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Mechanical Property Behavior of Cloisite 15A Mixed Epoxy Glass Fiber –Aluminium Sheets

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Abstract: Sheets made of alternate layers of Aluminium and Glass Fiber Reinforced layers are used in aerospace structures as these sheets possess good strength to weight ratio. In this work we have tried to increase the mechanical property of these sheets by mixing a minimum amount of Cloisite 15A in the epoxy resin system. Sheets with alternate layers of aluminium and GFRP were made with aluminium sheets on the outer side and tested for mechanical properties such as ultimate tensile strength, flexural strength and interlaminar shear strength for different percentage of Cloisite 15A in the epoxy resin matrix. It is found that the mechanical properties improved up to 3% addition of Cloisite 15A.
Keywords: Cloisite 15A, epoxy resin, GFRP, flexural strength, tensile strength

I. INTRODUCTION

Layers of Aluminium-Glass Fiber Reinforced sheet are made with thin sheets of aluminium fixed to both sides of GFRP layers. Since the layers are made of metal as well as FRP, these sheets show the best properties of both fiber and metal [1]. Metal like aluminium possess better impact damage behavior as well as good specific stiffness. GFRP have good corrosion resistance, fatigue resistance and high specific strength. Instead of entire solid metal, these layered sheets could be used to replace a portion of solid metal. This results in weight reduction but yet maintain good strength to weight ratio. Therefore, these layered material could be used as aerospace material where there will be large reduction in fuel cost due to savings in weight [2].

The layers of Aluminium and Glass Fiber Reinforced Plastic are so constructed such that the aluminium sheets form the outer side in the composite laminate. This arrangement is such that if there are ‘n’ number of GFRP layers, then the metal layers will be ‘n+1’[3]. Studies have been carried out to find the effect of thickness change in metal layers, change in fiber direction, change in the fiber type, change in the GFRP thickness and change in the volume of fiber percentage used on the mechanical properties of the system.A study about the drawing properties of metal composite system was carried out by Gresham et al [4]. He found that wrinkling was increased by a low blank holder force (2 kN) and when the blank holder force was increased to 14 Kn there was no wrinkling but there was a likelihood to fail due to tearing or fracture. Glyn Lawcock et al [5] carried out testing of mechanical strength and observed the effect of variation in adhesive bonding between aluminium and carbon fiber reinforced panel systems. They observed that the interfacial bond strength got lowered and this decreased the interlaminar shear strength by 10%. They found that the tensile strength and elastic modulus was not changed. The scaling effect on the tensile strength of sandwich aluminium composite laminates was studied about Carrillo et al [6]. They observed that the scaling did not affect the normalized elastic modulus and the modulus remained constant. They also found that there was a small decrease in tensile strength from 160 to 153 MPa in the 1D and 3D scaled samples with increase in scale size. However, there was an increase from 150 to 160 MPa when the scale size increased. The delamination buckling of metal fiber composite laminates was studied by Remmers et al [7]. They found that the laminates are showed high response to delamination buckling if a partially delaminated panel is loaded by a compressive force. The mechanical properties of steel/aluminium GFRP laminates was studied by Khalili et al [8]. They observed that the behavior of fiber metal hybrid panelsis superior to that of plain GFRP and this makes such systems for use as aerospace material. The off-axis inelastic and fracture characteristics of aluminum-GFRP laminates subjected to tensile force by Kawai et al [9]. They observed that there was a reduction in elastic modulus by 25% when there is an increase in off axis angle from 0 to 90$^{o.}$ They also found that transverse cracks appeared in the FRP layers before the fracture of hybrid laminate for off axis angle grater then 5^{o}.Wu et al [10] carried out experiments on the tension test specimens of hybrid laminated composites composed of aluminium and aramid fibers. They did tensile test experiments on both straight sided as well as dogbone shaped test specimens. They found that the specimen that was straight sided had 3% lower ultimate tensile strength than that of the dogbone shaped. The fatigue and damage tolerance of the aluminium-glass fiber epoxy hybrid laminates was studied by Alderliesten et al [11]. They observed that the crack growth resistance was very good because of delamination mechanism and bridging of fiber in hybrid panel systems.

In this work, we have done experiments to increase the mechanical properties and specific strength of Aluminium-Glass Fiber Reinforced Plastic layers by introducing a low percentage of Cloisite 15A in the epoxy resin system.

II. EXPERIMENTAL

The test specimens were made by using the following materials.

A. Aluminium alloy sheets – AA 1050 H 14;
B. E-glass fiber reinforced in epoxy resin
C. Epoxy resin as adhesive. (LY556 and HY 951)
D. Cloisite 15A particles of size 2 to 13 micrometer, a nanoclay organically modified with dimethyl, dehydrogenated tallow, quaternary ammonium salt.

The shape of the test specimens was made to that of dogbone. The thickness GFRP layer in the middle of the sandwich is 1.7mm and the thickness of outer aluminium sheet layers is kept at 0.4mm. This gives an aluminium thickness fraction of 0.32. The fiber volume fraction in the GFRP layer is maintained at 35%. The specimen was fabricated by hand layup method. A mold confirming to the shape of the specimen was made using acrylic. The cleaning of aluminium surface was done by using acetone liquid. The aluminium sheet was kept in the mold. Cloisite 15A of various weight percentages like 0,1,2,3,4 and 5 were mixed with the epoxy resin by mechanical shear mixing carried out for one hour at ambient temperature. Then the mixture is sonicated for six hours. Hardener is then mixed and stirred for about 20 minutes. This mixture is coated over the aluminum layer surface that is already kept in the mold. E -glass fibers in unidirectional orientation parallel to the longitudinal axis of the specimen were placed in the mixture. Thereafter, outside aluminium sheet was placed. The mold cavity was closed using a wax coated acrylic sheet. This arrangement was left curing for six hours at room temperature. Using a universal tensile testing machine (SIMADZU make) the specimens were tested for tensile strengthat room temperature with a crosshead speed of one mm per minute. Flexural testing was done using three point bending configuration that had a support span length of 40mm. The crosshead speed was kept at 10mm/ min.

III. RESULTS AND DISCUSSIONS

Table-1 shows the influence of Cloisite 15A mixing on the tensile, flexural strength and interlaminar shear strength of Aluminium-Glass Fiber Reinforced Plastic composite layers.

Table i
Variation in mechanical properties for various weight % cloisite 15a

S.No	Cloisite 15A %	Elastic modulus (GPa)	Ultimate Tensile Strength (MPa)	Flexural strength (MPa)	Inter Laminar Shear Strength (MPa)	Specific Stiffness	Specific strength
1	0	39.5	371	553	43	0.01845	0.1733
2	1	40.5	386	582	45	0.01919	0.1829
3	2	41.8	410	626	48	0.01981	0.1943
4	3	43.6	441	671	52	0.02066	0.2090
5	4	43.2	421	640	47	0.02047	0.1995
6	5	42.1	398	583	44	0.01995	0.1886

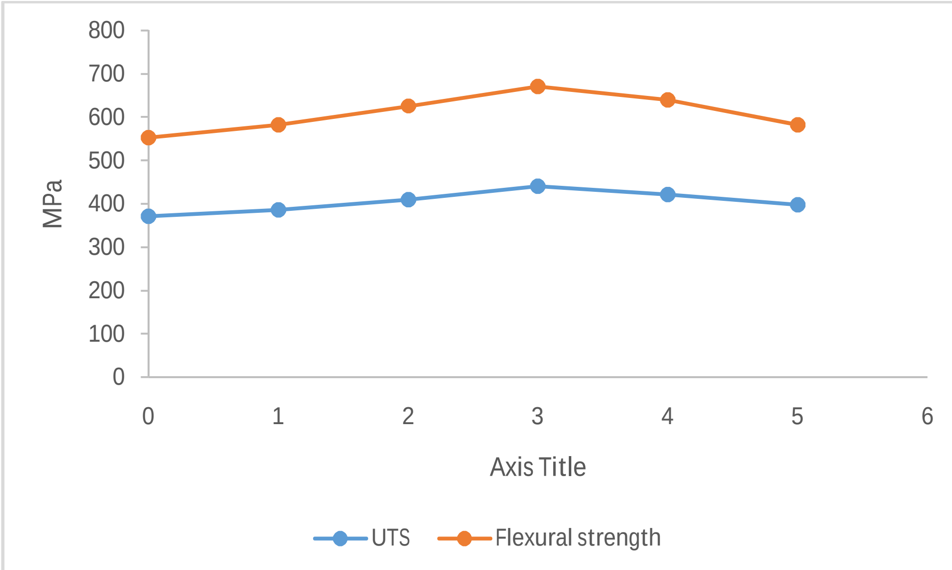

Fig.1 Variation in UTS and flexural strength for different weight % Cloisite 15A

It is observed that upto 3% loading of Cloisite 15A (Table-1), the elastic modulus increases. Thereafter, decreases for increase beyond 3% mixing. Properties such as ultimate tensile strength, flexural strength and interlaminar shear strength also increase upto 3% and then start decreasing. There is an increase of 10%, 19%, 21% and 20% in the elastic modulus, ultimate tensile strength, flexural strength and interlaminar shear strength respectively between the pure epoxy and 3% Cloisite 15Ablending. It is also found that the specific stiffness and the specific strength increases12% and 20% respectively upto 3% Cloisite 15A mixing. The reason for decrease in the tensile strength and increase in flexural strength is due to the area of contact becoming less between the Cloisite 15A and the epoxy resin.

IV. CONCLUSIONS

Specimens with Cloisite 15A mixed in epoxy resin of the Aluminium-Glass Fiber Reinforced layers were fabricated and tested for their mechanical properties under various blending percentage of Cloisite 15A. It is found from the results obtained that there is increase in the elastic modulus, tensile strength, flexural strength and interlaminar shear strength upto 3% mixing of Cloisite 15A and above 3% addition, the properties decreases.

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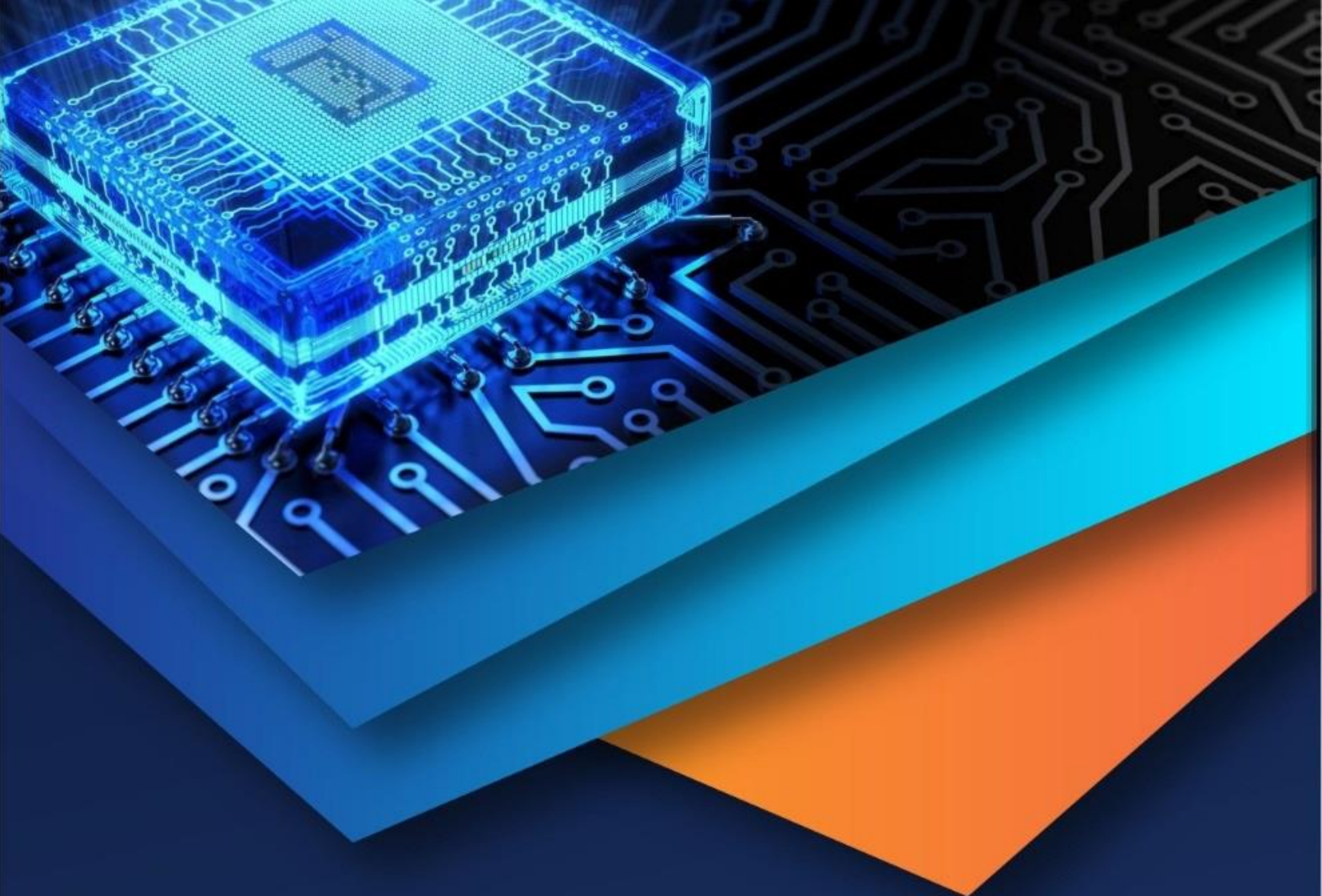

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