a parallel random alternation	Isotropic layers kept in the plane
Multilayered structures, corrugated strictly periodically	In two directions perpendicular to one another	Periodically corrugated layers with variable thickness	With a finite dimension in one direction (tip sheet)
Round layers (cylindrical) coaxial thickness	Cylindrical Spherical	Cylindrical objects with layers of thick aleratorie	Finite size in two directions
Spherical layers with constant thickness	Cylindrical Spherical	Spheroidal objects with thick layers of random	Finite dimensions, the three directions

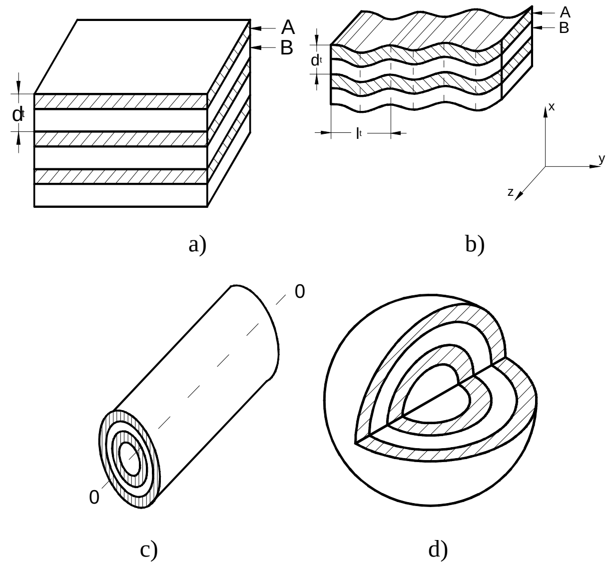


Fig. 2. Types of laminated composite with regular structure:
a: plane-parallel layers, d_t is the distance of transition from one layer to another in the direction perpendicular to the layers b: parallel corrugated layers, d_t and l_t are regular distances in the two directions (X and Y) c: Layers coaxial thickness in a cylinder, d: Sphere, separate layers of thickness spherical

In determining the physico-mechanical, more attention should be paid anisotropy. Upper and lower limits of actual values of physical properties for different composites were established by some researchers. In most cases, these values are expressed by well-known "brackets" Voicht-Reuss, [Al-Nimr, MA, 2001]:

$$P_{\max} = P_V = \langle P \rangle \quad (1)$$

$$P_{\min} = P_R = \left(\langle \frac{1}{P} \right)^{-1} \quad (2)$$

where, P is the physical property nescalară (sign < >representing the average volume). This estimate is valid for regular structures, and for irregular structures.

Actual values for thermal properties, thermoelastic and elastic laminated composites of flat, would correspond P_{ef} (||) and P_{ef} (⊥), longitudinal and transversal direction to maximum and minimum values. However, although the structure of these composites is relatively simple methods for calculating exact effective properties give some unusual and sometimes unexpected results.

Elastic tensions arising because of the coherence layers lead to different signs transverse elastic deformation, proportional to the values of Poisson's ratio. In metallic materials deformations coincide with the direction of thermal deformations and the ceramic layers have opposite them. As a result, we obtain the following expression of the actual coefficient of thermal expansion of a composite in the direction perpendicular to the layers:

$$\alpha_{ef}(\perp) = \langle \alpha \rangle + \left[(\alpha_1 - \alpha_{ef}(\|))\nu_1 v_1 - (\alpha_2 - \alpha_{ef}(\|))\nu_2 v_2 \right] \quad (3)$$

Deadline was in square brackets will always be positive.The mechanical properties play an important role in the operation, if the structural material may be considered two: modulus of elasticity and breaking the work.These conditions govern the behavior of structures under load, particularly appropriate tension and the critical level of elastic deformation capacity to withstand shock loads. Last feature is particularly important for laminated ceramic-metal composites and ceramic-ceramic.

Modulus of elasticity and Poisson ratio. Full description of the elastic properties of a laminated composite with elastic isotropic phase, requires a knowledge of the angular dependence of at least two features, usually being about module E and Poisson ratio, ν.

For a uniform composite, consisting of plane-parallel layers, the actual values of Young's modulus and Poisson ratio along the layers is determined by the average of Voicht, such as:

$$E_{ef}(\|) = \langle E \rangle ; \nu_{ef}(\|) = \langle \nu \rangle \quad (4)$$

The combination of layers of composite material is designed to increase resistance to impact or the work of fracture of the composite as a whole preserves the main functional properties.

1.3. Processing solid laminated composites. The process is used to combine the diffusion layers of foil and fiber.

Continuous fibers or preforms are placed between sheets of metal matrix and then subjected to hot pressure processing (Figure 3, [Al-Nimr, MA, 2001]). Merging of matrix and reinforcement material is achieved by interdifuzia between the two materials. Process parameters must be carefully controlled to achieve a proper mix. Preforms can be wires, strips or metal plates which had been introduced by infiltration, electrodeposition, and deposition of vapor, spray or powder in plasma shepherd.

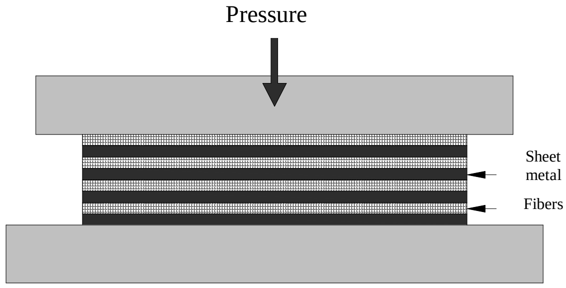


Fig. 3. Engineering merge by diffusion of continuous fiber composites

The scheme of completed various stages of fiber system - films during the consolidation process are shown in Figure 4, [Ghosh, A., 1993].

After running through the creep of the matrix of fibers to establish full contact metal fibers, films start at the interface diffusion.

To avoid degradation of the fibers is necessary to

maintain a low pressure during consolidation.
For a good mix is recommended that the film must have fine grains and the working temperature should be maintained at a value for which the matrix is soft or superplastic layer.
Such a process is used to obtain composites TiAl6V - SiC fiber or fiber type Borsi used to manufacture gas turbine engines. Interaction at the interface fiber - matrix during diffusion combination can lead to degradation of the interface.
The technique used for titanium matrix composites, fiber network is placed between the sheet metal. The assembly is then pressed in a vacuum. Uniaxal pressing is done, but more often used in hot isostatic pressing (HIP) that will produce products with varying geometric shapes.

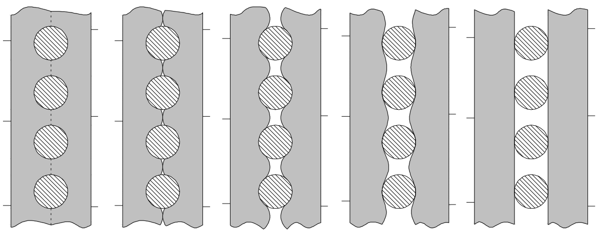


Fig. 4. The diffusion process scheme of consolidation of system fiber - film

Diffusion process of merging scheme is shown in Figure 5, [Ghosh, A., 1993].
The main advantage of this technique is the possibility of producing a wide variety of metal matrix composites with very good control of fiber orientation and volumetric fraction of them.

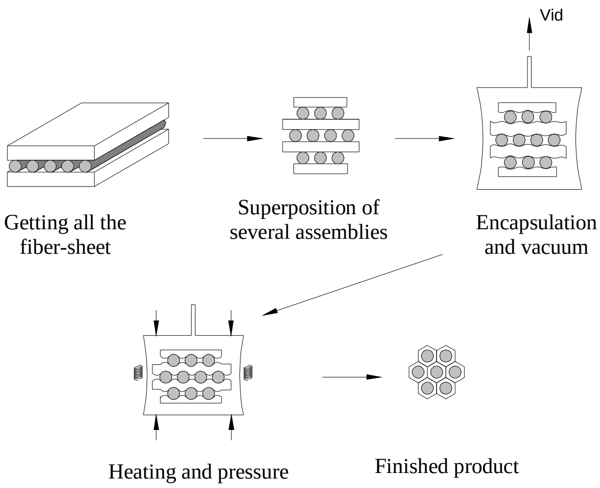


Fig. 5. The combining diffusion scheme to obtain metal matrix composites

2. EXPERIMENTAL TECHNIQUE

The methodology for obtaining laminated composites by liquid forging consists in doing the following stages:
-internal-surface preparation (mold and die) for sliding;
-lower mold-fitting lid;
-location ranfortului crucible bottom;
-matrix liquid preparation;
-matrix liquid pouring over ranfort;
-application of pressure;
-lifting equipment for placing the cap ring extraction;
-descent piston assembly for exhaust sample obtained;
-composite sample-extraction.
Liquid Forging was done using a matrix of their own design (Figure 6 and 7) mounted on a hydraulic press (Figure 8) 40tf. The matrix is under national file patent process.

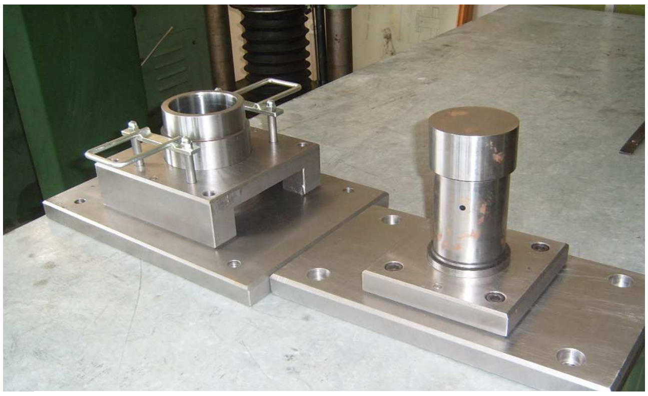


Fig. 6 The ensemble mold and die

In order to obtain blanks composite need these AMC sites and SDV sites:
-Temperature measurement matrix will be used thermocouple Cromel-alumel in wide temperature 400-900 [^{o}C];
-oven are developed matrix liquid (aluminum alumniu zinc);
-gauge for getting pressure forging liquids must be in a class high precision (the pressure required is at least 20MPa).

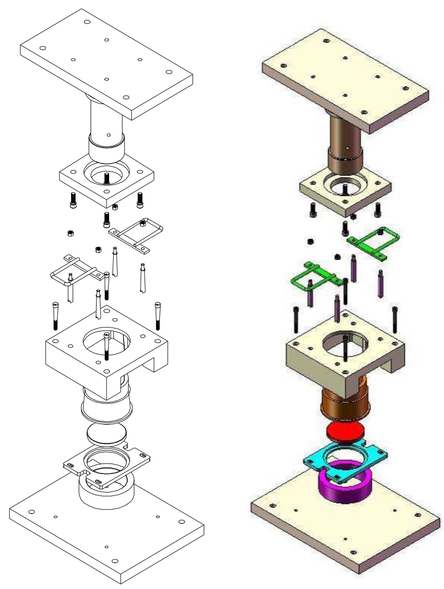


Fig. 7. The general scheme of the mold assembly

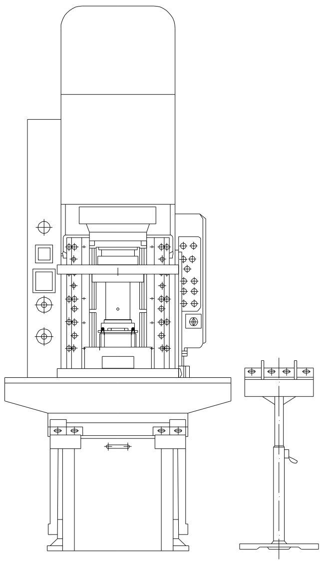


Fig. 8. The exterior front of hydraulic press

To realize the experimental research was used fiber glass fiber thickness (wire) of 0.3 mm and 1.4 mm size eye.

2.1. Tensile testing

Tensile testing was performed on standardized tests (EN10002-1) with the dimensions shown in table 3 (figure 9) using a tensile testing machine for INSTRON 3382 equipped with data acquisition system and specialized software Bluehill Series IXTM. Were taken into account: the speed sleeper [mm / min] and temperature [^{o}C]. For each composite combinations of table corresponding experiment planning has made three specimens which were tensile tested.

Table 3. Dimensions of test pieces tested

Calibrated diameter (d)	4 mm
Length between landmarks ($L_{0)}$	20 mm
The total length (L_t)	70 mm
Length calibrated (Lc)*	30 mm

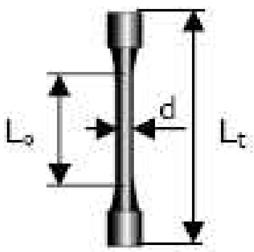
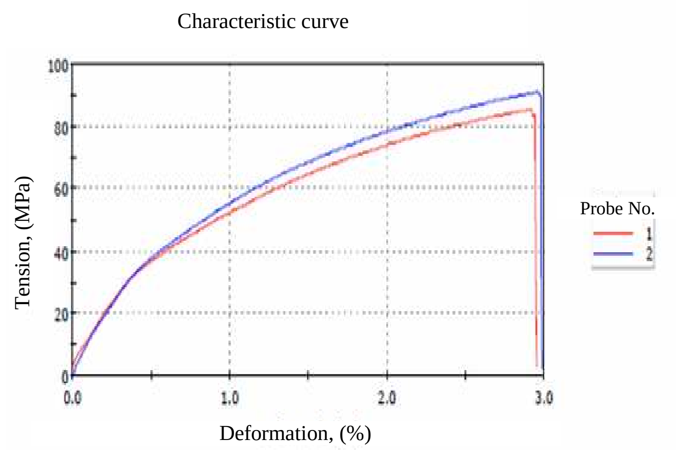
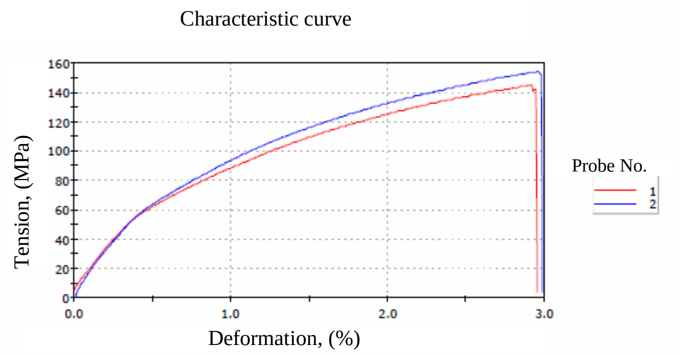


Fig. 9. Standard test-piece for tensile testing

For the base alloy (90.12% Al, 3.46% Cu, 4.8% and 0.24% Mn, 0.22% Mg, 0.4% Fe) tensile testing is shown in figure 10a and in figure 10b is presented for the test characteristic curve number 1. It can be concluded that with increasing concentration of inoxidable steel fibers increased traction resistance.



a)



b)

Fig.10. The characteristics curve: a-base alloy; b- composite material obtained

2.2. SEM and EDX imagines

If the reinforcements in Figure 11 presents the image fibers are embedded in aluminum metal matrix (SEM). Note the wire structure of glass fiber and relatively good wetting of glass fiber by the matrix metal.

Distribution of elements of matrix and fiber (EDX) is shown in figure 11b. Note the existence of micro-glass (SiO_2) and the presence and O. Figure 12 shows the variation of content of elements of matrix and fiber (Figure 12a) along the line benchmark (Figure 12a). It shows again the existence of glass fibers as the matrix metal ranfort.

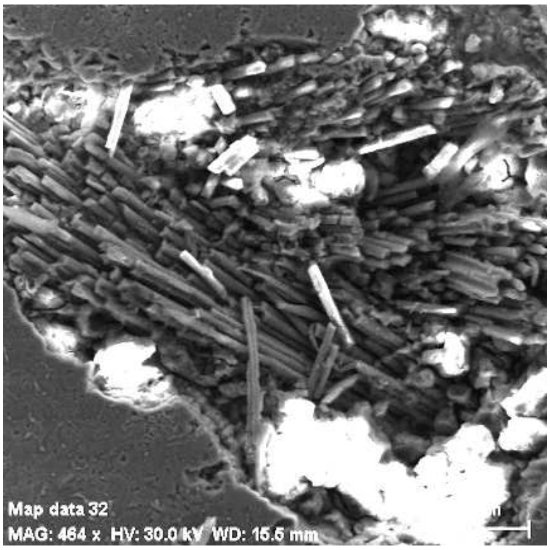
3. CONCLUSIONS

Manufacturing technology of metal matrix composites reinforced with fibers, described in the paper, by appropriate changes can be used to pilot or micro level.

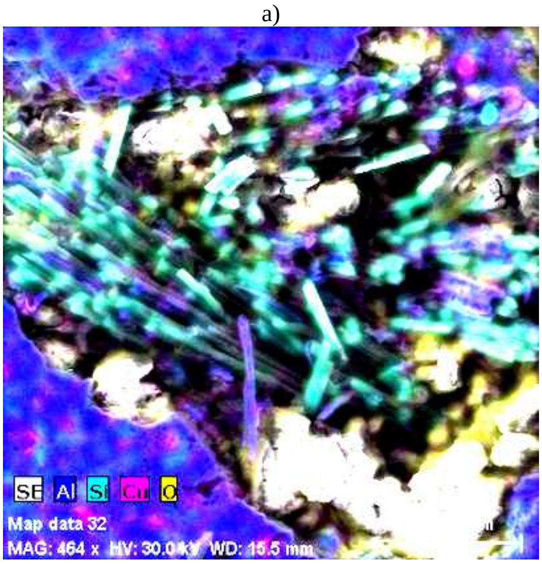
Composite materials obtained by the laboratory, by chemical or mechanical properties, are found to respond to new requirements for operation.

Tensile strength compared to alloy the base used, shows an increase of about (75-115)% for ranforsarii fiber glass.

Improving manufacturing technology and the choice of optimal ratio between the matrix and elements of reinforcement can lead to obtaining new materials with mechanical properties taxed and fit for purpose that will be used.



a)



b)

Fig. 11. Distribution of elements in the matrix and fibers

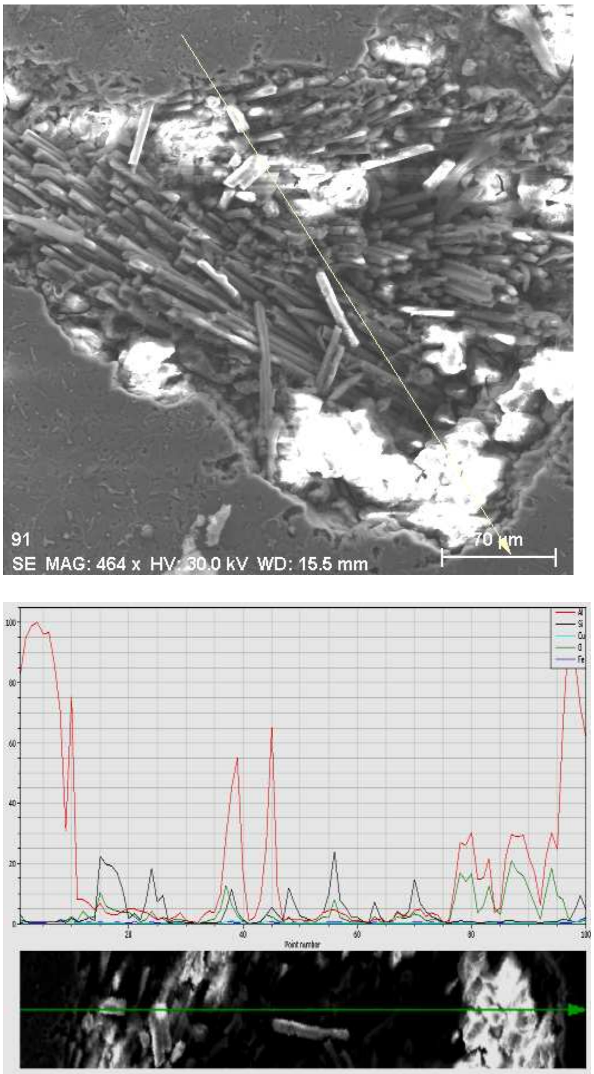


Fig. 12. Variation of content of elements in the matrix and glass fibers

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