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Development of E glass Epoxy Reinforced Composite with Graphite Powder as Filler Material

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Abstract - *In the present work, graphite (size under 75 µm) is taken as smaller scale filler for arrangement of epoxy composites and E glass as reinforcement. The experiment is done with the calculated compositions of the composite material and the mechanical properties are tested and compared to the existing metal. Mechanical properties, for example, Tensile Strength, Hardness and Impact Stress are considered according to ASTM models. The composite are readied utilizing hand layup method followed by vacuum bag molding.*

Key Words: Composite Material, Epoxy, E glass fibre, Graphite Powder, Hand layup, Vacuum bag moulding

1. INTRODUCTION

A composite material (likewise called a composition material or abbreviated to composite, which is the normal name) is a material produced using at least two constituent materials with fundamentally unique physical or synthetic properties that, when consolidated, produce a material with attributes not quite the same as the individual segments. The individual segments stay independent and particular inside the completed structure, separating the composites.

The new composite material might be favoured for many reasons. Regular models incorporate materials which are more compactable, lighter, or more affordable when contrasted with customary materials. Composites are comprised of individual materials alluded to as constituent materials. There are two primary classes of constituent materials: framework (folio) and support. In any event one part of each kind is required. The network material encompasses and supports the fortification materials by keeping up their relative positions. The fortifications grant their extraordinary mechanical and physical properties to improve the network properties. The synergy produces material properties that cannot be obtained by a single constituent material, and a wide variety of lattices and reinforcement materials allow the designer of the product or structure to choose the ideal combination.

Designed composite materials must be framed to shape. The network material can be acquainted with the fortification previously or after the support material is set into the shape depression or onto the form surface. The network material encounters a merging occasion, after which the part shape is basically set. Contingent on the idea of the lattice material, this merging occasion can happen in different ways, for example, synthetic polymerization for a thermoset polymer grid, or cementing from the liquefied state for a thermoplastic polymer network composite.

An assortment of embellishment strategies can be utilized by the end-thing structure necessities. The chief variables affecting the philosophy are the natures of the picked lattice and fortification materials. Another significant factor is the gross amount of material to be created. Enormous amounts can be utilized to legitimize high capital uses for fast and mechanized assembling innovation. Little creation amounts are suited with lower capital uses however higher work and tooling costs at a correspondingly more slow rate.

Numerous industrially delivered composites use a polymer network material frequently called a pitch arrangement. There are a wide range of polymers accessible relying on the beginning crude fixings. There are several general categories and each category has a different variety. The most famous are polyester, vinylester, epoxy resin, phenolic resin, polyimide, polyamide, polypropylene, PEEK, etc. The fortification materials are frequently filaments yet in addition regularly ground minerals. The different techniques portrayed underneath have been created to decrease the gum substance of the last item, or the fibre content is expanded. As a dependable guideline, lay up brings about an item containing 60% sap and 40% fibre, while vacuum imbuement gives a last item with 40% tar and 60% fibre content. The quality of the item is incredibly subject to the proportion.

1.1 Materials Used

The below mentioned materials are used in the preparation of the composite material that is, Epoxy as base matrix, E glass fiber as reinforcement and Graphite powder as filler material. The properties and history of each are discussed below.

1.1.1 Epoxy

It alludes to any of the essential parts or restored final results of epoxy saps, just as an everyday name for the epoxide practical group. Epoxy bitumen, also known as polyepoxide, is a class of sensitive prepolymers and polymers that contain accumulation of epoxy resin.

epoxy rubber can react with itself (interconnected) through a synergistic homopolymerization reaction, or with a variety of co-reactants (including multifunctional amines, acids, phenols and alcohols) (interconnected). These choreactants are often referred to as hardeners or curing agents, while the interconnection reactions are often referred to as repair agents.

Response of poly epoxides with themselves or with poly functional hardeners frames a thermosetting polymer, frequently with ideal mechanical properties and high warm and compound obstruction. Epoxy has a wide scope of uses, including metal coatings, use in hardware/electrical segments/LEDs, high strain electrical encasings, paint brush producing, fibre-strengthened plastic materials, and cements for basic and different purposes.

1.1.2 E glass Fiber

It was initially created for remain off separators for electrical wiring. It was later found to have amazing fibre shaping capacities and is presently utilized solely as the fortifying stage in the material usually known as fiberglass.

Glass strands are by and large delivered utilizing melt turning methods. These include liquefying the glass creation into a platinum crown which has little gaps for the liquid glass to stream. Filaments are sliced to length utilizing mechanical methods or air planes.

Fibre measurement and somewhat properties can be constrained by the procedure factors, for example, liquefy temperature (thus thickness) and drawing/turning rate. The temperature window that can be utilized to deliver appropriate consistency is very huge, making this arrangement reasonable for fibre shaping.

As strands are being delivered, they are regularly treated with estimating and coupling operators. These decrease the impacts of fibre-fibre scraped spot which can fundamentally corrupt the mechanical quality of the individual filaments. In addition, different drugs can be used to promote the wetting and adhesion of the matrix material to the fibers.

Table -1: Table indicating the properties of different fibers.

Fiber type	Density, (g/cm3)	Tensile Strength, MPa	Modulus, GPa	Percent Elongation
A-glass	2.44	3300	72	4.8
AR-glass	2.7	1700	72	2.3
C-glass	2.56	3300	69	4.8
D-glass	2.11	2500	55	4.5
E-glass	2.54	3400	72	4.7

1.1.3 Graphite Powder

Graphite is broadly utilized as a building material over an assortment of uses, for example, cylinder rings, push direction, diary orientation, and vanes. Carbon-based seals are utilized in the fuel siphons and shafts of a few flying machine airplanes.

It has a high liquefying point, like that of jewel. So as to dissolve graphite, it isn't sufficient to extricate one sheet from another. You need to break the covalent holding all through the entire structure. It has a delicate, elusive feel, and is utilized in pencils and as dry grease for things like locks. You can consider graphite rather like a pack of cards - each card is solid, yet the cards will slide over one another, or even tumble off the pack through and through. At the point when you utilize a pencil, sheets are focused on and adhere to the paper. It has a lower thickness than precious stone. This is a direct result of the generally enormous measure of room that is "squandered" between the sheets. It is insoluble in water and natural solvents - for a similar explanation that precious stone is insoluble. The attraction between the soluble particles and the carbon iota will never be enough to defeat the solid covalent bond in graphite.It also conducts power. The delocalized electrons are allowed to move all through the sheets.

2. LITERATURE SURVEY

Many studies have been conducted on composite materials to obtain better mechanical and physical properties compared to regular materials. As we are developing a composite material that can replace the body of an aircraft, the following are a few journal references that have helped us build our composite

G. Devendhar Rao has studied the mechanical properties of e glass/ epoxy composite materials for fillers ($SiO2$ Also PTFE) is conducted [1]. Recently produced composite materials are described as their mechanical properties in elastic tests and ultimately tensile strength tests and flexural tests. Their different mechanical characterization tests are accounted here. Result being, higher the filler material volume rate more excellent those quality to both $SiO2$ also PTFE loaded glass epoxy composites, $SnO2$ loaded composite hint at a greater amount manage values over PTFE.

Hanafi Ismail made natural rubber composites by incorporation of different loadings of bamboo fibre [2]. Two series of composites were studied i.e. Composite materials with and without binders. Determine the curing characteristics of the composite material, and use a hot press to vulcanize the composite material at 150 ° C. The adhesion between the bamboo fiber and natural rubber is enhanced by the addition of a binder, as shown by the tensile fracture surface of the composite material using a scanning electron microscope (SEM).

Mr. Chavan V.B. studied the work done in the area of characterization of Glass Fiber/Epoxy composite material [3]. Different manufacturing processes are used to make glass fiber/epoxy composites. The behavior before tensile, shear and bending loads and the different manufacturing processes of laminated glass fiber/epoxy composites are the main areas of interest for researchers.

Subita Bhagat experimented graphite fortified epoxy composites with distinctive particulate portions of graphite were researched for mechanical properties [4]. For example, tractable, sway and flexural. The graphite content was differed from 2% to 8% by weight of all out lattice in the composites. The outcomes indicated that the mechanical properties of the composites principally rely upon scattering state of the filler particles, molecule estimate and total structure. The composites indicated improved tractable modulus, flexural modulus and sway quality in twisting properties with increment filler content as the useful gathering will in general decline in composites with expanding filler content as gelation happens energetically in the composite.

R Vijay Kumar conducted an examination that has been completed to grow new PMC utilizing monetarily accessible Epoxy and Polyurethane tar frameworks [5]. These gum frameworks would be fortified with glass filaments, filler materials and aluminum foils. Overlays are set up by utilizing the hand lay-up procedures of eight layers and mechanical test, for example, tractable test and pressure test have been led. This work has been done to distinguish the suitable sap frameworks, filler materials what's more, glass fiber fortification to assess the quality of the composite. Two kinds of glass fiber (cleaved tangle and woven tangle) with fortification of filler material and aluminum foil used to appraise the quality of composite.

Nabil H. Hameed studied common elastic graphite composites (0, 1, 2, 3, 4 pphr of graphite). [16] They were built in the research facilities of two engine factories. More and more estimates are being used to evaluate the influence of graphite on regular elastic properties. The expansion results show that the regular elastic volume, the matching parameters, and the cross-connection thickness in the expanded gel decrease with increasing graphite charge, while the ordinary elastic normal atomic load between the cross-connections increases. . The vulcanization results show that the individual burn time parameter increases with increasing graphite load, while the different parameters (maximum torque, minimum torque, fixed rate, and fixed rate list) decrease. Both thermal conductivity and AC conductivity are expanded.

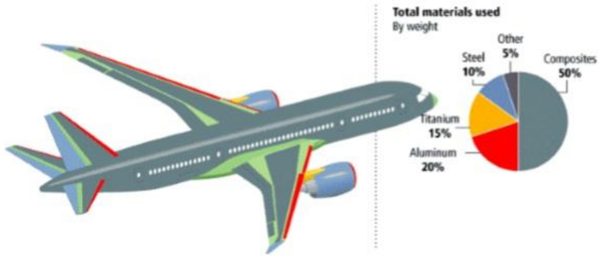

Fig -1: Total Material used by weight as of now.

3. CALCULATIONS

Table -3: Properties of selected fibers.

Fibres	Longitudinal Tensile modulus, e1 (Gpa)	Transverse tensile modulus, e2 (Gpa)	Poisson's ratio	Shear modulus (Gpa)
Glass	71	71	0.22	30
PBT	320			
Kelvar(49) Kelvar(29)	154 61	4.2	0.35	2.9
Graphite(AS)	224	14	0.2	14
Graphite(HMS)	385	6.3	0.2	7.7

Comparing the young's modulus of the existing material used in Aircraft i.e, Aluminum with our composite material to be designed in order to choose the most suitable composition for the fabrication of the new material. The values for the calculations are taken from the mechanical properties data table.

E aluminum alloy 7075= 71.7GPa

E filler, E graphite= 385GPa (e1 – Longitudinal tensile strength)

E matrix, E epoxy = 3.5GPa

E reinforcement, E E glass= 71GPa

E composite = (E reinforcement x V reinforcement) + (E matrix x V matrix) + (E fibre x V fibre)

E composite= (71 x 0.10) + (3.5 x 0.7) + (385 x 0.20)

E composite =86.55GPa

Therefore, E Composite > E aluminum alloy 7075.

Hence, we chose our composite compositions to be 20% graphite, 70% epoxy, 10% E glass for the preparation of composite material.

Calculation for Brinell Hardness Number,

$BHN = 2P/\pi D\ (D - \sqrt{D^2 - d^2})$
$D = 0.9$ mm
$D = 1/16 \times 100 = 1.5875$ mm
$P = 100$
$BHN = 2\times100/\pi \times 1.587\ (1.587 - \sqrt{(1.587)^2 - (0.9)^2})$
$= 143.33$ BHN
Calculation for Impact Strength,

Breadth = 10.86 mm
Depth below notch = 3.6mm
Area, B x D = 38.8 mm^2
Impact Energy, I = 8 Joules

Impact Strength, K = I/A
= 8/38.8
= 0.205 J/mm^2

4. METHODOLOGY

Once the compositions of each element were calculated, the preparation of the composite material was done in Reinforced Plastics Industry, Kavelbyrasandra with the help of industry experts. Firstly, the surface where the material is to be prepared has to be cleaned with acetone and release agent and wax ball is applied for easy removal once the material is made. Ten layers of E glass fiber is cut in Y direction and kept one top of the other. 556 epoxy resin and hardener 951 (ratio 10:1) along with 20% graphite powder is mixed and applied to each layer with a brush or blade. Applying resin on form surface preceding laying of texture encourages expulsion of captured air during compaction process - resin is constrained up through the texture alongside the air. Applying resin to texture on independent surface avoids resin rich (female shape) and resin starved (male shape) regions. A perforator is kept on top of which Teflon sheet and bleeder is kept to remove the extra resin from the composite which leaves the required amount behind during curing. The respirator is fixed on the top of the barrier film to uniformly apply vacuum pressure on the laminate and remove entrained air or volatiles during the curing process. Also resins which produce excessive volatile by-products during cure (must be vented) by using film with small perforations and large spacing to prevent breather from becoming clogged with resin. A vacuum bag is kept on top of the final laminate and bag sealant is taped and it is connected to the machine which is switched on for about 10 minutes and the finished composite is kept in an oven for post curing for about 2 hours 100 degree Celsius and the material is made.

The material was prepared by us in the Reinforced Plastics Industries, Kavalbyrasandra, Bengaluru with the help of industry experts including Mr. Pragalathan who is the CEO of the company. It took about 4 days to complete the composite material and the test specimens were made.

Fig -2: Graphite powder + E glass fibre + Teflon + Perforator + Breather = Composite

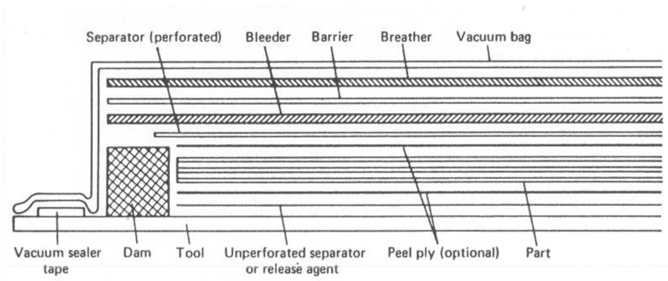

Fig -3: Vacuum bag molding with hand laid up composite inside.

As the idea is to incorporate the composite made in aircraft especially in the wings it was observed that the possibility of failure is more in the longitudinal axis. The wings take about 45% of the weight of the airplane. The skin/body transmits the streamlined powers to the longitudinal and transverse supporting individuals by plate and layer activity. I t creates shearing stresses which respond to the applied torsional moments also, shear powers. It acts I longitudinal axis when the structure is pressurized and the calculations are done accordingly.

5. RESULT ANALYSIS

Certain properties such as low density, good fatigue, performance, high wear, corrosion resistance and low cost are seen as universal requirements for effective functioning in the aerospace industry.

1. Ultimate Tensile Strength
2. Shearing Strength
3. Impact Strength
4. Hardness

We compared the existing results of Aluminum alloy to our results and these are the results obtained:

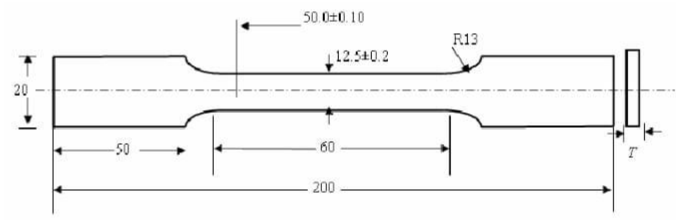

Fig -2: Dimension according to ASTM standards.

5.1 Ultimate Tensile Strength

The Ultimate tensile strength test was conducted using an UTM machine. The specimen dimension were taken according to ASTM standards.

Fig -2: Tensile specimen made by milling.

Material	Calculated Ultimate Tensile Strength	Obtained Ultimate Tensile Strength
Aluminum Alloy 7075	71.7 GPa	71.7 GPa
Our Composite material	86.55 GPa	82.5 GPa

5.2 Impact Strength

Material	Calculated Impact Strength	Obtained Impact Strength
Aluminum Alloy 7075	0.18 J/mm²	0.18 J/mm²
Our Composite Material	0.205 J/mm²	0.205 J/mm²

5.3 Hardness

The hardness test was done in 515 Armybase workshop using a digital Brinell Hardness Tester.

Material	Obtained Hardness
Aluminum Alloy 7075	150 BHN
Our Composite Material	143 BHN

5.2 Weight of the Material

Density of Al 7075 = 2.81 g/cm³ and Our composite material is 2.231 g/cm³

Trial	Weight (gms)	Volume (cm³)	Density (g/cm³)	Avg Density
1	100	55.836	1.79	**2.231 g/cm³**
2	62	27.659	2.24	
3	58	21.721	2.67	

6. CONCLUSION

As the idea is to incorporate the compound of aircraft, especially the wing, it was observed that the possibility of failure was on the longitudinal axis. The wings take about 45% of the weight of the plane. The skin / body transmits simplified energy to longitudinal and supported persons laterally by plate and layer activity. It produces cutting stress to react to the cutting force and the cutting force. The structure is pressurized and acts on the longitudinal axis when the calculation is made accordingly.

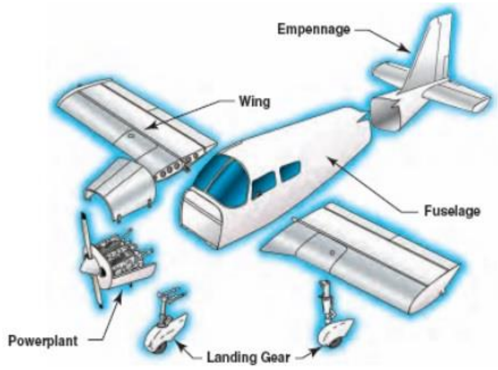

Fig- 3: Parts of an aeroplane

Since it is an application-based project, we need to compare the composite material to be manufactured with existing metals to predict the future performance of the material to obtain the required performance. In this case, we need the existing metal (ie aluminum) to have a higher tensile strength, which can theoretically be obtained using the above formula. The results can be predicted by impact test, hardness testing, and tensile testing. These tests will be studied according to ASTM standards. Typical Transport Aircraft Wing Structural Weight Distribution. From the data, we can see that 45% of the weight is the weight of the aircraft wing, which is used to make lightweight and effective composite materials.
Engine 20%
Interior: 15%
System: 20%

Airframe: 45%
Wing 45%
Fuselage 45%
Tail 10%
Improving quality and cutting cost are vital factors in the manufacturing industry. In our project we have focused on these two areas within the aviation industry. We have fabricated a composite material consisting of E-glass fibre, Graphite powder and epoxy resin. After conducting various tests on our material, we have culminated that our composite shows more desirable properties than that of the presently used material in the industry which is Aluminum 7075.
A total of four properties of our material have been tested:

- First being the tensile strength in which our material proved to be greater (14% stronger).
- Second is hardness in which our material is resulted to be slightly lesser than Al 7075 (by 4.6%).
- Third is impact which again favored our material hardness (12.1% harder)
- Lastly was the weight (20% lighter), where our material proved to be lighter than the aluminum alloy.

So overall 3 out of the 4 properties tested obtained results which were desired by us and 1 was slightly against. Also the cost of manufacturing our material turned out to be much more economical (by 7.5 % cheaper) and easier to produce than that of Aluminum 7075. With all the above observations, we can conclude that our composite material can replace the presently used Aluminum 7075 in the aviation industry with few more test as it is more feasible, has better properties and is also more economical.

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