International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.03, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

ANALYSIS OF VARIOUS MATERIALS FOR CENTRAL FRAME OF HEXACOPTER TO SUSTAIN VARIOUS STRUCTURAL LOADS

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ABSTRACT

In present time, Hexacopter is being used in every field. For E.g. agriculture, search/rescue mission, aircraft inspection etc. Hexacopter is usually had to withstand different type of environmental conditions as well as structural Aspects, For that materials with good basic mechanical properties are required to fabricate these copters. Different types of materials are used in hexacopter from aluminum to carbon fiber etc. Materials for each of its components have to be selected by suitability of material properties with parts use. In this paper we are going to work on carbon fiber, Aluminum and fiber metal laminates (FML). The Frame of Hexacopter consists of Central HUB which should have strength to withstand different types of forces. Its work is to fasten the four arms of the quad-rotor together and hold the electronics part off the ground. There is also Arms of Hexacopter which is important as it houses the motor and withstands the main vibration of motor. Other than mechanical properties for a particular material its weight and damage tolerance characteristics plays important role for the development of advance material for specific application in aerospace industry. Aiming this objective, we have selected the Fiber Metal Laminate (FML) for considered in hexacopter frame. FML is a combination of metal and polymer composite laminates can create a synergistic effect on many properties. The mechanical properties of FML show improvements over the properties of both aluminum alloys and composite materials individually. Main advantages of FML are Low moisture absorption as compared to other conventional materials. The moisture absorption is slow in FML as compare to Polymer composites in any substantial conditions.

Keywords:Hexacopter, fiber metal laminate, Impact, Composites, carbon fiber, glass fiber , Hub

I.INTRODUCTION

Multicopter, is an integrated system which is lifted and propelled by multi rotors. Multicopter is classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors.

Multicopter are used in different set of rotor for e.g. 3, 4, 8 etc. This multicopter is used as their application. Multicopter has different application in different field. Like in military, multicopter is used for surveillance, search/rescue missions, etc. As the important part of multicopter is its structure i.e frame of multicopter. So it is very important to have best frame as to sustain the various loads of multicopter. In order to provide the maximum payload the material selection for frame should be optimized.

Fig.1Hexacopter [1]

So the multicopter frame material should have small density, high rigidity, and high strength, As the commercial multicopters have to carry heavy payloads so the material should be strong enough to sustain the various loads as well as it should be easy to process.

The Properties of some kinds of materials used in Multicopter frame should have small density, high rigidity, and high strength and easy to process. So in order to meet the above characteristics the following types of materials are used to manufacture different parts of multicopters. Some of them are steel, composite material, glass fiber, carbon fiber, aluminum etc.

The most common material used is Carbon fibers or carbon fibers which are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. The unique properties of carbon fibers which are high stiffness, high tensile strength, high chemical resistance, low weight, high temperature resistance ,very low thermal expansion etc. makes the material most popular in the field of advance sciences in aerospace manufacturing, civil, automobiles etc. in spite of its expensiveness as compare to glass and plastic fibers it is commonly used.

Fig.2 Fabric made of woven carbon fiber **Fig.3 Glass fiber woven form**

Carbon fibers can be combined with other fibers to form a composite. When its combined with a resin wound or molded it gives the formation to carbon-fiber-reinforced polymer, having the property of high strength-to-weight ratio, also it is rigid and little brittle. This carbon fiber can be mixed with other material or fibers to form a new material with improved properties; the best example for this is when carbon fiber mixed with graphite it forms carbon-carbon composites with high heat tolerance properties. Temperature has no statistically significant effect on the tensile modulus. The average tensile strength showed no systematic variation with temperature. This shows that carbon fibers have high temperature resistance.[2]

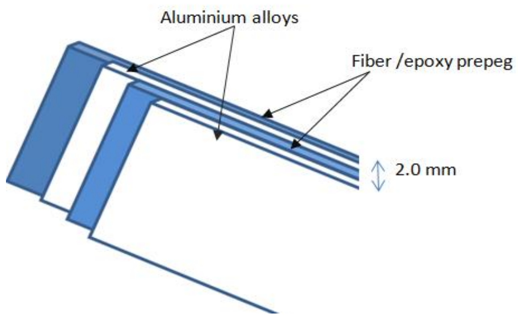
Glass fiber is a material consisting of various number of fine fibers of glass.. Glass fiber is not as rigid as compare to polymers and carbon fibers. But it is the cheapest fibre and it also has less brittle when used as composites. AS this fibers have unique properties it can be used as a reinforcing agent to form a very strong and relatively lightweight fiber-reinforced polymer (FRP), composite material called glass-reinforced plastic (GRP), it is popularly known by "fiberglass".According to the tensile end three point bending test results, the Carbon fiber composites were stronger than the Glass fiber composites, except for 90o orientation for tensile test. Tensile strains were higher in Carbon fiber composites, except for 90o orientation. In all orientations Glass fiber composites had higher flexural strains than the Carbon fiber ones. [3]

The combination of numerous different types of fibers (Bio fibers, Synthetic fibers & Metal fibers) into a single matrix or it may be two resin systems which led to the development of hybrid composites. The behavior of hybrid composites is total addition of the individual components in which there is a more favorable balance between the intrinsic advantages and disadvantages. hybrid composite which contains two or more types of fiber, the merits of one type of fiber could compensate with what are lacking in the other. This result a balance in cost and performance can be achieve by proper material design.[4]

Introducing the newFiber metal laminate (FML) which is an advanced hybrid material system that consists of layers of thin metallic sheets which are smartly bonded in alternate arrangement and whose curing is done by composite prepregswith heat and pressure. prepregs consist of several resin impregnated unidirectional fiber layers which is similar or different in orientation.

Fiber metal laminates is a hybrid composite materials built up from smart arrangement of various layers of thin metals and fiber with reinforced adhesives. The main incentive for the development of these hybrids is of high impact properties, along with damage tolerant behavior as compared other metal alloys.

II .CHARACTERISTIC FEATURES OF FML



High Residual Strength

The FML material provides high strength. The damage tolerance of FML could be high which is depending on the composition. It can sustain higher loads in damaged condition.

High Corrosion ResistanceFig.4 Layout of FML

The composite layers protect the internal metal layers from corrosion. The layered structure of FML is beneficial for the corrosion and absorption properties of the laminate.

High Flame Resistance

The flame resistance of FML is based on carbonization of the first composite layer and the de-lamination of the remaining layers. The aluminum alloy contributes with rapid heat dissipation due to its high thermal conductivity.

Ductility

The plastic deformation will relieve the peak stresses and prevent or premature failure.

High Fatigue Resistance

The fatigue resistance is due to the crack-bridging of the fibers. When the laminate is subjected to fatigue loads crack will initiate in the metal layers, but the fibers in the composite layers will bridge and retard the crack growth: The bridging of the crack reduces the stress intensity at the crack tip. This result in crack growth rates which are one or two orders of magnitude smaller than for aluminum alloys.

There were also different problem arises when fabrication process started such as

a) Selection of resin which can react with both material so that it can act as adhesive between both material.

b) Selection of process for fabrication such that material loss would be minimum.

c) As carbon fiber is costlier so limited amount is used for fabrication and testing, so loss of material also creates a problem.

III. PROBLEM IDENTIFICATION

Initial problem is the strength of central HUB of multicopter. As the progress is done in development of new alloys. Different materials are used to fabricate hub, but problem was that the strength of the hub get increased but its weight also get increased. So material which high strength has to be used but without increasing weight. After the development of carbon fiber, it was used in fabrication of central hub. It satisfy the high strength to weight condition.

But problem arises as carbon fiber is much costlier than other material. Some other materials like glass fiber was also used in fabrication but results were not as satisfactory as carbon fiber.

There were also different problem arises when fabrication process started such as

a) Selection of resin which can react with both material so that it can act as adhesive between both material.

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ISSN: 2319-8354

IV. FABRICATION OF FML

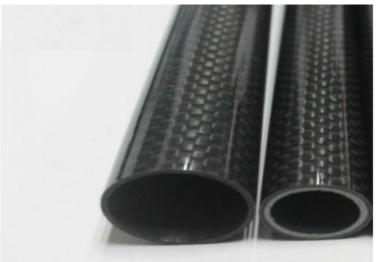

Fig. 5 Carbon Fiber tubes

The uses of Carbon fiber tubes are being more used in recent days due to its properties like like high strength, fracture and fatigue resistance, and high shear resistance which make them a unique substitute in spite of high costing. It is used as polymer tubes like P.V.C tubes in aerospace and aircraft applications.

Fiber-reinforced composite materials with high strength fibers are embedded in a matrix. Both the fibers and matrix consist of fibers with high strength and modulus embedded in a matrix. Both fibers and matrix preserves its physical and chemical properties gives a new material whose properties cannot be achieve if it is used single. Fibers are the main load-carrying members and matrix acts as a medium of transferring stresses and it also provide a barrier against an antagonistic environment. As well as it also protect the fiber surface from mechanical abrasion.

Now a days Polymer composites had a variety ofapplication in industries like aeronautics, ocean engineering, civil, sporting goods, appliances, furniture, etc. It has almost replace material such as aluminum, wood, steel etc. for more than fifty years. These polymer composites have a unique combination of advantages over these conventional materials which gives the flexibility of improving the designs. As its specific property gives the advantage to enter into variety of markets instead of metals and ceramics. Nevertheless, the tailoring of well-bonded and/or durable interphase between the matrix and reinforcement remains a critical issue in this kind of material. This factor is critical with thermoplastic polymer matrices such as polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polystyrene (PS) and polyamide (PA).[5]

The effectiveness of reinforcement essentially depends on the adhesion between matrix and fiber, so this is a key factor in determining the final properties of the composite material, particularly its mechanical properties. The fiber-matrix adhesion is confined to a region or “third phase” known as interphase, where stress-transfer occurs. The interphase is defined as the tridimensional region, located between the fiber and the matrix. It is considered as a transition region or third phase with its own characteristics, corresponding neither to fiber properties nor to matrix ones. Wu postulated that the extent of molecular or local segmental diffusion across the interface determines the structure of the interfacial zone, which critically affects the mechanical strength of an adhesive bond. Negligible diffusion will give a sharp interface with weak adhesion. In this case, high adhesive strength can be expected only when strong polar interactions or chemical bonds exist across it.

On the other hand, if the interphase is relatively thick and gradual as a result of extensive diffusion, a high adhesive strength will result just by the effect of dispersion forces. [5]

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4.1 FABRICATION PROCESS

The most common process used to produce carbon tubes, as for composite materials, involves the use of autoclave method. As autoclave method is industrial purpose method, it can't be applicable for our project. As autoclave method is industrial purpose method, it can't be applicable for our project. In our project we are going to use hand lay up method. As hand layup method is easier and cheaper than other method.

The carbon fiber tube is fabricated with the different layers of the single fiber cloth which is rolled around rod and is laminated using the epoxy resin.[6] The strength of the fiber tube is depends on the size, layers of the cloth in tube and its orientation. The following materials are required of the fabrication of the carbon fiber tube:

- Carbon fiber cloth
- Araldite hardener and resin
- Roller
- Scale and other apparatus like scissors, brush, stick, cup, marker, rod etc. carbon fiber tube:

Fig.6 Carbon Fiber Cloth and Other ApparatusFig.7 Araldite Resin and Hardener

4.1.1 HAND LAY UP METHOD

Hand layup method is easiest and simplest method. In our project we rolled the fiber cloth around rod of diameter we required in internal diameter. With each layer of roll we apply resin and hardener mixture. With a complete rolled tube, we keep it aside and wait for nearly 15 to 20 hrs to let it completely dry.

Some of the precaution must be taken while doing this method:-

- Roller should be used carefully to fully remove air bubble in roll.
- With each roll cloth should be carefully used, as we can't afford

any waste.

- Resin and hardener layer should not be thick or thin, as it effect properties of tube like weight as well as binding between layers will be weak.

Carbon fiber is one of the costliest materials. So using it with proper care and method is important. After the procedures we will get our carbon tube of required length and diameter (internal as well as external).

Fig.8 Carbon Rod Specimen

4.1.2 CARALL Preparation

CARALL specimens were manufactured using hand layup method with carbon fiber (240gsm) unidirectional fiber, aluminium sheet of grade 2024 T3 with thickness of 0.2mm and epoxy resin of grade Araldite LY556 and hardener HY951.Before laminating, the aluminum sheets were scrubbed with emery paper to remove the smoothness of the surface which enables good bonding between the aluminum sheet and carbon fiber [7].

After the fabrication of the specimen by hand layup method, it is cured naturally for four hours and then it is hot cured by using compression molding machine at a temperature of 7000C at a pressure of 70 bar for 10 minutes duration and the FML is cut in required dimension as per the ASTM standards for Mechanical Testing.

The most common process used to produce FML laminates, as for polymeric composite materials, involves the use of autoclave processing. The overall generic scenario for the production of FML composite aerospace components involves about five major activities:

- Preparation of tools and materials. During this step, the aluminum layer surfaces are pre-treated by chromic acid or phosphoric acid, in order to improve the bond between the adhesive system and the used aluminum alloy.
- Material deposition, including cutting, lay-up and debunking.
- Cure preparation, including the tool cleaning and the part transferring in some cases, and the vacuum bag preparation in all cases.
- Cure, including the flow-consolidation process, the chemical curing reactions, as well as the bond between fiber/metal layers.
- Inspection, usually by ultrasound, X ray, visual techniques and mechanical tests.

The cure preparation step involves primarily the bagging of the part and the placement of much ancillary materials. The common cure preparation arrangement, including the part, the tool, the bagging and the ancillary materials.

V. TESTING OF MATERIAL

The main objective of this project is to study the mechanical behavior of the FML and carbon fiber material under tensile, compressive and impact loads. It is a Fiber Metal Laminate (FML) which consists of layers of carbon fiber and thin layers of aluminum sheet bonded by epoxy resin. FML has a wide range of applications in Aerospace, Automotive, marine industries and it is also used in making of Sports goods due to their good strength. In this study, the tensile, compressive and impact performances of CARALL was investigated by experimental and finite element analysis. The FML and carbon fiber is fabricated by hand layup method and then compressed using roller. The experimental method is used to determine the tensile strength, compressive strength and impact toughness of the laminates by UTM and compression testing machines.

5.1 COMPRESSION TESTING

The compressive test has performed on the compression testing machine to determine the compressive strength of the materials. The two compressive grips are attached in compression testing machine load. The load is gradually increases up to the specimen failure to determine the compressive strength of the specimen. The pressure indicator is shows that applying load on the specimen.

Compressive Strength = Ultimate Load / Surface area

Ultimate Shear Stress = Ultimate load / (2 x Area)

The failure of the specimen is depends upon the cross sectional area, thickness and applying load.

CALCULATION:

Fig. 9 Compression testing machine

Tubular FML, Reading = 150 Div.

Ultimate load = 150x 5 = 750KN [1Div. = 5KN]

Area of the specimen = $2x\Pi x16x350 = 3518.5mm^2$

Compressive strength = Ultimate load/Surface area

$= 750x1000/3518.5x10^{-6}$

$= 1365.89MN/m^2$ or $1.365GN/m^2$

Fig. 11 Failure mode of specimen

Ultimate shear strength = Ultimate load/2xArea

= 750x1000/2x3518.5x10-6

$= 637.44MN/m^2$

The compressive strength of the FML material is $1.365GN/m^2$ and the ultimate shear strength is $637.44MN/m^2$ which is very higher strength.

Fig. 10 Testing mode of specimen

5.2 IMPACT TESTING

Impact tests are designed to measure the resistance to failure of a material to a suddenly applied force such as collision, falling object or instantaneous blow. Material toughness is the ability of a material to absorb energy during plastic deformation. Izod impact testing is an ASTM D 7136 standard method of determining impact energy. The specimens are cut into required dimension as per standards and tested. The Izod test is most commonly used to evaluate the relative toughness or impact toughness of materials and as such is often used in quality control applications where it is a fast and inexpensive test. It is not a definite test it is just used as a comparison test. A pendulum with adjustable weight is released from a known height. A rounded point on the tip of the pendulum makes contact with the specimen. The impact strength of the specimen is obtained directly from the reading scale in the impact tester.

5.2.1 IZOD AND CHARPY IMPACT TEST

One of the advantages of this test with respect to the Charpy and Izod tests is that a wider range of test geometries can be examined, thereby enabling more complex components to be tested.
Parameters:

a. The angle between the top face of grips and face holding the
specimen vertical = 900
b. The angle of tip of hammer = 750±10
c. The angle between normal to the specimen and undesirable face
of the hammer at striking point = 100±10
d. The speed of the hammer at impact =3.99 m/s.
e. The striking energy = 168 Nm or Joules.
f. The angle of drop of pendulum = 900
g. The effective weight of pendulum = 2 1.79Kg.
h. The minimum value of scale graduation = 2 Joules.
i. The permissible total friction loss of corresponding energy =0.5%
j. The distance of the axis of rotation of distance between the base of the specimen and the paint of specimen hit by the hammer = 22mm ± 0.5mm.

Fig. 12 Impact testing machine

5.2.1.1 IZOD IMPACT TEST

In this testing, a notched specimen is placed into a large machine with a pendulum of a weight. The pendulum is raised up to a certain height and allowed to fall. As the pendulum strikes, it impacts and breaks the specimen, rising to a measured height.

The izod and charpy test both are performed in impact testing machine. The notch of the specimen may have single, two or three and the single notch is used in izod test.

TYPES OF TEST SPECIMEN

The types of test pieces are used for the impact test as given:

i. Square cross-section

ii. Round cross-section

The round cross-section is generally used in impact test and the requirement of specimen dimension is 75x10 mm.

Fig. 13 Izodimpactor

IMPACTOR

The impactor is used to impact the specimen at high velocity from a certain height. The impactor is fitted with the hammer and it has rectangular in shape. The impactor has played important role in the impact testing.

a. Calculate the impact strength accordance to the reading.

CALCULATION:

Impact strength = Absorbed energy/Cross-section area of the specimen

I = K/A

For aluminum, Reading = 28 Div.

K = 28x 2 = 56Joules [1 Div. = 2 Joules]

A = 75x10 mm^2 = 750x10-6 m2

I = 56/750x10-6

I = 74.67KJ/m^2

For carbon fiber, Reading = 29Div.

K = 29x2 = 58Joules [1Div. = 2Joules]

A = 75x10 mm^2 = 750x10-6 m^2

I = 58/750x10-6

I = 77.33KJ/m^2

For FML, Reading = 31 Div.

K = 31x 2 = 62 Joules [1 Div. = 2 Joules]

A = 75x10 mm^2 = 750x10-6 m^2

I = 62/750x10-6

I = 82.67 KJ/m^2

5.2.1.2 CHARPY IMPACT TEST

The charpy test has also performed in universal testing machine. In the impact test, the specimen is broken by allowing a standard hammer from a fired distance to fall one time. The energy absorbed is determined, from which the impact value is obtained. The specimen has placed in horizontal and the face of the v-notch toward in front of the hammer.

Impact Strength = Energy absorbed /Cross Specimen Area of the piece

I = K/A

CALCULATION:

Impact strength = Absorbed energy / Cross-section area of the specimen

I = K/A

For aluminum, Reading = 19 Div.

K = 19x 2 = 38 Joules [1 Div. = 2 Joules]

A = 50x10 mm^2 = 500x10-6 m^2

I = 38/500x10-6I = 76 KJ/m^2

For carbon fiber, Reading = 20Div.

K = 20x 2 = 40Joules [1Div. = 2 Joules]

A = 50x10 mm^2 = 500x10-6 m^2I = 40/500x10-6 = 80KJ/m^2

For FML, Reading = 24Div.

K = 24x 2 = 48 Joules [1 Div. = 2 Joules]

A = 50x10 mm^2 = 500x10-6 m^2I = 48/500x10-6 = 96 KJ/m^2

The Charpy and Izod impact tests are commonly used to compare the impact response of isotropic materials that are different in composition or manufacturing condition. Both impact tests use a pendulum, but the difference is that in the Charpy impact test the specimen is supported as a simple beam, and in the Izod impact test the specimen is supported as a cantilever. Izod and Charpy impact testing can provide a large amount of data since they are easy to set up and can collect a large amount of data quickly. However, the results obtained from these tests are not in depth such that they will show more of the characteristics of the material. Nevertheless, researchers have advanced the usage of Charpy impact tests to obtain results that show crack propagation and measure force more accurately using high speed photography.

The main functions of the Izod and Charpy test are follows:-

a. To test the impact toughness of the material

b. To compare composites with different layups, including woven and unidirectional laminates.

VI.STAGES OF THE FAILURE MODES IN FML

Impact behaviors and impact damage depend on many parameters such as the projectile/impactor shape, impact velocity and energy, boundary conditions and lay-up sequence. Furthermore, laminated fiber reinforced composite materials have various damage modes such as fiber breakage, matrix cracking etc. These various damage modes appear together under the impact loading. The possible failure stages in the FML are:

a. Micro-cracking And Matrix Deformation
b. Interfacial debonding
c. Lamina splitting
d. Delamination
e. Fiber Breakage
f. Fiber Pull-out

VII. RESULTS

We get following results from our specimen's different test:-

1. IZOD TEST

Impact strength = Absorbed energy/Cross-section area of the specimen

For aluminum,I = 74.67KJ/m2 For Carbon fiber, I = 77.33KJ/m2

For FML, I = 82.67 KJ/m2

2. CHARPY IMPACT TEST

Impact Strength = Energy absorbed /Cross Specimen Area of the piece

I = K/A

For aluminum, I = 76KJ/m2

For Carbon fiber, I = 80KJ/m2

For FML, I = 96 KJ/m2

3. COMPRESION TESTING

Compressive strength = Ultimate load/Surface area

Compressive strength = 1388.89MN/m2 Or 1.389GN/m2

Ultimate shear strength = Ultimate load / 2xArea

Table 1 Comparison table

Ultimate shear strength = 694.44 MN/m2

And we also get following graphs by comparing our data's:-

	PARAMETERS	ALUMINIUM	CARBON FIBER	FML
1.	Impact Strength (Izod)	Low	Medium	High
2.	Impact Strength (Charpy)	Low	Medium	High
3.	Compressive Strength	Low	Medium	High
4.	Tensile Strength	Low	Medium	High
5.	Shear Strength	Low	Medium	High
6.	Strength/weight	Low	Medium	High
7.	Stiffness	Low	Medium	High
8.	Ductility	High	Medium	Low
9.	Machinability	Best	Better	Good
10.	Fabrication	Easy	Comparatively difficult	Difficult
11.	Cost	Low	High	Comparatively higher

International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.03, March 2018
www.ijarse.com
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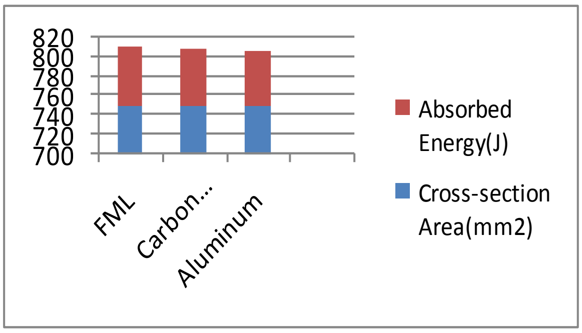
ISSN: 2319-8354

1. IZOD IMPACT STRENGTH COMPARISION GRAPH



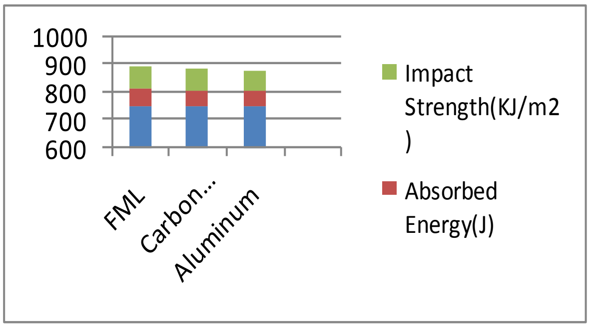
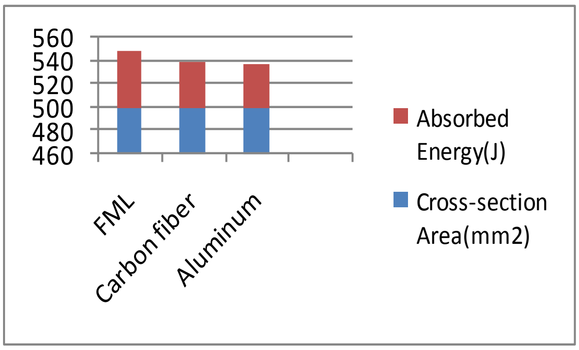


Fig. 17 Absorbed energy comparison Fig. 18 Impact strength comparison

2. CHARPY IMPACT STRENGTH COMPARISION GRAPH



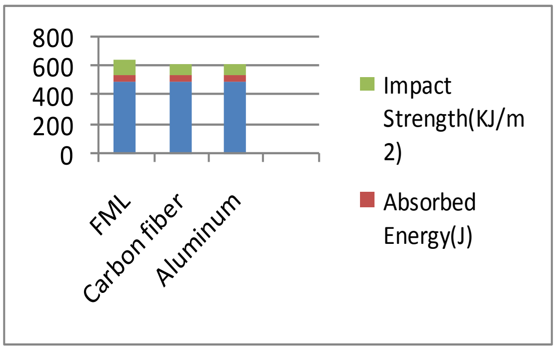


Fig. 19 Absorbed energy comparisonFig. 20 Impact strength comparison

And we compare our product data with steel, we get following graph
With this results and graphs we found that our product has greater use in aerospace as well as other industries. This product has shown that carbon fiber strength and other property can be enhanced with combining with other material.

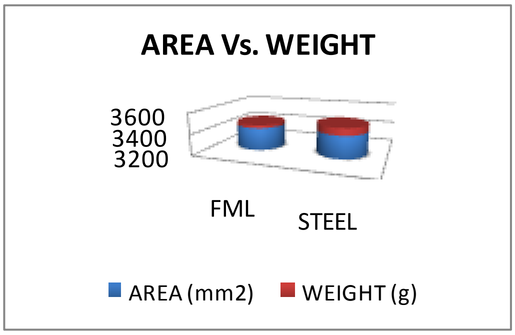


Fig. 21 Comparison between Steel and FML

VIII. TEST RESULT AND DISCUSSION

CONCLUSIONS:-

Thus we get following conclusions from our project results:

- Carbon tube offers light weight as well as great strength which make it greater choice for aerospace and aircraft industries.
- Carbon tube can show increment in properties if it is combined with other material.
- Fiber Metal Laminates offer very good properties for structural applications especially in impact properties.
- Fiber Metal Laminates offer very good properties for structural applications designed or damage tolerance. Besides that, the laminates can be processed rather easy and also the joining and assembly is not too complicated.
- The hybrid materials such as FML having the unique mechanical properties which constituent of metals and other meterials The FML can more beneficial for various areas of industries
- Since the FML is a concept with many opportunities, new developments may result in much more variants of the concept. The trend in this is to more specific or dedicated laminates.

IX.FUTURE DEVELOPMENTS

Carbon fiber offers good strength as well as light weight. These properties are very applicable in aerospace industries as well as other industries. The future development should be aimed at further development of its hybrid properties with other material and development of manufacturing process. Since carbon fiber properties require curing for enhancement, different methods should be researched for this issue.

Fiber Metal Laminates offer very good properties for structural applications especially in impact properties. The future developments should be aimed at the further development of the laminates and structures, and the development the manufacturing processes. Carall, for instance, can be included in the next generation category of hybrid fiber material. As in future work Titanium can be used as the next material for hybridization for FML laminate which provides high stiffness, yield strength, good fatigue and impact properties at elevated temperatures.

Other issued can be workout such as bonding properties of fibers and metals, work on various elevated temperatures, environmental damages to materials, flow properties of adhesive and glass transition related to FML composites. Unique resin material can be taken other than epoxy for PMS composites. Fiber Metal Laminates offer very good properties for structural applications designed or damage tolerance. Future developments should be aimed for introducing the new hybrid materials with easy manufacturing process

REFERENCES

[1.] Image of multicopter - http://blog.planet5d.com/wp-content/uploads/A-multicopter-before-takeoff.jpg

[2.] Alan T. Nettles and Emily J. Biss 1996 "Low Temperature Mechanical Testing of Carbon-Fiber/Epoxy-Resin Composite Materials" NASA Technical Paper 3663.

[3.] N. Ozsoy, A. Mimarolu, M. Ozsoy, M.I. Ozsoy, 2014 "Comparison of Mechanical Behaviour of Carbon and Glass Fiber Reinforced Epoxy Composites" 4th International Congress APMAS2014.

[4.] Brijesh Patel et al. "Hybrid composites- a concept of ecological, bio inspired and synergistic strengthening material" Volume 5, Issue 6, June (2014), pp. 64-69

[5.] Mariana Etcheverry. et al. "Glass Fiber Reinforced Polypropylene Mechanical Properties Enhancement by Adhesion Improvement" Materials 2012, 5, pp. 1084-1113;

[6.] T D Jagannatha et al. 2015 "Mechanical Properties Of Carbon/Glass Fiber Reinforced Epoxy Hybrid Polymer Composites" International journal of Mechanical Engineering and Robotics Research",2015, Vol. 4, No. 2.pp. 89-96;

[7.] PatilDeogonda, Vijaykumar N Chalwa, 2013 "Mechanical Property of Glass Fiber Reinforcement Epoxy Composites" International Journal of Scientific Engineering and Research (IJSER).

[8.] Sudhir S Mathapati, Shivukumar S Mathapati, 2015 "Testing And Analysis of Mechanical Properties of E-Glass Fiber Reinforced Epoxy Polymer Composites" International Journal of Research and Innovations in Science and Technology Volume 2 : Issue 1