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EXPERIMENTAL INVESTIGATION OF MECHANICAL PROPERTIES FOR MULTILAYER GFRP COMPOSITES WITH DIFFERENT ORIENTATIONS

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Abstract- *Composites are very efficient in dealing with tensile and compressive loads when compared to metals. Now a day's metals are replaced with composites because of their high strength to weight ratio and are externally used. In aircraft and automobile industries in our project tensile, compressive, brinell hardness and impact tests were carried out for GFRP specimens with different orientation of fiber in unidirectional, Bidirectional and multi directional. Hand layup method was used for the production of GFRP composites. Through the results of this study, it will be evaluated that which one have good tensile and compression strengths and brine hardness and impact tests are also evaluated and the best one among the unidirectional, bidirectional and multi directional GFRP composites which have optimum properties will be considered and are preferred.*

Key Words: Glass Fibers, Ceramic Fibers, Thermo Plastics, Metal Composites, Epoxy resin, Aradur R Fly 9511 Hardener.

I. INTRODUCTION

Fibers or particles embedded in matrix of another material are the best example of modern-day composite materials, which are mostly structural. Laminates are composite material where different layers of materials give them the specific character of a composite material having a specific function to perform. Fabrics have no matrix to fall back on, but in them, fibers of different compositions combine to give them a specific character. Reinforcing materials generally withstand maximum load and serve the desirable properties. Further, though composite types are often distinguishable from one another, no clear determination can be really made. To facilitate definition, the accent is often shifted to the levels at which differentiation take place viz., microscopic or macroscopic. In matrix-based structural composites, the matrix serves two paramount purposes viz., binding the reinforcement phases in place and deforming to distribute the stresses among the constituent reinforcement materials under an applied force. The demands on matrices are many. They may need to temperature variations, be conductors or resistors of electricity, have moisture sensitivity etc.

This may offer weight advantages, ease of handling and other merits which may also become applicable depending on the purpose for which matrices are chosen. Solids that accommodate stress to incorporate other constituents provide strong bonds for the reinforcing phase are potential matrix materials. A few inorganic materials, polymers and metals have found applications as matrix materials in the designing of structural composites, with commendable success. These materials remain elastic till failure occurs and show decreased failure strain, when loaded in tension and compression. Composites cannot be made from constituents with divergent linear expansion characteristics. The interface is the area of contact between the reinforcement and the matrix materials. In some cases, the region is a distinct added phase. Whenever there is interphase, there has to be two interphases between each side of the interphase and its adjoint constituent. Some composites provide interphases when surfaces dissimilar constituents interact with each other. Choice of fabrication method depends on matrix properties and the effect of matrix on properties of reinforcements. One of the prime considerations in the selection and fabrication of composites is that the constituents should be chemically inert non-reactive.[1] EmadS. Al-Hasani (07-02-2007)Study Of Tensile Strength And Hardness Property For Epoxy Reinforced With Glass Fiber LAYERS From the results in the present work, it was found that depending on the number of layers, the specific failure load could be enhanced from a value of about obtained for epoxy resin after reinforcing with woven rovenglass fibers, while the failure tensile load changed after reinforcing with random glass fiber sand finally it changed after reinforcing with the two types of the fibers as a sandwich, and in all the types the failure tensile load increased with increasing the number of layers except in sandwich composite when it decreased for a layers due to the high volume fraction. The Brinell hardness of epoxy resin is increased after reinforcing with glass fibers in all the types of composite with increasing the number of layers. [2] ShahzadAlam, Farzana Habib, Muhammad Irfan, Waqas Iqbal, And Khuram Khalid (06-01-2010) Effect Of

Orientation Of Glass Fiber On Mechanical Properties Of Grp Composites. The orientation of glass fiber has no effect on the hardness of the GRP composites. The difference in values did not show any significant effect on the behaviour of this type of composites but difference in the orientation has a small effect on the density and impact strength of the composite materials because of the difference in the number of strands per unit area but it widely affects the tensile strength of composites. The maximum value of tensile strength of the composites is of orientation A (Chopped Fabric + Vertical Roving). Therefore this kind of orientation can be used their high tensile strength is required. [3] PrashanthBanakar, H.K. Shivananda and H.B. Niranjan (21-02-2012) Influence Of Fiber Orientation And Thickness On Tensile Properties Of Laminated Polymer Composites.Theexperimental investigations used for the analysis of tensile behavior of glass fiber reinforced polymer laminates leads to the following conclusions. The laminated specimens with lesser thickness leads to more ultimate tensile strength irrespective fiber orientations, Specimen sustain greater load in 90^0orientation specimens than other orientations. Young's modulus of specimens increases with decrease in thickness. Extension is minimum in case of 90^0orientations and maximum in case 30^0orientations.[5] K.Devendra, T. Ranga Swamy (28-10-2013)Strength Characterization Of E-Glass Fiber Reinforced Epoxy Composites With Filler Materials. Based upon the test results obtained from the various tests carried out, following conclusions were made From the obtained results, it was observed that composite filled by 10% volume of $Mg(OH)_2$ exhibited maximum ultimate strength of when compared with other filled composites. Composites filled by Al_2O_3 exhibited better ultimate strength compared with composites filled by flyash and hematite. Increase in addition of $Mg(OH)_2$,Al_2O_3 and flyash to composites leads to decrease in ultimate tensile strength Experimental results show that composites were filled by 10% volume of flyash having high impact strength when compared with other filled composites. Composites filled by 10% volume Al_2O_3 and $Mg(OH)_2$ exhibited good impact strength but increase in addition of Al_2O_3 and $Mg(OH)_2$ leads to decrease in impact strength. Test results indicated that impact strength increases with adding more hematite powder to composites. The experimental results indicated that composite filled by $Mg(OH)_2$ exhibited maximum hardness number when compared with other filled composites. From the results, it is observed that increase in addition of Al_2O_3 and hematite to composites increases the hardness of the composites. Increase in addition of flyash to composites leads to decrease in hardness number. [6] TD. Jagannatha and G G. Harish (02-04-2015) Mechanical Properties OfCarbon / Glass Fiber Reinforced Epoxy Hybrid Polymer Composites. Thecarb on fiber and glass fiber reinforced hybrid composites have been fabricated by vacuum bag method. Experimental evaluation of mechanical properties like micro hardness, tensile and flexural strength of hybrid composites as per ASTM standards has been successfully completed. The micro hardness of carbon fiber reinforced composite is higher than the other composites. The tensile properties have been studied and the breaking load has been measured. The inclusion of carbon fiber mat reinforced polymericcomposite significantly enhanced the ultimate tensile strength, yield strength and peak load of the composite. The ductility of carbon fiber reinforced composite is higher than the other composites. [7] Jelena M.Petrovic, Darko M.Ljubic, MarinaR. Stamenovic, Ivana D. Dimic, and SlavisaS. Putic (2012)Tension Mechanical Properties Of Recycled Glass Epoxy Composite Material. The aim of this study was to examine and compare the properties of the composites prepared with RGF sand non-recycled GFs, as well as to present the possibility for recycling of CMs. The obtained values of tensile properties of the composites with RGFs are acceptable and satisfactory, although they are lower than the corresponding values of the composite with non-recycled GFs (tensile strength values were 14.5% and module of elasticity by 13.2% lower than the corresponding values CM with non-recycled GFs). It can be concluded that the RGECM retains its tensile properties with minimal fluctuation compared to GECM, and as such it can be used for different purposes.

Also, on the basis of the obtained results It can be concluded that the method of recycling GECM based on the exposure to nitric acid can be applied to recycle small amounts of the material, and further research should be directed toward the improvement of the applied method to solve the problem of recycling of the compounds from the decomposed epoxy resin from composite material obtained by boiling in nitric acid. The method should be developed in the direction of the application of several different acids to shorten the time of exposure of the composites to acid attack and increase the efficiency of the recycling process at lower temperatures. There cycling of composite materials and recycling in general can significantly save the energy and the raw materials, and certainly pollution would be drastically lowered.

II.MATERIALS AND METHODS

2.1. Glass Fiber Material:

Glass fiber is by far the most predominant fiber used in the reinforced polymer industry and among the most versatile. Although melting glass and drawing into fibers is an ancient technique, long continuous fiber drawn from glass was introduced in the 1930's by Owens-Corning as glass wool and given the popular name fiberglass. Fibers made from glass are manufactured in many varieties for specific uses. It typically has a silica content of greater than 50 percent, and the composition with different mineral oxides give the resulting product its distinct characteristics.

Fig no:1 Glass fiber

2.2. Resin:

various solid or semisolid amorphous fusible flammable natural organic substances that are usually transparent or translucent and yellowish to brown, are formed especially in plant secretions, are soluble in organic solvents (such as ether) but not in water, are electrical nonconductors, and are used chiefly in varnishes, printing inks, plastics, and sizes and in medicine is known as resin.

Fig no: 2 Araldite LY556 Resin

2.3. ARADUR R FLY 9511N Hardener:

A chemical substance added to something in order to harden it; used especially with paints, varnishes and resins.

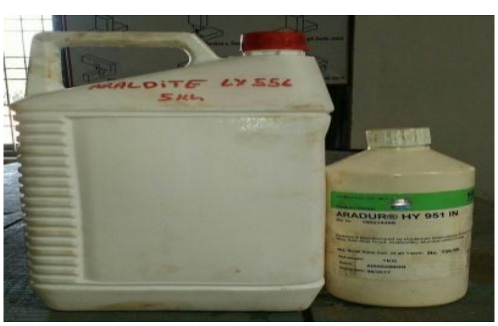

Fig no: 3 ARADUR R FLY 9511N Hardener

2.4. Hand Lay-up Method:

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after Perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed. The schematic of hand lay-up is shown in figure 1. The time of curing depends on type of polymer used for composite processing. For example, for epoxy based system, normal curing time at room temperature is 24-48 hours. This method is mainly suitable for thermosetting polymer based composites. Capital and infrastructural requirement is less as compared to other methods. Production rate is less and high volume fraction of reinforcement is difficult to achieve in the processed composites. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, diase board, deck etc.

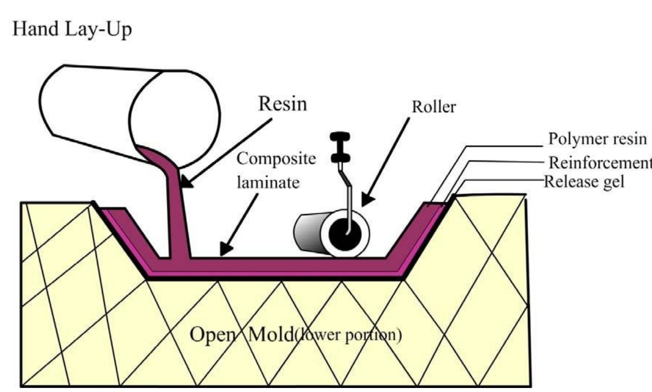

Fig no: 4 Hand Lay-up Method

2.5. Experimental Setup:

2.5.1. Compression Test:

The exact opposite of a tensile test. This is where you compress an object between two level plates until a certain load or distance has been reached or the product breaks. The typical measurements are the maximum force sustained before breakage (compressive force), or load at displacement (i.e. 55 pounds at 1" compression), or displacement at load (i.e. 0.28" of compression at 20 pounds of force).Several m/c and structure components such as columns and struts are subjected to compressive load in applications. These components are made of high compressive strength materials. Not all the materials are strong in compression. Several materials, which are good in tension, are poor in compression. Contrary to this, many materials poor in tension but very strong in compression. Cast iron is one such example. That is why determine of ultimate compressive strength is essential before using a material. This strength is determined by conduct of a compression test. Compression test is just opposite in nature to tensile test. Nature of deformation and fracture is quite different from that in tensile test. Compressive load tends to squeeze the specimen. Brittle materials are generally weak in tension but strong in compression. Hence this test is normally performed on cast iron, cement concrete etc. But ductile materials like aluminium and mild steel which are strong in tension, are also tested in compression.

Fig no: 5 Compression Test

2.5.2. Tensile Test:

Various m/c and structure components are subjected to tensile loading in numerous application. For safe design of these components, their ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conducted on UTM.A material when subjected to a tensile load resists the applied load by developing internal resisting force. These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress. The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be sensing during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area (Ao) goes on decreasing and finally reduces to its minimum value when the specimen breaks. About of UTM & its Specifications: The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e.; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment. The pipes connecting the lift and right parts are oil pipes through which the pumped oil under pressure flows on left parts to more the cross-heads.

Fig no: 6 Tensile Test

2.5.3. Brinell Hardness Test:

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear indication of strength. In all hardness tests, a define force is mechanically applied on the piece, varies in size and shape for different tests. Common indentors are made of hardened steel or diamond.

Rockwell hardness tester presents direct reading of hardness number on a dial provided with the m/c. principally this testing is similar to Brinell hardness testing. It differs only in diameter and material of the indentor and the applied force. Although there are many scales having different combinations of load and size of indentor but commonly 'C' scale is used and hardness is presented as HRC. Here the indentor has a diamond cone at the tip and applied force is of 150 kgf. Soft materials are often tested in 'B' scale with a 1.6mm dia. Steel indentor at 60kgf.

Fig no: 7 Brinell Hardness Test

2.5.4. Izod Impact test:

In manufacturing locomotive wheels, coins, connecting rods etc. the components are subjected to impact (shock) loads. These loads are applied suddenly. The stress induced in these components are many times more than the stress produced by gradual loading. Therefore, impact tests are performed to asses shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed as (i) Rupture energy (ii) Modulus of rupture and (iii) Notch impact strength.

Fig no: 8 Izod Impact Test

III. RESULTS AND DISCUSSION

Table1: Compression Test Results

SI. NO	Type of fiber orientation	Load Acting (KN)	Crushing Strength (N/mm^2)	Average (N/mm^2)
1	Uni-Directional	13 13 13 13 13 13	80.6	80.6
2	Bi-Directional	13 12 11 12 11	80.6 74.4 68.2 74.4 68.2	73.16
3	Multi-Directional	10 8 8 10 8	62.0 49.6 49.6 62.0 49.6	54.5

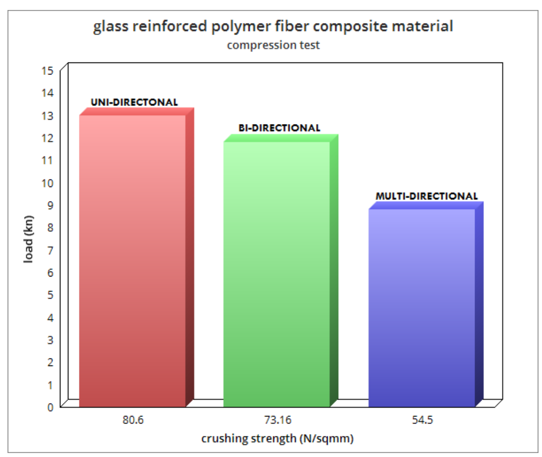

Fig no: 9 Crushing strength vs load

Table 2: Tensile test Results

SI. NO	Type of fiber orientation	Maximum Load (KN)	Ultimate Strength (N/mm^2)	Average (N/mm^2)	Strain	Percentage of Elongation
1	Uni-Directional	25 29 25 25 26	333.33 386.6 333.33 333.33 346.6	346.6	0.016 0.012 0.020 0.024 0.017	1.6 1.2 2.0 2.4 2.6
2	Bi-Directional	38 39 36 38 37	506.6 520 480 506.6 493.3	501.3	0.024 0.064 0.036 0.032 0.035	2.4 6.4 5.6 2.4 3.2
3	Multi-Directional	10 10 10 11 11	133.3 133.3 133.3 146.6 146.6	138.6	0.024 0.064 0.036 0.032 0.032	2.4 2.4 6.4 2.4 3.2

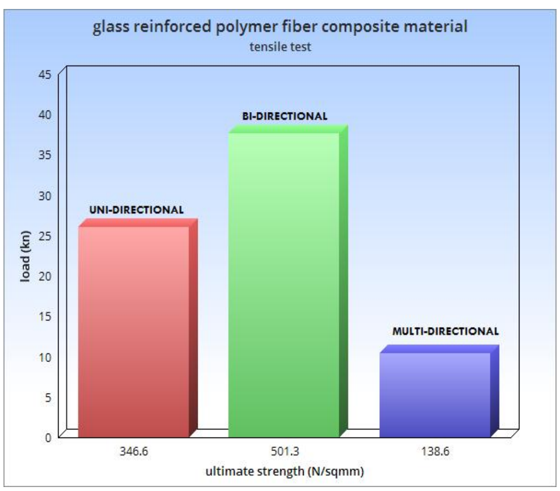

Fig no: 10 Ultimate Strength vs Load

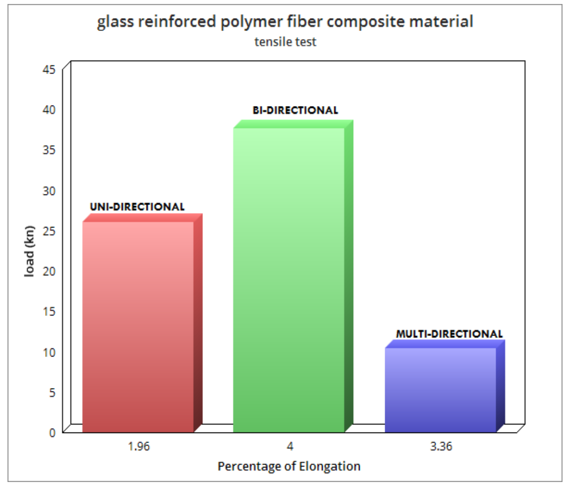

Fig no: 11 Percentage of Elongation vs load

Table 3: Brinell Hardness Test Results

SI.NO	Type of fiber orientation	Hardness in Brinell (KN)	Average (N/mm^2)
1	Uni-Directional	56.79 51.8 49.6 54.25 54.25	53.11
2	Bi-Directional	35.69 38.62 35.69 35.69 36.69	36.66
3	Multi-Directional	51.8 46.5 47.5 47.5 47.5	48.93

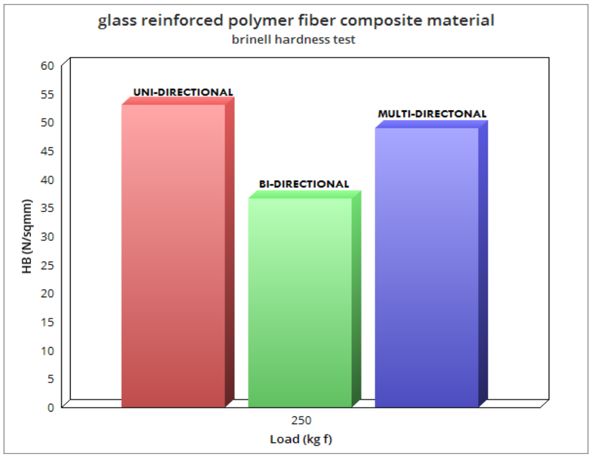

Fig no: 12 Load vs Hardness in Brinell

Table 4: Izod Impact Test Results:

SI.NO	Type of fiber orientation	Breaking Load (J)	Impact Strength (N/mm^2)	Average (N/mm^2)
1	Uni-Directional	10 8 8 8 8	0.26 0.20 0.20 0.20 0.20	0.212
2	Bi-Directional	10 10 10 8 8	0.26 0.26 0.26 0.20 0.20	0.236
3	Multi-Directional	6 6 6 6 6	0.15 0.15 0.15 0.15 0.15	0.15

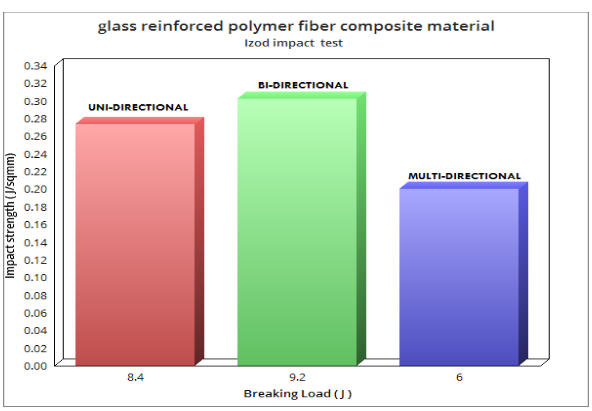

Fig no:13 Breaking load vs Impact Strength

IV. CONCLUSIONS

In all testing of mechanical properties of materials as Compression, Tensile, Hardness and impact strength on samples of uni-directional, bi-directional and multi-directional glass fiber reinforced epoxy resin based polymer composites, following points have been concluded.

1. Bi-directional oriented glass fiber reinforced epoxy composites have large value of all the properties such as Ultimate force, Compressive strength, Tensile strength, Elongation, Hardness, Impact strength etc. In tensile as well as impact test it means bi-directional glass fiber composites have more strength than other fiber composites.

2. The comparison between result of both the Tables 1&2 shows that the value of ultimate force in Tensile test in case of Uni-direction, Bi-direction fiber composites.

3. It means that the Uni-directional fiber is greater than bi-directional fiber in hardness and compression test. The Bi-directional fibers is greater than Uni-directional fibers in tensile and impact test.

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