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Development of FRP Composite Torque Tube for HTSC Machine Application

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ABSTRACT:

Torque tubes are non standard, proprietary items and are not available in the market as they are made of special material and used in strategic applications. The project " Development of FRP composite torque tube for HTSC machine application is proposed to develop capability to design, and test torque tube by doing material testing with various composite specimens and hence develop core competency in making the torque tubes for large capacity HTSC machines. Torque tubes are used only in HTSC based machines. It is a very critical component subjected to extremely stringent conditions of steep temperature gradient, vacuum and mechanical stress.

Torque tube act as Insulated support structure for pole coils maintained at 30K by minimizing heat in leak from surrounding environment at 300K from shaft side to pole coils at 30K and should be suitable for degassing in the ultra low vacuum level of 10-6 milli bar. The natural composite has emerged and have the potential reinforcement material for composites and thus gain attraction by many researchers. This is mainly due to their applicable benefits have they offer low density, low cost, renewable, biodegradability and environmentally harmless and also Chopped mat E-glass/ epoxy composite is emerging as a promising material for marine application due to their excellent superior strength, moisture resistance and electrical and fire insulation. The steel heat exchanger is being failure of continuous heat developed by the pole coils so it is being replaced with insulator made by composite material.

In this project natural fibers (jute, kenaf) and glass hybrid composites were fabricated by using epoxy resin combination of hand lay-up method .Specimen was cut from the fabricated laminate according to the ASTM standard, and analyze and discussed the mechanical properties such as tensile test, compression test, and water absorption. Composite material has extensive engineering applications such as transport industry, aeronautics, naval, automotive industries.

I. INTRODUCTION:

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is obvious, especially for composites that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material,

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process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years. Increasingly enabled by the introduction of newer polymer resin matrix materials and high performance reinforcement fibers of glass, carbon and aramid, the penetration of these advanced materials has witnessed a steady expansion in uses and volume. The increased volume has resulted in an expected reduction in costs. High performance FRP can now be found in such diverse applications as composite armouring designed to resist explosive impacts, fuel cylinders for natural gas vehicles, windmill blades, industrial drive shafts, support beams of highway bridges and even paper making rollers.

For certain applications, the use of composites rather than metals has in fact resulted in savings of both cost and weight. Some examples are cascades for engines, curved fairing and fillets, replacements for welded metallic parts, cylinders, tubes, ducts, blade containment bands etc. Further, the need of composite for lighter construction materials and more seismic resistant structures has placed high emphasis on the use of new and advanced materials that not only decreases dead weight but also absorbs the shock & vibration through tailored microstructures. Composites are now extensively being used for rehabilitation/ strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects.

II. LITERATURE SURVEY:

This chapter outlines some of the recent reports published in literature on mechanical behavior of special emphasis on natural fiber reinforced polymer composites.

Muralidharan.S[1] at all have carried out a study to investigate Kenaf and jute reinforced epoxy resin polymer matrix composites have been developed by compression moulding technique with jute fiber treated conditions and kenaf with different volume fraction of fibers as in 1:2 ratio (25%, 30%, 35%). Test specimens are prepared with different weight fractions of kenaf fiber at the optimization point of ultimate strength a small percentage of jute are added and tests were conducted and the substitution of the traditionally used composite of natural fibers such as, kenaf and jute can lead to a reduction of the component's weight. The main objective of this experimental study is to fabricate the kenaf – jute fibers reinforced hybrid composites and to evaluate the mechanical properties such as tensile strength, flexural strength and impact strength of hybrid kenaf – jute reinforced epoxy composites.

R.Panneerdhass[2] this paper presents the study of the tensile, compressive, flexural, impact energy and water absorption characteristics of the luffa fiber and Ground nut reinforced epoxy polymer hybrid composites. Luffa fiber and Ground nut reinforced epoxy resin matrix composites have been developed by hand lay-up technique with luffa fiber treated conditions and Ground nut with different volume fraction of fibers as in 1:1 ratio (10%, 20%, 30%, 40% and 50%). Effects of volume fraction on the Tensile, Compressive, Flexural, Impact strength were studied. SEM analysis on the composite materials was performed. Tensile strength varies from 10.35 MPa to 19.31 MPa, compressive strength varies from 26.66 MPa to 52.22 MPa, flexural strength varies from35.75 MPa to 58.95 MPa and impact energy varies from0.6 Joules to 1.3 Joules, as a function of fiber volume fraction.

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The optimum mechanical properties were obtained at 40% of fiber volume fraction of treated fiber composites

M. R. Sanjay, B. Yogesha[3] at all have carried out a study to investigate This paper deals with the hybrid effect of composites made of jute/E-Glass fibers which are fabricated by hand layup method using LY556 Epoxy resin and HY951 hardener. The properties of this hybrid composite are determined by testing like tensile, flexural, impact, and inter laminar shear strength which are evaluated experimentally according to ASTM standards. The result of the test shows that hybrid composite of jute/ E-glass fiber has far better properties than that of jute fiber composite. However, it is found that the hybrid composite has better strength as compared to jute fiber composite fabricated separately with glass fiber.

Properties of Natural Fiber:

Plant Fibers	Density (Kg/m^3)	Tensile Strength (MPa)	Young's Modulus (GPa)
Jute Fiber	1300-1500	200-450	20-55
kenaf Fiber	1150-1300	200-950	25-55

Table3.1.5: Properties

NaOH Solution:

Sodium Hydroxide (NaOH) is a alkaline solution used to enhance the surface morphology of natural fiber

NaoH Salt

III. COMPOSITIONS:

Glass fiber: Glass has been used extensively in polymer matrix composites, commonly termed "fiberglass". These materials exhibit good mechanical properties.

Table: properties of glass fiber:

Density (g/cm^3)	Tensile strength (MPa)	Young's modulus (GPa)	Poisson's Ratio
2.6	2050	85	0.23

In this work ,the araldite epoxy resin LY556 is mixed with araldite hardner hy 951 as per instruction provided by vendor, and glass are arranged. Resin has applied on plastic Poly Propylene film sheet, placed chopped glass mat (Fig2) for various number of layers by applying resin on each layers. Glass mat is positioned manually in the open mold, and resin is poured, brushed, or sprayed over and into the glass plies. Entrapped air is removed manually with squeegees or rollers to complete the laminates structure. The thickness is controlled by layers placed against the mold. After the work piece prepared, curing is done for 18 to 24 hrs so that work pieces will get hard. After this, the specimens were cut according to ASTM standards using cutting machine.

Epoxy resin : 300 ml
Hardner : 30 ml
Glass fiber : 49 x6 = 295 gms

Fig: 4.1: glass fiber

Jute Fiber:

Jute fibres have many advantages such as low cost, eco-friendly and moderate mechanical properties which makes them better alternative of synthetic fibre in many applications . It was observed that during the lifespan of 120 days, jute plants absorbs 15 tons of carbon dioxide (CO_2) from the atmosphere and give 11 tons of oxygen (O_2). This potential of jute shows that jute is the best eco-friendly natural fibre.

FIBER	DENSITY [G/CM^3]	TENSILE STRENGTH [N/MM^2]	MODULUS OF ELASTICITY (GPA)	MOIST ABSORPTION [%]
JUTE	1460	400-800	10-30	13

In this work ,the araldite epoxy resin LY556 is mixed with araldite hardner hy 951 as per instruction provided by vendor, and jute fiber are arranged. Resin has applied on plastic Poly Propylene film sheet, placed jute fiber for various number of layers by applying resin on each layers. jute is positioned manually in the open mold, and resin is poured, brushed, or sprayed over. Entrapped air is removed manually with squeegees or rollers to complete the laminates structure. The thickness is controlled by layers placed against the mold. After the work piece prepared, curing is done for 18 to 24 hrs so that work pieces will get hard. After this, the specimens were cut according to ASTM standards using cutting machine.

Epoxy resin : 360 ml
Hardner : 36 ml
Jute fiber : 48 x 4 = 192 gms

Fig 4.2:Jute Fiber

Kenaf Fiber:

Kenaf bast fibres are used to rope, twine, and course sacking materials. However, beside biodegradable and environmentally friendly crop, this natural material also has a potential as reinforced fibres in thermosets and thermoplastics composites.

FIBER	TENSILE STRENGTH (MPA)	ELASTIC MODULUS (GPA)	ELONGATION (%)
KENAF	930	53	1-6

In this work ,the araldite epoxy resin LY556 is mixed with araldite hardner hy 951 as per instruction provided by vendor, and kenaf fiber are arranged. Resin has applied on plastic Poly Propylene film sheet, placed kenaf fiber for various number of layers by applying resin on each layers. Kenaf is positioned manually in the open mold, and resin is poured, brushed, or sprayed over. Entrapped air is removed manually with squeegees or rollers to complete the laminates structure. The thickness is controlled by layers placed against the mold. After the work piece prepared, curing is done for 18 to 24 hrs so that work pieces will get hard. After this, the specimens were cut according to ASTM standards using cutting machine

Epoxy resin : 400 ml
Hardner : 40 ml
kenaf fiber : 56 x4 = 224 gms

Combination Fiber:

It consists of 5 layer .the araldite epoxy resin ly556 is mixed with araldite hardner hy 951,Glass fibers are arranged on the top, bottom and one in the middle.the natural fiber jute and kenaf are arranged in between the glass layers.Epoxy mixture is placed on layers . these layers are positioned manually in the open mold, and resin is poured, brushed, or sprayed over. Entrapped air is removed manually with squeegees or rollers to complete the laminates structure.The thickness is controlled by layers placed against the mold. After the work piece prepared, curing is done for 24 to 36 hrs so that work pieces will get hard. After this, the specimens were cut according to ASTM standards using cutting machine

Epoxy resin : 360 ml
Hardner : 36 ml
Glass+kenaf+jute fiber: (49 x 3) + 58 +49= 254 gms

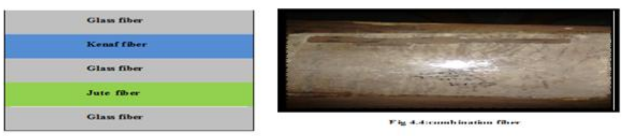

Fig 4.4:combination fiber

TESTING AND RESULTS:

Tensile test:

The Tension test which is conducted on a universal testing machine at room temperature is a common method to evaluate strength and ductility under static load conditions.

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The tension test is carried out by loading a standard specimen gripped at both ends and measuring the resultant elongation of the specimens at various increments of loads. If a ductile material such as copper is stretched until it breaks and its stress and strain measured and plotted, a graph like that in Figure may be obtained.

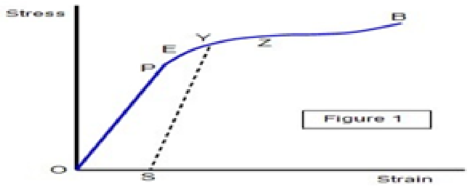


Fig 5.1: Universal testing machine

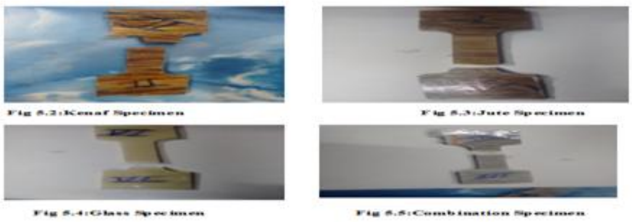


Fig 5.2:Kenaf Specimen
Fig 5.3:Jute Specimen
Fig 5.4:Glass Specimen
Fig 5.5:Combination Specimen

Compression test:

Compressive test is conducted at room temperature to determine the ultimate compressive strength. The external faces of work piece are made perfectly plane. The block is held between the lower and upper cross head of C. T. M. Inter mutual loads are applied gradually on the specimen. The work piece undergoes compression. At a particular load the needle of the control unit starts to rotate anti clock wise, which can be noted as ultimate crushing load.

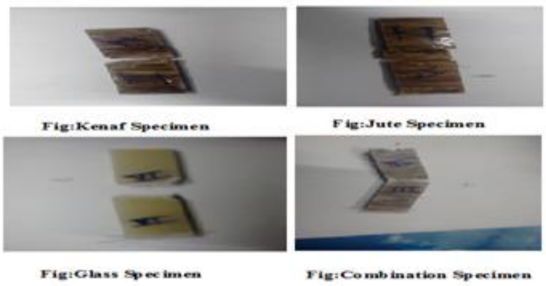
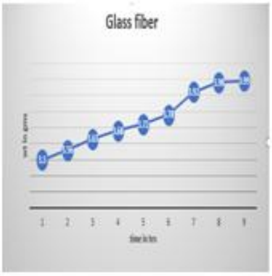


Fig:Kenaf Specimen
Fig:Jute Specimen
Fig:Glass Specimen
Fig:Combination Specimen

Water Absorption Test For Glass Fiber:

Table:

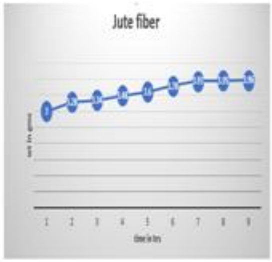
Materials	0hr	1hrs	2hrs	3hrs	4hrs	5hrs	6hrs	7hrs	8hrs
Glass/gms	3.5	3.58	3.60	3.68	3.72	3.78	3.82	3.86	3.96



Water Absorption Test For Jute Fiber:

Table:

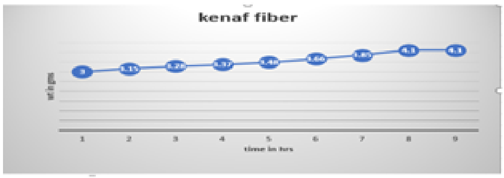
Materials	0hr	1hrs	2hrs	3hrs	4hrs	5hrs	6hrs	7hrs	8hrs
Glass/gms	3.1	3.23	3.34	3.40	3.6	3.78	3.85	3.85	3.96



Water Absorption Test For Kenaf Fiber:

Table:

Materials	0hr	1hrs	2hrs	3hrs	4hrs	5hrs	6hrs	7hrs	8hrs
Glass/gms	3.0	3.15	3.28	3.37	3.48	3.66	3.85	4.1	4.1



IV. CONCLUSION:

- Glass fiber gives good results comare to natural fibers
- Glass fiber has best tensile properties compared to natural fibers, i.e 86.264 N/mm^2
- Glass and kenaf fiber have good compression strength compare to other fibers, i,e 23.951N/mm^2 ,24.972N/mm^2.
- Glass fiber absorbes less water and becomes stable quickly.
- Natural fibers also gives good results next to glass fiber.

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