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Fabrication and Experimental Testing of Kevlar, E-Glass and Chopped Mat Fibres Reinforced with Epoxy LY556, Hardener HY951 and TiO_2

K. Gowthami, B. Yaswanth, D. Teja, M. Jagadish Kumar

Department of Mechanical Engineering, Godavari Institute of Engineering and Technology(A), JNTUK, Kakinada.

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ABSTRACT

Fiber materials have been widely used for several years and their market share is continuously growing. Composite fibers are lightweight and environmentally friendly as well as low cost compared to traditional engineering materials. The primary aim of this study was to using Kevlar, E-glass and Chopped mats along with titanium oxide (TiO_2). By using the above mentioned three reinforcement with epoxy resin we will be provided with combinations of Kevlar/E-glass, E-glass/Chopped mat and Carbon /Kevlar hybrid composites. By the combination of all the three fibers we get E-glass /Kevlar/Caron fiber hybrid composites. In all compositions commonly 10% of Titanium oxide powder used.Testing such as tensile, flexural, impact, and hardness determine the properties of these composite was made the crossover material which are assessed tentatively as per ASTM norms.

KEYWORDS: Kevlar fiber, E-glassfiber, Chopped mat fiber, Epoxy LY556, Hardener HY951, and Titanium oxide.

1. INTRODUCTION

Composite materials are a significant type of materials which are presently accessible to humankind in huge amount. Lately, many glass reinforced by fiber composite materials are broadly utilized in the aviation and car businesses. Composite materials are significant for mechanical, chemistry and structural architects, material researchers for utilizing them on a lot of building and different applications. These materials have turned into the option of customary basic materials, for example, steel, wood or metals in numerous applications.

The technological development has increased on advances in the materials field. A random composite material is one, which consists of mixing the particles of the materials working together to produce new metal have properties which are dissimilar to the properties of singular material that they possess. It contains the most important characteristic that the materials are not soluble to each other. Likewise, the random composite material assumes the role of the advancements designing material because of their fantastic mechanical properties while being low weight, minimal cost, and profoundly adaptable. Composite essentially comprises a matrix which around the reinforced in this way the strength and durability is existed that is important in a specific field of utilization. Chopped strand mats are arbitrarily situated, give good strand, great wet ability, and scattering, and show even strength thought every which way. A researcher examined the investigation of mechanical properties of E-Glass fiber chopped strand material with epoxy resin nano clay composites; the point of this work

is to dissect the impact of nanoclay effect on the mechanical conduct of chopped strand E-glass fiber, strengthened in the matrix of epoxy with filler of nano clay.

Composite materials are huge kind of materials which are by and by open to mankind in immense sum. Recently, many glass supported by fiber composite materials are huge for mechanical, science and primary engineers, material analyst for using them on a great deal of building and various applications. These materials have transformed into the alternative of standard fundamental materials, for instance, steel, wood or metals in various applications.

Types of natural fibers are Jute, Cotton, Wool, Asbestors, Chopped mat etc. And the types of synthetic fibers are Rayon, Nylon, Polyester, Acrylic, Acetate etc.

1.1 Composite:

A "Composite" can be defined as where two or more different materials are physically combined together. Two constituent materials which are having different mechanical, physical and chemical properties are bonded will produce a material with different characteristics from the individual material is called a composite material. The two constituents are reinforcement and matrix. The reinforcement and matrix are the main load carrying elements in a composite material.

Types of composites are Metal Matrix Composites (MMC), Ceramic Matrix Composites (CMC), and Polymer Matrix Composites (PMC).

1.2 Resin:

In polymer science and materials science, sap is a strong or exceptionally thick substance of plant or engineered beginning that is ordinarily convertible into polymers. Gums are generally combinations of natural mixtures. Plants emit pitches for their defensive advantages in light of injury. Plants tars are esteemed for creation of cements and food coating specialists. There are likewise esteemed as crude materials of the manufactured of natural mixtures. Numerous materials are delivered through the change of engineered pitches to solids. Significant models are bisphenol A diglycidyl ether, which is a pitch changed over to epoxy stick upon the expansion of a hardener. Silicones are regularly ready from silicone saps by means of room temperature vulcanization.

Types of resins are Thermo Sets (Epoxies, Polyester, Phenolics, and Polyamides etc..) and Thermo Plastics (Polyethylene, Polystyrene, Polyether ketone etc..).

1.3 Hardener:

Hardener was utilized as a cover during the creation. It has low thickness, fix at room temperature, great mechanical strength, good protection from air and compound corruption.

Types of hardener are Aliphatic and Aromatic amines, Anhydrides and Polyamides.

2. MATERIALS:

On among various kinds of pitches and hardener. Epoxy LY556, hardener HY951and Titanium oxide in all orientations is picked. The fiber materials taken to manufacture are Kevlar, E-glass and chopped mat. These are taken in the various proportions and various mixes. The seven distinct composites are examined the tensile,impact, hardness and flexural tests.

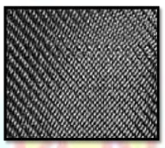


Fig 2.1 E-glassFig 2.2Epoxy LY951 and Hardener HY951

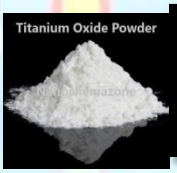


Fig 2.3 TiO2 Fig 2.4 Kelvar Fig 2.5 Chopped mat

3. FABRICATION OF COMPOSITE SPECIMEN (HAND LAYUP):

Hand lay-up procedure is the straightforward and least expensive strategy for composite handling. The infrastructural need for this strategy is additionally insignificant .The standard test method for Mechanical properties of fiber-sap composites; ASTM-D790M-86 is used to as per the estimations. The shape is ready on smooth clear film with 2 way tape to the necessary estimation. At that surface form is arranged keeping the 2 way tape on the unmistakable film.

Long fiber support is cut to the shape size and placed on the outside of a thin plastic sheet. The thermosetting polymer in fluid structure is thenmodified to the appropriate extent with a specified hardener (restoring expert) and poured over the outside of transparent.

With the help of a brush, the polymer is evenly distributed. Then second layer of fiber is placed on the polymer surface and another layer of polymer is applied after this is closed with another thin plastic sheet after squeezer is moved with a gentle pressure on the thin plastic sheet to remove air.The consequential mold is cured for 24 hours at room temperature.

Fig 3.1 Complete sequential process for fabrication

After fabrication specimens are cut form sheets according to the ASTM standard 165 mm long, 12.5 mm wide and 4.5 mm thick in thick are fabricated for tensile testing. ASTM-D790M-86 and the sample dimensions are 100 mm long, 25 mm wide and 4.5 mm thick are fabricated for flexural testing. ASTM D256-97. The samples are having measurements of 63.5 mm long, 12.36 mm wide and 4.5 mm in thick are fabricated for impact testing. Hardness testing was done as per ASTM D 2583 test standard with a dimension of 12.7 × 12.7 × 4.5 mm.

3.1 Steps Involved In the Fabrication ofSpecimen:

The E-glass, Kevlar fibre, chopped mat, Kevlar+ E-glass, Chopped mat + Kevlar, Chopped mat+ E-glass and Kevlar +chopped mat + E-glassspecimens was fabricated by hand layup technique. In this process 7 sheets of 250GSM.

Epoxy fibre along with hardener of 25grams and 10 grams of Titanium oxide is mixed with 250 grams of Epoxy (LY556) which is used as matrix in the composite. The thickness of the specimen is 4.5 mm for tensile test and flexural test. Thickness of the specimen that obtained by 6 sheets. For obtain 4.5mm thickness six sheets of E-glass or chopped mat or Kevlar or combinations of these are used. And the thickness of specimen for impact test is 4.5 mm.

3.1.1 E-glass with 10gms of TiO_2: While preparation of E-glass was initially a thin coat of epoxy resin with titanium oxide was applied on the Base of film cover sheet then add a layer of E-glass matrix on it will adds a thickness of 0.75mm. In this sheet all layers are E-glass matrix sheets total no of 6 sheets are required to attain a thickness of 4.5mm as per ASTM standards for testing specimens. after that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing specimens for Tensile, Flexural, Impact and Hardness tests respectively.

3.1.2 Kevlar with 10gms of TiO_2: While preparation of kevlar was initially a thin coat of epoxy resin with titanium oxide was applied on the base of film cover sheet then add a layer of kevlar matrix on it will adds a thickness of 0.75mm. In this sheet all layers are kevlar matrix sheets total no of 6 sheets are required to attain a thickness of 4.5mm as per ASTM standards for testing specimens. after that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing specimens for Tensile, Flexural, Impact and Hardness tests respectively.

3.1.3 Chopped mat with 10gms of TiO_2: While preparation of chopped mat was initially a thin coat of epoxy resin with Titanium oxide was applied on the Base of film cover sheet then add a layer of chopped mat matrix on it will adds a thickness of 0.75mm. In this sheet all layers are chopped mat matrix sheets total no of 6 sheets are required to attain a thickness of 4.5mm As per ASTM standards for testing specimens. After that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing specimens for Tensile, Flexural, Impact and Hardness tests respectively.

3.1.4 Chopped mat+E-glass with 10gms OF TiO_2: While preparation of chopped mat+E-glass are initially a thin coat of epoxy resin with Titanium oxide was applied on the base of film cover sheet then add a first layer as a chopped mat on it will adds a thickness of 0.75mm and second layer as a E-glass fiber with resin and doing the same sequence for remaining four layers. In this sheet 3 layers are chopped mat matrix sheets and 3 layers are E-glass matrix sheets total no of 6 sheets are required to attain a thickness of 4.5mm as per ASTM standards for testing specimens. After that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing

specimens for Tensile, Flexural, Impact and Hardness tests respectively.

3.1.5 Chopped mat +Kevlar with 10gms of TiO_2: While preparation of chopped mat + Kevlar are initially a thin coat of epoxy resin with titanium oxide was applied on the Base of film cover sheet then add a first layer as a chopped mat on it will adds a thickness of 0.75mm and second layer as a kevlar fiber with resin and doing the same sequence for remaining four layers. In this sheet 3 layers are chopped mat matrix sheets and 3 Layers are kevlar matrix sheets total no of 6 sheets are required to attain a thickness of 4.5mm as per ASTM Standards for testing specimens. After that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing specimens for Tensile, Flexural, Impact and Hardness tests respectively.

3.1.6 Kevlar + E-glass with 10gms of TiO_2: While preparation of E-glass + Kevlar are initially a thin coat of epoxy resin with titanium oxide was applied on the base of film cover sheet then add a first layer as a E-glass on it will adds a thickness of 0.75mm and second layer as a kevlar fiber with resin and doing the same sequence for remaining four layers. In this sheet 3 layers are E-glass matrix sheets and 3 layers are kevlar matrix sheets total no of 6 sheets are required to attain a thickness of 4.5mm as per ASTM Standards for Testing Specimens. After that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing specimens for Tensile, Flexural, Impact and Hardness tests respectively.

3.1.7 E-glass + Chopped Mat + Kevlar with 10gms of TiO_2: Whilea preparation of hybrid E-glass + chopped mat + kevlr are Initially a thin coat of epoxy resin with titanium oxide was applied on the base of film cover sheet then add a first layer as a E-glass on it will adds a thickness of 0.75mm and second layer as a kevlar fiber third one as chopped mat layer with resin and doing the same sequence for remaining three layers. In this sheet 2 layers are E-glass matrix sheets, 2 layers are kevlar matrix sheets and 2 layers are chopped mat sheets to obtained no of 6 sheets are required to attain a thickness of 4.5mm As per ASTM Standards for Testing Specimens. After that remove the air bubbles by using rubber pad than cure it into 24hrs at room temperature after that cut to required shapes of a testing specimens for Tensile, Flexural, Impact and Hardness tests respectively.

4. TESTS AND RESULTS:

4.1 Tensile Test:

Fabrication and testing successfully completed in this project the tensile properties of Kevlar, E-glass,chopped mat, E-glass + chopped mat, Kevlar + E-glass, Kevlar+ E-glass+chopped mat, Kevlar+ chopped matfabricated by using hand lay-up method. The tensile strength was calculated by the relation.

Tensile stress, σ_t = Tensile load /Area

= P/A. N/mm^2

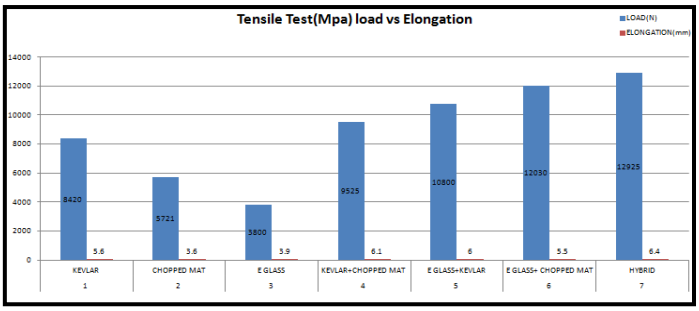
After testing the tensile strength and elongation are summarized in table. The percentages of elongations for all the composites are also calculated with the following formula.

% elongation = $\frac{change\ in\ length}{original\ length} \times 100$

S. NO	COMPOSITE	TENSILE TEST(MPA)		TENSILESTRESS(Mpa)	ELONGATION(%)
		LOAD(N)	ELONGTION(mm)		
1	KEVLAR	8420	5.6	11.59	3.4
2	CHOPPED MAT	5721	3.6	7.88	2.19
3	E GLASS	3800	3.9	5.23	2.37
4	KEVLAR+CHOPPED MAT	9525	6.1	13.11	3.71
5	E GLASS +KEVLAR	10800	6	14.87	3.65
6	E GLASS + CHOPPED MAT	12030	5.5	16.57	3.35
7	HYBRID	12925	6.4	17.8	3.9

Table 4.1: Tensiletestresults for7composites

After successful completion of the tensile strength we are getting maximum values forthe Kevlar + E-glass + chopped mat 12925 N,



Graph 1: Tensile test result graph

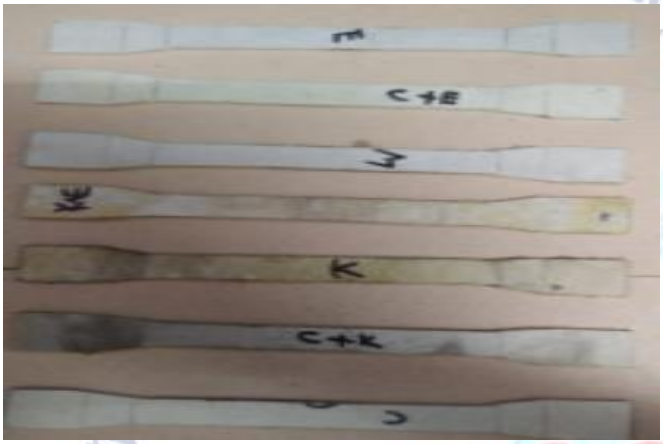


Fig 4.1:Tensile test specimens

4.2. Impact Test:

Fabrication and testing successfully completed in this project-Ialso focused onimpact strength of E –glass, Kevlar,choppedmatandE-glass +choppedmat,E-glass + Kevlar, Kevlar + chopped mat, E-glass + Kevlar + choppedmat with Titanium oxide fabricatedbyusinghandlay-upmethod.Andfinallyconcluded theKevlar+ E -glass materialpossess high impact strength value is 7.2Jcompared toremaining compositions as shown in below figure. Impact strength was calculated by the following relation,

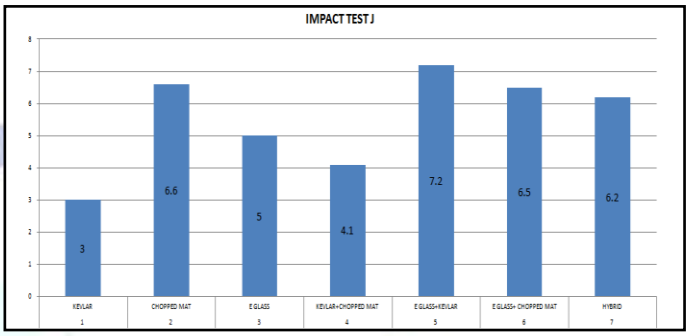
$\sigma = \frac{2P}{A}$

P= Energy observed in J

A= Area in mm

S.NO	COMPOSITE	IMPACT TEST (J)
1	KEVLAR	3
2	CHOPPED MAT	6.6
3	E GLASS	5
4	KEVLAR+CHOPPED MAT	4.1
5	E GLASS+KEVLAR	7.2
6	E GLASS+ CHOPPED MAT	6.5
7	HYBRID	6.2

Table 4.2: Impacttestingresults for7composite



Graph 4.2:Impactstrengthresult graph

Fig 4.2: Imapact test specimens

4.3 Flexural Test:

Fabricationandtestingsuccessfully completedinthisprojecttheflexuralstrengthofE-glass,Kevlar,choppematandE-glass +choppedmat,E- glass + Kevlar, Kevlar + chopped mat, E –glass + Kevlar +choppedmatwith Titanium oxide are fabricated by using hand lay-up method. Theflexuralstrengthwascalculatedbasedthefollowingrelation,

Flexural strength S = $\frac{3PL}{2bt^2}$.

After testing the Flexural strength and elongation are summarized in table. The percentages of elongations for all the composites are also calculated with the following formula.

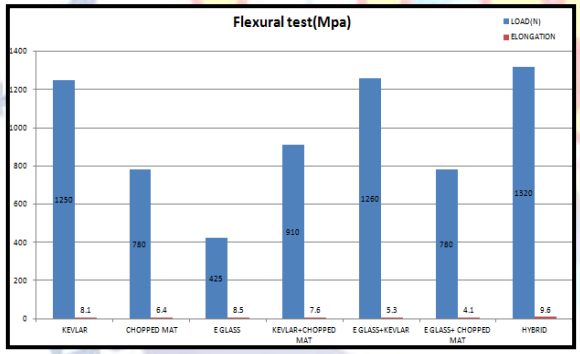
% elongation = $\frac{change\ in\ length}{original\ length} \times 100$

S.NO	COMPOSITE	FLEXURAL TEST(MPA)		FLEXURAL STRESS (Mpa)	ELONGATION
		LOAD(N)	ELONGATION		

1	KEVLAR	1250	8.1	328.12	4.93
2	CHOPPED MAT	780	6.4	204.75	3.9
3	E GLASS	425	8.5	111.56	5.18
4	KEVLAR+ CHOPPED MAT	910	7.6	238.8	4.63
5	E GLASS+KEVLAR	1260	5.3	330.75	3.23
6	E GLASS+ CHOPPED MAT	780	4.1	204.75	2.5
7	HYBRID	1320	9.6	346.5	5.85

Table4.3: Flexuraltestingresultsfor7composites

Based on the flexural strength finally concluded that Kevlar+ Chopped mat+ E-glass ofTitanium oxide epoxycompositepossesshighflexuralstrengthcomparedto remainingcompositeasshowninfigure.And E-glass + Kevlar havingasecond highestflexural strengthcomparedtoremainingcomposite



Graph 4.3: Flexuraltestresultgraph

Fig 4.3: Flexural test specimens

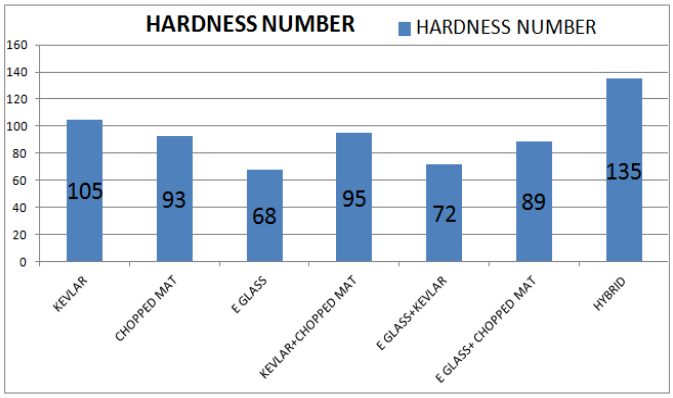
4.4 Hardness Number:

Brinellhardnessvaluesofthesenaturalcomposites.Experiment gives the Kevlar +chopped mat + E-glass having maximum Brinell hardnessvalue,where Wt% ratio of resin & hardener: On the other and, epoxy + E-glass reveals theminimum hardness.Brinell hardness vs. experiment number graph of the composite.

Figure reveals thegraphindicatingBrinellhardnessvaluescorrespondingtotheexperimentnumber.The graph shows, experiment with Kevlar E GLASS with chopped mat gives the higher value of Brinell hardness. On the other hand, experiment with E GLASS gives the lower Brinellhardnessvalue.

S.NO	COMPOSITE	HARDNESS NUMBER
1	KEVLAR	105
2	CHOPPED MAT	93
3	E GLASS	68
4	KEVLAR+CHOPPED MAT	95
5	E GLASS + KEVLAR	72
6	E GLASS+ CHOPPED MAT	89
7	HYBRID	135

Table 4.4: Hardnesstestingresultsfor7composites



Graph 4.4:Hardnessnumber result graph

Fig 4.4: Hardness Test Specimen

5. CONCLUSION

The present work has been done with an objective to explore the use of Kevlar, E-glass, Chopped mat,

Kevlar/Chopped mat, Kevlar/E-glass / Chopped mat, Kevlar/ Chopped mat & E-glass / Chopped mat are manufactured using hand lay-up method. Epoxy is used as matrix in the reinforced composite and investigated the mechanical properties like tensile, flexure, impact and hardness number of composites.

This work is focused to find the best composite among the seven combinations. After all the tests has performed on the specimens the Kevlar / E-glass / Chopped mat shows a best result in the tensile strength impact strength, hardness test and as well as flexural strength . For the above investigations we are proposed the Kevlar + E-glass + Chopped mat + 10gms of TiO2 having good mechanical properties when comparing with other results.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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