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SHORT COMMUNICATION
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PRODUCTION OF HYBRID LAMINATED COMPOSITE MATERIALS WITH NANOPARTICLE REINFORCED 7075-T6 ALUMINUM MATRIX

Babanli Mustafa[1], Gurbanov Nurlan[2]

Department of Computer Engineering, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan

E-mail: [1]mustafababanli@yahoo.com, [2]nurlan.gurbanov@asoiu.edu.az

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ABSTRACT

In the present work, 1 mm thick 7075-T6 quality aluminum sheet, one-sided carbon fiber (unidirectional) fabric and epoxy resin were used as matrix material and Fiber Metal Laminated (FML) composite materials suitable for 4/3 assembly were produced. In the first production, epoxy resin was used without additives. In the second production, 0.2%, 0.5% and 1% graphite, clay and SiO_2 nanoparticles were added to the epoxy resin, respectively. The production of 7075-T6 aluminum matrix graphite, clay and SiO_2 nanoparticle reinforced hybrid laminated composite materials was carried out at 120°C and 1 ton pressure for 3 hours in a Hot Press Series branded hot pressing device.

Keywords: Composite material, FML, 7075-T6 Al, Graphite, Clay, SiO_2.

ABOUT THE STUDY

Composite materials are new materials that are created by combining materials with two or more different properties at the macro level. Composite materials consist of a matrix and filler. According to the matrix material, composites are divided into 3 groups: Metal, polymer and ceramic matrix, by type of filler: fiber reinforced, particle reinforced and structural composites.

Production of metal matrix composite materials began in the early 1960s to meet the demand for existing materials that could not be used at high temperatures and for new materials with high resistance (Mazumdar 2001)

Al and its alloys are widely used in industry as a matrix material in the production of metal matrix composites. The main advantages of aluminum are its wide distribution in nature, light weight, easy processing and corrosion resistance. Alloys are divided into groups according to their mechanical, physical, chemical properties and microstructure as 1XXX, 2XXX, 3XXX, 4XXX, 5XXX, 6XXX, 7XXX and 8XXX. The most heat-treated 2XXX, 3XXX and 7XXX series aluminum alloys are used in the production of composite materials (Kashfi et al, 2017).

Fiber metal layered composite materials are hybrid composite materials produced by combining fiber-reinforced polymeric materials into thin metal sheets. Production processes of metal matrix hybrid composites, which initially began only with the reinforcement of aluminum metal sheets with fiberglass and aramid fiber, are now developing rapidly using alternative metal alloys and various fillers. Due to their superior properties, these materials are widely used in the aerospace and aerospace industries, especially in the defense industry.

Ashkin and friends produced 0.8 mm thick 2024-T3 quality aluminum sheets, one-sided carbon fiber fabric and epoxy resin+0.5% graphite filler, Fiber Metal Layer (FML) composites according to 3/2 assembly method.

One of the most effective ways to increase the adhesion of polymer resins between sheets can be achieved by adding clay and SiO_2 nanophils to these resins (Zareei 2019 and Benedict 2012).

It has been observed that graphite nanoparticles are very effective in increasing the shear resistance between fiber metal layers.

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Due to the positive contributions mentioned above, the purpose of this study is to strengthen the fibrous metal hybrid layered composites with graphite, clay and SiO_2 nanoparticle and to carry out the production process (Vallellano 2008).

In this study, hybrid layered composite materials: Al/CF0°-CF0°/Al/CF0°-CF0°/Al/CF0°-CF0°/Al thickness 1 mm 7075-T6 aluminum plate and 2 layers Reinforced with carbon fiber fabric and produced according to 4/3 assembly procedure. The carbon fiber fabric used in this composite material is unidirectional. The fiber directions are placed parallel to the direction of propagation of the aluminum plate. The sequence of the composite material produced is schematically shown in Figures 1 and 2.

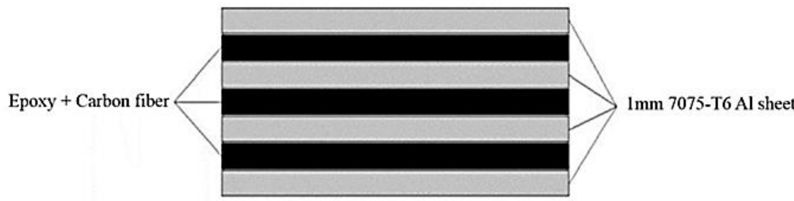

Fig 1. The sequence of the composite material produced is given schematically.

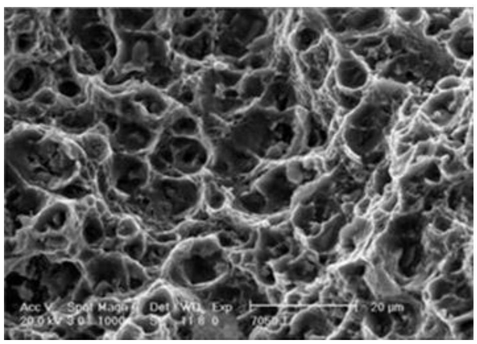

Fig 2. SEM microstructure of 7075-T6 aluminum alloy.

Table 1**.** Mechanical properties of 7075-T6 aluminum alloy.

Flow resistance (MPa)	**Towing resistance (MPa)**	**Elongation (%50)**	**Hardness (Brinel)**
min-max	min-max	min-max	min-max
460-505	530-570	10	140-160

The surfaces of the aluminum sheets were hardened with 60-grain sumbata paper before the production process (Figure 3A). After the aluminum plates are surface hardened, the plates were washed with clean water and ethanol and then dried. After these processes, aluminum plates were kept in 7% chromic acid solution for 30 minutes to remove residues such as oil and dirt that may remain on the surfaces. These processes are shown in Figure 3B. The plates were then washed again with distilled water and ethanol and dried again (Figure 3C).

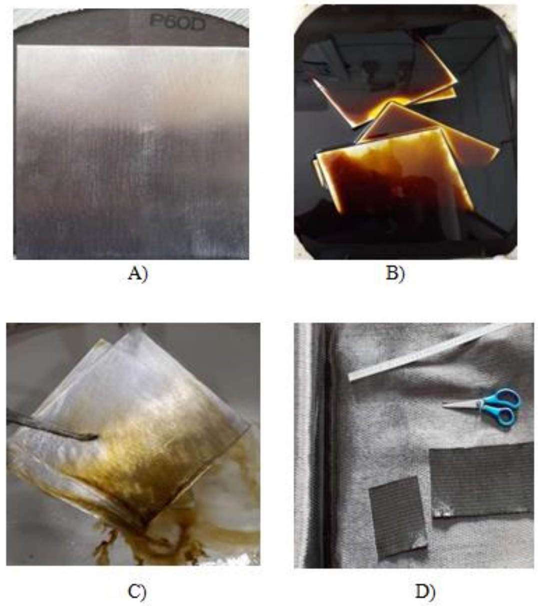

Fig 3. Preparation steps for the production of hybrid composite materials consisting of 7075-T6 aluminum sheet and carbon fiber fabrics. A. Hardening of the 7075-T6 aluminum sheet with 60 grit sumbata paper; B. 30 minutes retention time of 7075-T6 aluminum sheets in 7% chromic acid solution; C. Washing the 7075-T6 plates with water and ethanol alcohol; D. Cutting the carbon fiber fabric in 10 × 10 cm dimensions.

One-way high modulus carbon fiber fabric, which is used as reinforcement between metal sheets, is preferred for high performance, one-sided stiffness and strength. Carbon fiber has a fiber density of 300 g/m^2 and contains 12000 filaments in a single package, and DOSTKIMYA Co. Ltd. provided by. Carbon fiber pieces were cut into metal sizes 10 × 10 cm shown in Figure 3D plates. 2D structured graphite used as filling material, 3 nm thick, 1.5 µm (GNP) diameter (500 m/g, 99.5% purity), 18 nm thick nanogil (99.95%) and 15nm thick (99%, 50 purity) SiO_2 is supplied by the Nanocar company.

The microstructures of graphite, clay and SiO_2 nano materials, which are used as fillers in the production of composite materials, taken under the Carl Zeiss brand Scanning Electron Microscope (SEM).

Problem and solution

In the first step, pure MGS-L326 epoxy resin and MGS-H265 hardener (100:25) were homogeneously mixed in a bowl for the production of hybrid layered composite materials. Provided by Nanokar for subsequent production processes: 0.2%; Graphite, clay and SiO_2 nano fillers+MGS-L326 epoxy resin are homogeneously mixed at 0.5% and 1%, respectively. Nano powders were mixed with epoxy resin (100:25) by adding MGS-H265 hardener to form 9 different homogeneous compounds. After all the preparations for the production of composite materials are completed, the mold is placed on a 1 mm thick and 10 × 10 cm 7075-T6 aluminum sheet, then the epoxy resin is impregnated into the carbon fiber through a trowel by hand (Figure 4A). Then a 7075-T6 aluminum layer is added to the fibers, this process is completed in 4/3, AI/CF 0°-CF 0°/AI/CF 0°-CF 0°/AI/CF 0°-CF 0°. Protective paper, 7075-T6, is used to prevent the top and bottom of the aluminum plates from sticking to the mold during the pressing process (Figure 4B). The sequence of these actions is shown in Figures 4A-4C.

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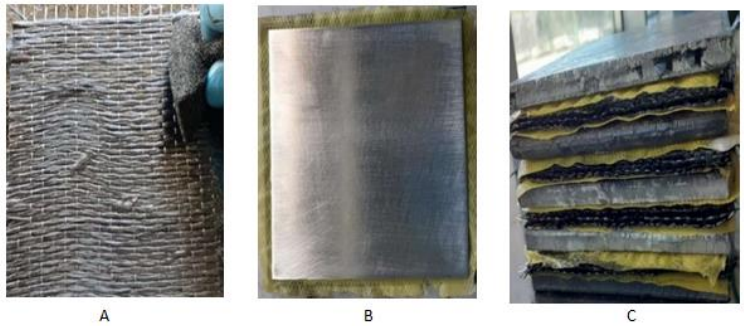

Fig 4. Stages of the preparation of composite samples. A. Absorption of resin into carbon fiber; B. Placing the 7075-T6 aluminum sheet on the protective paper inside the mold; C. Composite material ready for pressing.

The collected materials are presented in a Hot Press Series hot pressing device at 120°C for 3 hours and a pressure of 1 ton in a protective gas environment (Figure 5). After 3 hours, the composite materials prepared in the hot press device are taken from the device and left to cool at room temperature for 24 hours (Figures 6 and 7). The plot of the production stage mode of 7075-T6 aluminum matrix nanoparticle reinforced hybrid laminated composite materials is given in Figure 6 (Hui, 2012, Askin, 2019 and de Cicco, 2017).

Fig 5. Hot pressing device used in composite production.

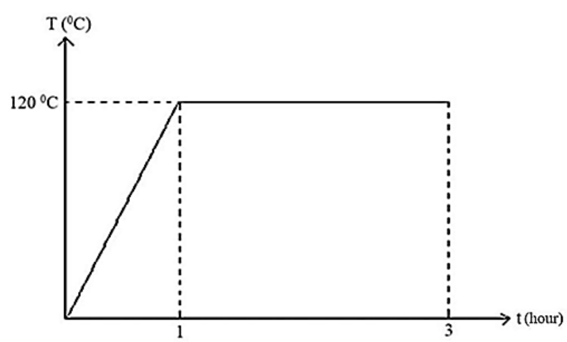

Fig 6. Graph of processing mode of hybrid laminated composite materials with nanoparticle reinforcement with 7075-T6 aluminum matrix

Fig 7. 7075-T6 Al matrix hybrid laminated composite materials.

CONCLUSION

The main goal of our research is to create new materials with higher mechanical properties that meet the needs of our developing defense industry. As a result of research in the literature, various methods have been identified for the production of hybrid composite materials, the most ideal of which is the Hot Pressing Method. When different proportions of nanomaterials are used in composites, the adhesion between the board's increases and, consequently, the mechanical properties of the composites improve.

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