A REVIEW OF MECHANICAL AND SLIDING WEAR BEHAVIOUR OF E-GLASS FIBRE REINFORCED EPOXY COMPOSITES

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ABSTRACT

Due to increasing demand and widespread application of Fibre reinforced polymer (FRPs) composites, they need been utilized in a spread of application like aerospace, automotive, sports, ships and constructional work. owing to their many blessings like relatively low price of production light weight, straightforward to fabricate and superior strength to weight magnitude relation. In the present work E-glass fiber is used as reinforcing agent with and without alumina filler. The objective of the present research work Is a review of mechanical and sliding wear behaviour of e-glass fibre reinforced epoxy composites. and we will mechanical testing of composites, sliding wear test of composite and taguchi design of experiments.

Keyword: - *e-glass fibre, epoxy composites,*

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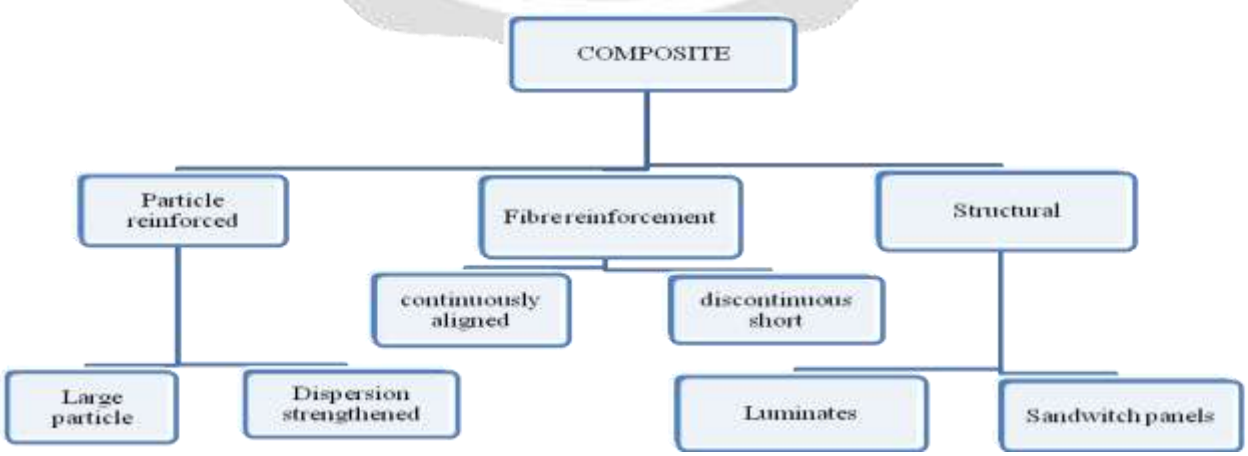
1. INTRODUCTION

A combination of two or a lot of materials with totally different properties, or a system composed of two or a lot of physically distinct phases separated by a definite interface whose combination produces mixture properties that are superior in some ways, to its individual constituents. a brand new material with a mixture of two or a lot of material will give increased properties that manufacture a cooperative result.

In composite materials, there are a unit two constituents one is the matrix and different is reinforcement. The constituents that area unit continuous and gift in bigger amount is termed matrix. the most functions of the matrix area unit to holds or bind the fiber along, distribute the load equally between the fibers, shield the fiber from mechanical and environmental injury and conjointly carry inter-laminar shear. whereas the opposite constituent is reinforcement; its primary objective is to boost the mechanical properties e.g. stiffness, strength etc.
On the basis of type matrix material, composites can be grouped into three main categories, polymer, metallic and ceramic. While on the basis of reinforcement classification of composite is shown in Figure



1.1 MATRIX MATERIALS

The main elements of polymer matrix composite are resin (matrix), reinforcement (e.g. fibre, particulate, whiskers), and the interface between them. The present work deals with the fibre reinforced polymer. FRP's offers significant advantages, like combination of light weight and high strength to weight ratio and it is way easy to fabricate which is better than many metallic components

The matrix of FRPs is further classified into-

A. Thermosetting resin
B. Thermoplastic resin

Thermoset resin (e.g. polyester, vinyl esters and epoxy) undergo chemical reaction that cross link the polymer chain and thus connect the entire matrix into three dimensional network due to this they possesses high dimensional stability, resistance to chemical solvent, and high temperature resistance. On the other hand unlike thermoset, curing process of thermoplastic resin (e.g. polyamide, polypropylene, and polyether-ether-ketone) is reversible. Their strength and stiffness depends on the molecular weight. They are generally inferior to thermoset in case of high temperature, strength, and chemical stability but are more resistant to cracking and impact damage

1.2 REINFORCEMENT MATERIALS

As way we tend to involve regarding the reinforcement, their area unit big variety of it, like fibre (e.g. hemp, kenaf, sisal, coir, jute etc), artificial fibre (e.g. glass fibres, ceramic etc) and organic fibre (e.g. aramid). Natural fibres area unit low cost, simply obtainable, and bio-degradable, however, these benefits don't seem to be comfortable to beat their major drawbacks like wet absorption, It may be simply attacked by chemicals and has low strength compared to artificial fibres. Now, in manmade fibres their area unit two forms of fibres,

A. Synthetic fibre
B. Organic fibre

There square measure various kinds of artificial fibres like nylon, acrylic, polyester, glass fibres etc. currently each day most ordinarily used artificial fibre is glass fibres. There are kinds of glass fibres e.g. A-glass, C-glass, D-glass, E-CR glass, E- glass and S-glass, among them E-glass and S-glass square measure most generally and normally used, in several industries they represent over ninetieth of reinforcements used. Glass fibres that square measure out there commercially square measure in the main manufacture within the kind of woven roving (cloth), sliced strands, long continuous fibres, woven rovings comprises continuous roving, that could be a cloth square measure woven in two reciprocally perpendicular directions. In sliced strand, continuous fibres square measure move the short length and fibres square measure organized within the kind of bundle. On the opposite facet S-glass has higher lastingness, larger modulus and better elongation at failure compared to the E-glass, and S-glass is principally used wherever strength could be a primary concern alongside weight e.g. airplane body, tail wings of airplane, pipes for carrying binary compound liquid, ship hulls, chopper blades, tanks, and vessels. however its price is primary issue that restricts its application in normally used things like house appliances e.g. fibre glass doors, framing, bath etc. and sports things e.g. hockey sticks, fishing pole, the arrow of athletics etc.

Table 1 Composition of glass fibres

Compositions (%)	**E-glass**	**C-glass**	**S-glass**
SiO2	52.4	64.4	64.4
Al2O3 + Fe2O3	14.4	4.1	25.0
CaO	17.2	13.4	-
MgO	4.6	3.3	10.3

$Na_2O + K_2O$	0.8	9.6	0.3
B_2O_3	10.6	4.7	-
BaO	-	0.9	-

Table 2 properties of glass fibres

Compositions (%)	**E-glass**	**C-glass**	**S-glass**
Density (gm/cm^3)	2.60	2.49	2.48
Thermal Conductivity (W/mK)	13	13	13
Coefficient of Thermal Expansion (10^{-6} K^{-1})	4.9	7.2	5.6
Tensile Stress (GPa)	3.45	3.30	4.60
Elastic Modulus (GPa)	76	69	85.5

2. COMPOSITE FABRICATION

2.1 MECHANICAL TESTING

In the present work short glass fibre is taken as reinforcing agent. The epoxy resin (LY-556) and hardener (HY-951) were supplied by Ciba Geigy India Ltd. Alumina (Al_2O_3) is used as a filler material, having particle size in the range of 80-100 μm. The short E-glass fibre mixed with epoxy resin and hardener in the ratio of 10:1 by weight with and without use of alumina filler. Then combined mixture is carefully mechanically stirred and poured into different moulds using hand lay-up technique. A mould releasing sheet is used for the easy removal of composites from the mould. The cast is allowed to cure under a load of 20 kg at room temperature 270C for 24 h. By varying weight percentage of E-glass fibre different composite samples are made (EG-1 to EG-4) with no use of filler material. Other composite samples with varying fibre loading and 5% of alumina (EGA-1 to EGA-3) are also prepared. After curing, samples were cut to the desired dimensions for different mechanical test.

2.2 WEAR TEST

In case of wear test, the samples are prepared using syringe needle of 2.5 ml volume, of circular cross-section having diameter of 10 mm and 50 mm length. The fibre and filler percentage of the composites, curing temperature and duration remains same as before.

2.3 COATING OF COMPOSITE

Thermal evaporation technique is used for coating of composites. The target material (aluminium) is heated in an evacuated chamber so that it attains a gaseous state. Vapour of this aluminium traverse the space from the source to the substrate. The typical deposition rate for aluminium is (~8nm/s). Aluminium (Al) and Gold (Au) metals are suitable for thermal evaporation system because they can be melting in heated crucible and produces enough quantity of vapours. But in present work aluminium is chosen as coating material because it has low melting point, low cost and easily available. When temperature is high enough, the gas impingement rate $\Phi = \Phi$ (Pe) can cause deposition of material (thin-film) on a substrate ($T_s \ll T$).
Where,
T_s = Substrate temperature and
T = Source temperature

3. TESTING

3.1 MECHANICAL TESTING OF COMPOSITES

The tensile take a look at is conducted on all the samples as per ASTM D3039-76 take a look at standards. Specimens are positioned within the grips of universal testing machine and a uniaxial load is applied through each the ends till it gets failure. throughout the take a look at, the crosshead speed is taken as a pair of mm/min as per ASTM standards, specimens of rectangular cross-sections having length and breadth of one hundred millimeter and fifteen millimeter severally are used.

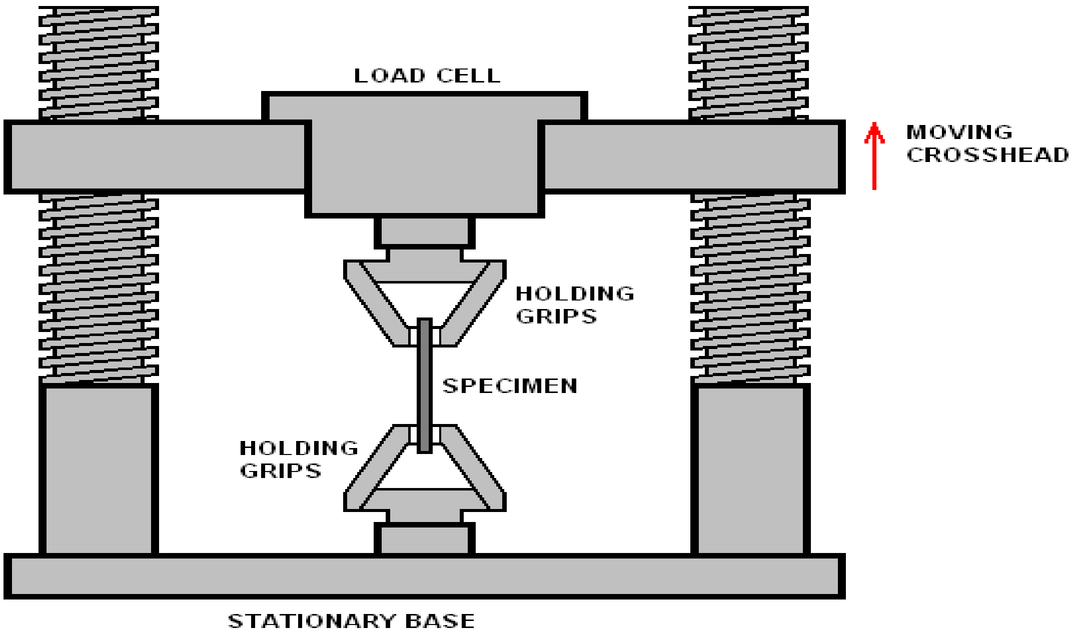


Fig -1: Block diagram for tensile test set up.

To determine the flexural strength of composites a three point bending test is performed using (Tinius Olsen H10KS). Before testing width and thickness of specimens measured at different point and mean value is taken. Samples were placed horizontally upon two points and midpoint is perpendicular to loading nose. The crosshead speed for test is maintained at 2 mm/min. Flexural strength in terms of MPa is determined using the equation

F = 3PL / 2wt2 (3.3)

Where,

P = Load applied on centre of specimen (N)

L = Span length of specimen (m)

w = Width of specimen (m)

t = Thickness of specimen (m)

3.2 SLIDING WEAR TEST OF COMPOSITE

Wear behaviour of composites is studied employing a pin-on-disc equipment below dry slippery condition. Figure 2 shows the schematic diagram and pictorial read of pin-on-disc setup, severally. Wear watching setup was equipped by DUCOM and therefore the slippery wear take a look at is performed in step with ASTM G99 take a look at standards (standard take a look at technique for wear testing with a pin-on-disk apparatus). The specimen is command stationary in pin assembly and counter disc is turned whereas the conventional load is applied through a lever arm mechanism. The counter disc is formed of case hardened steel (72HRC, EN-32, 0.6µm surface roughness). Series of wear and tear take a look at area unit conducted at totally different slippery velocities and at traditional load. Weight loss of composites is measured employing a exactitude balance with accuracy of zero.1 mg.

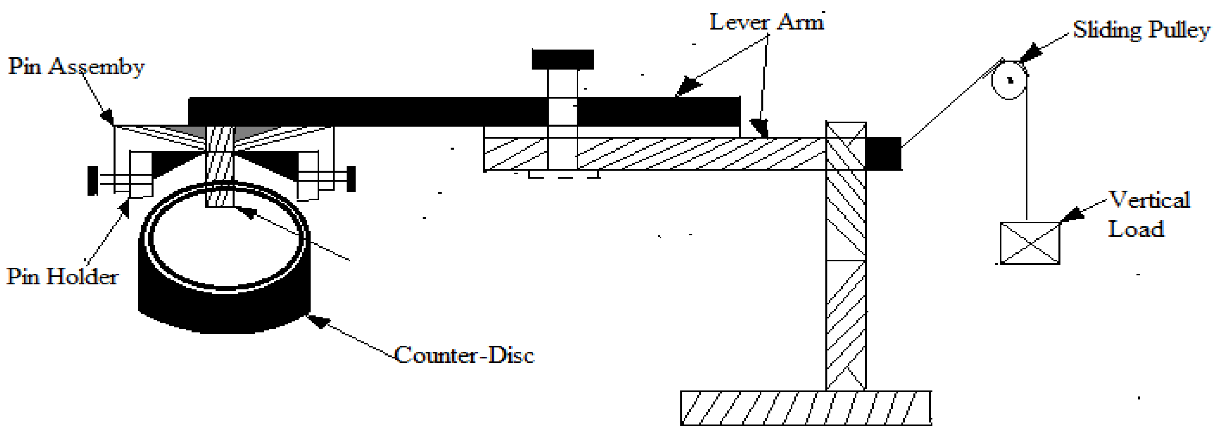


Figure 2 Block diagram of "Pin-on-Disc" set up

3.3 TAGUCHI DESIGN OF EXPERIMENTS

Taguchi method is the technique based on performing experiments to test the sensitivity of a test of response variables to a set of control factors (or independent variables) by designing experiments in *"orthogonal array"* with an objective to attain the finest set of control. An array indicates the number of rows and columns and also number of level in each column. The important tools for robust design is Taguchi method, design of experiment (DOE), and regression analysis. For instance $L_4(2_3)$ has four rows and three "2 level" columns. The no. of rows of orthogonal array represents required number of experiments. The no. of rows must be at least equal to degree of freedom associated with control variables. In present study, four parameters is, sliding velocity, sliding distance, normal load, and fibre loading are set at three levels while filler content. Mixed level type L_{36} (2^11 3^12) orthogonal array design is used. Table 3 shows the experimental details of control factors and their level.

Table -3: Experimental details of control factors and their level

Control factors	Units	Levels		
		I	II	III
Filler Content	%	0	5	-
Coating Thickness	µm	0	0.25	-
Sliding Velocity	m/s	0.523	0.7854	1.1
Sliding Distance	M	314.16	471.3	659.73
Normal Load	N	5	10	15
Fibre Loading	%	10	15	20

4. CONCLUSIONS

In the present work E-glass fibre is used as reinforcing agent with and without alumina filler. The objective of the present research work is a review of mechanical and sliding wear behaviour of e-glass fibre reinforced epoxy composites. and we will mechanical testing of composites, sliding wear test of composite and taguchi design of experiments.

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