Experimental Investigation of Novel Nylon-Epoxy Composite Material using UTM

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Abstract: To obtain the objective of choosing optimal material for the product, it is necessary that it withstand the given condition with the minimum usage of resources. For this, researches have been made and various product materials have been evolved as a result. This increases the need to choose wisely the material for the product which should have following characteristics, Withstand the conditions, applied loads without failure, temperature and serve accurately for flexibility, rigidity, toughness, hardness, fatigue. Usage of minimum resources – amount of materials required at minimum and maximum stress generation areas. With the coming time, more use of plastics is used in manufacturing components of car bodies and other components due to its high strength and low weight. In this research work fabricated the nylon-mesh (i.e. mosquito net) reinforced epoxy composite by using the hand layer by layer method. In this novel composite, nylon mesh provides the reinforcing agent whereas epoxy resin is the matrix material.

***Keywords**:* Nylon-Epoxy, Composite Material, Universal Testing Machine (UTM)

I. INTRODUCTION

History is often marked by the materials and technology that reflect human capability and understanding. Many times scales begins with the stone age, which led to the Bronze, Iron, Steel, Aluminum and Alloy ages as improvements in refining, smelting took place and science made all these possible to move towards finding more advance materials possible. Progress in the development of advanced composites from the days of Jute / Phenolic random structures of the early 1940's to the graphite/ polyamide composites used in the space shuttle orbiter-is spectacular. Silica composite tiles used as reinforcement material as thermal protection over space shuttle for space mission in. The recognition of the potential weight savings that can be achieved by using the advanced composites, which in turn means reduced cost and greater efficiency, was responsible for this growth in the technology of reinforcements, matrices and fabrication of composites. If the first two decades saw the improvements in the fabrication method, systematic study of properties and fracture mechanics was at the focal point in the 60's. Since than there has been an ever increasing demand for newer, stronger, stiffer and yet lighter-weight materials in fields such as aerospace, transportation, automobile and construction sectors. Composite materials are emerging chiefly in response to unprecedented demands from technology due to rapidly advancing activities in aircrafts, aerospace and automotive industries. These materials have low specific gravity that makes their properties particularly superior in strength and modulus to many traditional engineering materials such as metals. There have been many researches on nylon composite material in the past on use of nylon composite material for engineering applications. Few of the important research work are briefly discussed here. B.S.Gorton [1] used Blends of nylon-epoxy resins which are used as adhesives, performed swelling tests with the epoxy resin crosslinks the nylon and studied the effect of the epoxy on the nylon with the overall effect in the combined adhesive. J.F.Mandell et al. [2] studied fatigue behavior of injection-moulded tensile bars of short-fibre-reinforced thermoplastics and fatigue behavior of the matrices with the consideration of different matrix system (nylon 6, 6 included.) J.F. Mandell et al. [3] Studied for Cyclic tension fatigue S-N curves for injection molded Nylon 6/6 and discussed the degradation and crack mechanism with the effect of the layer and matrix system for the same material. Khondker et al [4] have investigated on the mechanical properties of aramid/nylon and aramid/epoxy composites and their relationship to the fibre/matrix interfacial adhesion and interaction. R. Narendara et al. [5] prepared Coir pith/epoxy, nylon/epoxy, and coir pith/nylon/epoxy composite keeping the coir pith content at 65%. Two series of the above composites, one with chemically treated coir pith and another without chemically treated coir pith were fabricated and water stabilization dielectric property along with effect of different chemical treatment were studied and evaluated. Anup anand et al.[6] studied the electro spun Nylon 6/6 nanofibers of diameter 80–100 nm on bidirectional E-glass fabric. The fabric with nanofibers on one surface was used to fabricate glass/epoxy structural composites, through resin film infusion with studies of different mechanical properties reflecting to the increase in the compressive strength by 30%. Meshram et al. [7] investigated the mechanical strength of a nylon-epoxy composite. They discovered higher thrust force and tensile strength when compared to pure epoxy polymer. Dorigato et al. [08] looked into the mechanical properties of carbon fibre reinforced materials with an epoxy-clay matrix. They discovered improved mechanical properties as well as a greater degree of clay nanoparticle dispersion in the composite. Md. Tauhidul Islam et al. [09] gives addition of nylon-mesh to the epoxy matrix improved the mechanical properties.

Md. Tauhidul Islam important point is that very limited studies were observed on the different properties such as mechanical properties, electrical and optical properties of nylon-mesh/epoxy composite [10-12]. Ritesh et al Work on mechanical property contingency over material thickness is investigated using a glass fibre reinforced is ophthalic polyester composite material. The specimens are made using a basic hand lay-up process. ASTM standards are followed when performing mechanical tests [13]. An epoxy polymer composite, banana fibre is combined with nylon fibre as reinforcement. Banana fibre has a weight proportion of between 20% and 30%. Experiments on tensile strength, flexural strength, flexural modulus, and impact characteristics are conducted. The hand lay-up method [15], [16], [17] is one of the simplest and oldest methods of producing fiber reinforced polymer composites. It is also the most cost-effective procedure when compared to resin transfer molding and the vacuum process. The hand lay-up approach was employed in the current project to generate the required glass fiber reinforced polymer composites due to its cost savings and popularity. Many of the research investigations on nylon epoxy composite shows that the nylon composite has enough strength to withstand the loads even better than other composites.

This research investigation focusses on static structural analysis of novel nylon epoxy composite. The Ultimate tensile and compressive strength of nylon epoxy composite measured using pc based data accusation on universal testing machine (UTM) available at GEC Bilaspur (India).

II. MATERIALS AND METHOD

Raw Materials:

Raw material used in this experimental work is listed below**:**

a) Nylon honeycomb mesh

b) Epoxy resin

c) Hardener

A) Nylon Fiber: As stated earlier nylon have attracted worldwide attention as a potential reinforcement for composite because of their durability, strength, resistant to moisture, comparatively less expensive than any other plastic composite and its insulating properties. Nylon is a manufactured fiber in which the fiber forming substance is a long-chain synthetic polyamide in which less than 85% of the amide-linkages are attached directly (-CO-NH-) to two aliphatic groups.

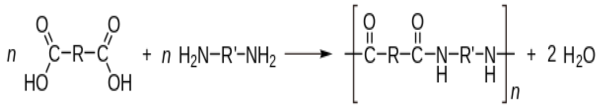

Figure 1: Production of nylon polymer

B) Epoxy Resin: Softener (Araldite AW 106) made by Huntsman International (INDIA) private Ltd. having following outstanding properties have been used as the matrix material: Excellent adhesive to many different materials, Great strength, toughness, and resilience, Excellent resistant chemical attack and moisture, Outstanding electrical insulating properties, Absence of volatile on curing Negligible shrinkage

C) Hardener: Hardener (Hardener HV 950 IN) made by made by Huntsman International (INDIA) private Ltd. is used which has some desirable qualities to be used with the araldite epoxy resin.

Preparation of Composites:

The following procedures have been adopted in order to make the material:

A) Nylon fiber preparation: The woven sheets of nylon are cut from the large sheet of nylon which are generally used as mesh to prevent the mosquitoes from coming inside home. They are cut into rectangular sections of dimension (35mmX10mm) from the whole sheet.

B) Composite preparation: The nylon composite containing the nylon sheets were fabricated in the form of rectangular sheets. Epoxy resin (araldite), hardener were mixed in appropriate proportion at room temperature. While mixing, care was taken to avoid the formation of bubbles in the resin system. On addition of the hardener and resin, the mixture started becoming more viscous. Proper stirring was continued until the mixture lost its ability to flow. This is known as the gel point.
A flat, smooth surface was used for casting the composite sheet. Different groups of samples were manufactured. The schematic view of the layered composites is shown in Figure 2. For quick and easy removal of the composite sheet a mould release sheet was

put over the glass plate. Mould release spray was also applied at the inner surface of the surface after it was set on the glass plate. The prepared mixture of resin and hardener was poured into the mould and the layered samples were cast.

Care was taken to avoid formation of air bubbles during pouring. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 72 hrs. During the application of pressure some polymer squeezes out from the mold. For this, care has already been taken during pouring. After 72 hrs the samples were taken out of the mold, cut into different sizes and kept in air tight container for further experimentation.

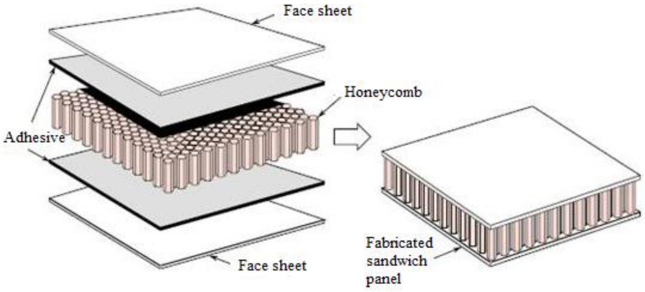

Figure 2: Structural view of composite layer

Experimental Procedure:

To find out the tensile and compressive strength of the material made, it is tested for same using the UTM which has the maximum load capacity of 1000 KN as shown in the Fig. It is clamped to the machine and the data was calculated using the readings provided by the software installed in the machine.

(a)

(b)

(c) 

Figure 3: Universal testing machine (UTM) with PC based data acquisition system at GEC Bilaspur (India)

Compression Test: For the compression test to be performed the composite material was made into a cuboidal shape with the cross section under the load with width and thickness equal to the 38.9 cm and 33.8 cm respectively as shown in figure 4.

Figure 4: Untested material for compression

Tensile Test: For the tensile test the two end of the composite material rod of length 27.9 cm and diameter 2.655 cm as shown in figure 5 and is clamped and the tensile load is applied on it.

Figure 5: Untested material for tensile

III. RESULT

The results are obtained by performing the tensile and compressive test on Universal Testing Machine (UTM) procedure for which is stated in the previous chapter. The composite was prepared with hand layup technique. The test data and report are calculated and prepared by the software developed By Mechatronic control systems installed in the computer. The results are compressive and tensile strength of the material with the increase in load and displacement as applied by the machine. The test data is in the table 1 and table 2 with the Figure 6 and Figure 7 shows the plot between load and displacement for the respective test.

Table 1: Test data for compression Test in UTM

S. No.	Test Data	
01.	Test Type	Compression Test
02.	Specimen Type	Cube
03.	Width (mm)	38.91
04.	Thickness (mm)	33.80
05.	Cross Section Area (mm^2)	1315.158
06.	Pre Load (%)	0.2
07.	Machine Capacity (kN)	1000.00

Table 2: Test result in compression test in UTM

S. No.	Test Result	
01.	Ultimate Compressive load(N)	83800.0
02.	Ultimate Compressive Strength (N/mm^2)	63.719

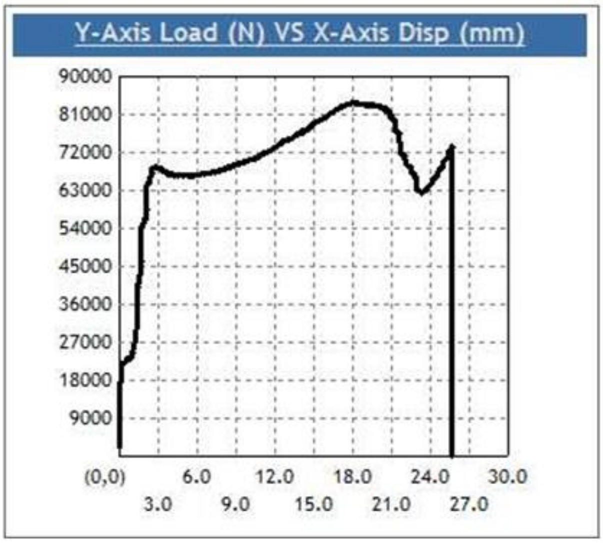

Figure 6: Load vs. displacement graph by compression test in UTM

Table 3: Input for tensile test in UTM

S. No.	Test Data	
01.	Test Type	Load Vs Displacement
02.	Specimen Type	round
03.	Initial diameter(mm)	265.5
04.	Final diameter (mm)	0.0
05.	Cross Section Area (mm^2)	55363.04
06.	Original gauge Length (mm)	279.00
07	Final gauge Length (mm)	0.0
08.	Pre Load (%)	0.2
09s.	Machine Capacity (kN)	1000.00

Table 4: Test result in tensile test in UTM

S. No.	Test Result	
01.	Ultimate Tensile load(N)	21300.0
02.	Ultimate Tensile Strength (N/mm^2)	0.385
03.	Displacement at Ultimate Load (mm)	7.0
04.	Maximum Displacement (mm)	13.9
05.	Percent elongation (%)	4.982
06.	Breaking Load (N)	13300.00
07.	Breaking Stress (N/mm^2)	0.24
08.	Yield Load (N)	13100.00
09.	Yield Stress (N/mm^2)	0.237

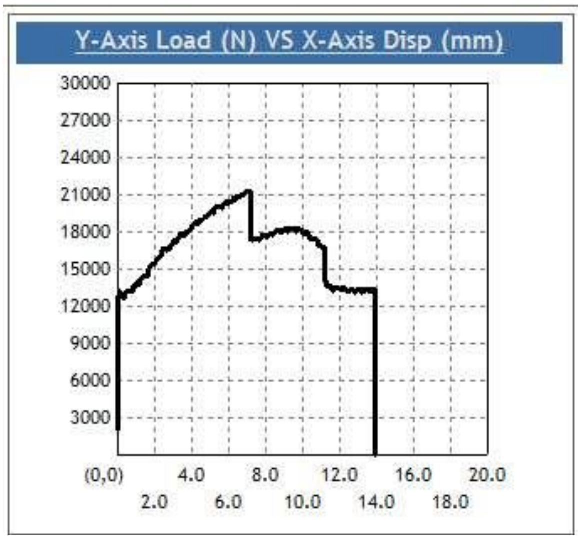

Figure 7: Load vs. displacement graph by tensile test in UTM

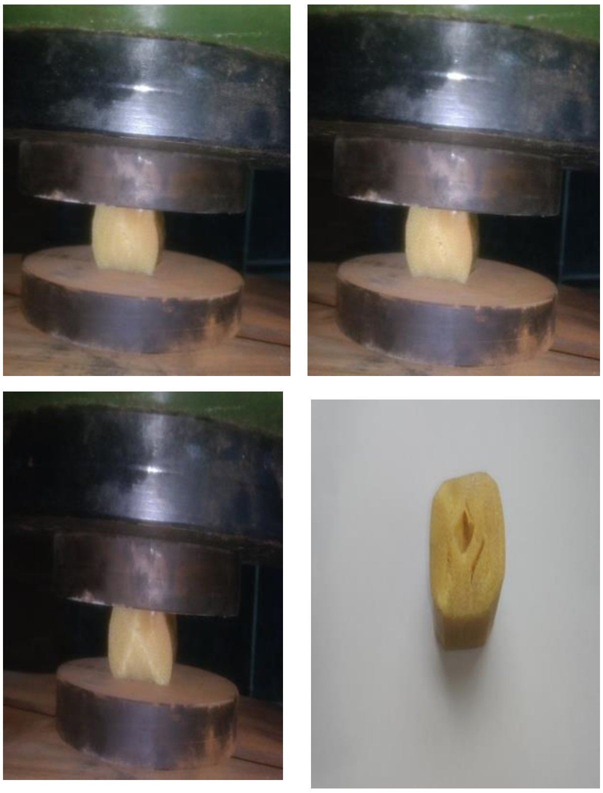

Figure 8: Material under compressive test

(a)

(b)

Figure 9: Material under tensile test

Table 1 shows that for the composite material tested ultimate compressive load is found to be 83800N with the compressive strength tabulated as 63.79 N/square millimeter. Table 2 shows that the result obtains in compression test in UTM. Figure 6 showing the load vs displacement graph for the compressive test, we see that there is no displacement for the load of 17500N after which the displacement starts to occur with the increase in the load with the start of deformation of material under the compressive load. Now from the figure it can be seen as that after reaching the yield point at 68000N with the displacement of 3.2 mm of the material. After which the displacement starts to increase with the load with similarities to the Hooke's law reaching the ultimate compressive load of 83800N at displacement of 17.9 mm after which the load starts to decrease with the increase in the displacement. Figure 8 (a) shows the initiation point of the failure in the material under compressive load. Figure 8 (b) shows the start of the failure of a layer in the material under the increasing compressive load. Figure 8 (c) shows the material under the ultimate compressive load after which the load starts to decrease but the breaking of the material continues. The material didn't get break into two parts as it was made up of the layers of the nylon and epoxy resin which enables the materials to hold up to the strength and not completely deforming instead deformation takes place only at the area around the initiation point at different layer. Figure 8 (d) shows the material after the compressive test has been carried out on it. Table 4.2 shows the data collected for the tensile test performed on the composite material with the ultimate tensile load as 21300N and tensile strength as 0.385 N/ square millimeter. From Figure 9 (a) The plot of load vs displacement for the tensile test, it can be seen that there is no displacement up to the tensile load of 12.3 kN (similar to yield point) in the material after which the displacement increases with the load similarly like Hooke's law up to the ultimate tensile load of 21300N at which the material breaks from the point near the lower clamp position in the test at the displacement of 7.2mm. Figure 9 (b) shows the composite material clamped in the UTM under the load for the tensile testing. Figure 9 (a) shows the material after the tensile test is performed and the material has been broken as it can be seen the material breaks near the end of the road which was clamped at the lower side of the machine while testing the material.

IV. CONCLUSION

1. The compressive strength calculated is less than that of epoxy resin (190N/square millimeter) but is more than that of nylon (55N/ square millimeter) hence the strength has been increased for the reinforcement used.
2. The ultimate tensile load and tensile strength both which were extremely low as compared to the constituent materials used to make the composites. The reason here can be the fact that the material formed has very smooth surface and tends to slip under the tensile load while testing.
3. It has been seen that percentage elongation for the material is near about 5% which is in range for the epoxy resin but far from the nylon's 60% under the same load. Making the material a good replacement of the nylon for the application under tensile loads.

4. As seen from the failure pattern under compressive load, that it fails layer by layer and that too not completely break can be used in impact loading conditions for e.g. in end bearings, forging supports etc.

5. It can be used for the applications which are under the effect of the electro chemical rusting due to its low absorbency of the water and can be useful for the underwater marine applications.

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