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Interpulation of Mechanical Properties of Polyvinylpyrolidone Surfacetant Assisted Nano Composite Laminates

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***Abstract*— The present study focuses on Fabrication and evaluation of mechanical properties of Surfactant (PVP-10) assisted Glass Fiber Reinforced polymers (GFRPs) packed with Low specific Multi-Walled Carbon Nano Tube (MWCNT) contents. The MWCNTs Reinforced GFRP laminates finds more potential applications in the fields of Radar Absorbing Structures (RAS) and sports instruments. In generally, the matrix system (Epoxy) in the Polymer Composite Laminates is modified with Nano-Fillers; namely, CNTs and CNFs (Carbon Nano Fibers) to increase strength of composite. In this study, the GFRP laminates are modified with 0.3%, 0.6%, 0.9% and 1.2% MWCNTs by Weight to escalate the mechanical properties; such as Tensile, Flexural, and Fatigue and also add considerable amount of Surfactant (PVP-10) for better homogeneous dispersion of MWCNTs in the epoxy system. The Fabrication and Testing methods are followed as per ASTM standards. The Tensile, Flexural tests were conducted for both with and without Surfactant assisted GFRP/MWCNT Composite Laminates. The Morphology of The Nano Composites, Delaminating mechanisms and Fiber-Matrix interfacial effects are perceived through Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM).**

***Index Terms*— Surfactant, GFRPs, MWCNT, RAS, Carbon Nano tubes, SEM.**

I. Introduction

These composite materials composed of two phases, namely Matrix and Reinforcements. In order to withstand to heavy loads and various forces acting on the body, different materials having its own individual properties are joined together to form a new material, and these materials are lighter in weight and cheaper when compared to the metals that are used for different applications, it also improves the stiffness, hardness and flexibility of the newly formed material. Composite materials in this regard represent nothing but a giant step in the ever-constant endeavor of optimization in materials. Strictly speaking, the idea of composite materials is not a new or recent one. Nature is full of examples wherein the idea of composite materials used. The coconut palm leaf, for example, is essentially a cantilever using the concept of Fiber Reinforcement. Wood is a fibrous composite: cellulose fibers in a lignin matrix. The cellulose fibers have high tensile strength but are very flexible, while the lignin matrix joins the fibers and furnishes the stiffness. Bone is yet another example of natural composite that supports the weight of various members of the body. Its consist of short and soft collagen fibers embedded in a mineral matrix called apatite .This naturally led to a resurgence of the ancient concept of combining different materials in an integral-composite material to satisfy the user requirements. Composites have introduced an extraordinary fluidity to design engineering, in effect forcing the designer-analyst to create a different material for each applications as he pursues savings in weight and cost. Thus, a common piece of metal is a composite of many grains. The term composites often is often used both in the modern context of Fiber Reinforced Plastics (FRP) and also in the wider context to cover honeycomb structures and bonded metal laminates for primary structural applications. The fiber or matrix (Resin) alone cannot be used for any applications because of the limitations in other properties. Fiber are thin and integrity is not maintained. Fibers are comparatively heavier. In matrix materials the modulus and strength values are less and hence matrix alone cannot be used for any structural applications, but when these two materials are combined we get a composite materials which is light weight, stiff, strong and tough, When it comes to safety and security the aerospace is one sector which needs a word “super” to be prefixed with these words “safety” and “security”.

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II. EXPERIMENTIAL PROCEDURE

A. Materials and Procedures

The fiber reinforced fiber is also known as fiber glass, fiber glass a type of Fiber Reinforced Plastic where the Reinforcement fiber is specially a glass fiber, the glass fiber may be randomly arranged, flattened into a sheet or woven into a fabric. The plastic matrix may be a thermos set polymer matrix most often based on thermosetting polymer such as Epoxy

a. Figure: Glass Fiber Cloth

b. Figure : Mild Steel Rectangular Plate

c. Figure: Mild Steel Rectangular Bar

B. Procedure Of Supports

Initially mild steel plates of 4mm thickness and 25cm length each and totally 10 square plates which acts as supports and weights are taken and a pair of mild steel plates one at the top and the other at the bottom support are used for each samples material Figure 2,and also mild steel rectangular bars of thickness 4mm and length of 25cm long having width of 3cm,totally ten bars which acts as support from sides, a pair of rectangular bars were used for each sample material Figure 3,this square plates and rectangular bars have been used to support the sampled material and to position the sampled material at one place without any disturbances, and these square shaped glass Fiber Reinforced Polymer are placed one over the layer by layer which should be nearly of 4mm which needs approximately six layers of polymers one over the other

d. Figure: GRFP

To cut these layers into the required size cutters with more accuracy is needed and care should be taken that the fibers don't come out from layer

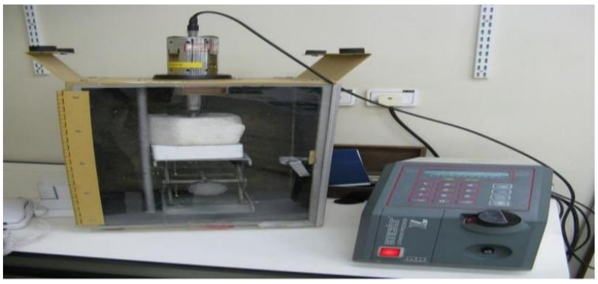
C. Preparation of MWCNTE

In this step, five beakers are taken in which one of the beaker is filled with only Epoxy and another four beakers are filled with the mixture of Epoxy, multi-walled carbon Nano tubes and ethanol, and in these four beakers the Nano tubes content is varied such as 0.3,0.6,0.9 and 1.2,Initially the ethanol in this mixture acts as binder of two different matters, the only function of ethanol in this mixture is to combine the Epoxy and Nano tubes with high strength later on in the process this ethanol is evaporated by using magnetic stirring process, this epoxy, carbon Nano tubes, ethanol mixture is subjected to two main processes:

D. Sonication Process

Sonication is the process of applying sound energy to agitate particles in a sample, the Sonication has both chemical and physical effects, the chemical effect of the ultra sounds are concerned with understanding the effect of sonic waves on chemical system, this is called as Sono chemistry, Sono chemistry arises from acoustic cavitation's which mean formation, growth, and implosive collapse of bubbles in a liquid. Sonication is mechanism used in ultrasonic cleaning-loosening particles adhering to surface, In addition to laboratory science applications, Sonication baths have applications include cleaning objects such as spectacles and jewelry

e. Figure: Sonication Process



E. Magnetic Stirring Process

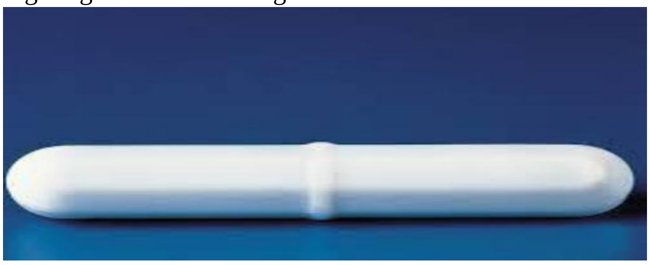
The magnetic stirrer is a device that consists of a bar magnet which is attached to a shaft of an electric motor and a small magnet is placed in the solution, when the motor is activated the attached magnet starts to rotate to set the small magnet in the solution which in turn causes the solution to be stirred, the magnetic stirrer consists of a speed controlling knob which helps in controlling the speed of magnetic stirrer and also a temperature controlling knob.

f. Figure : Magnetic Stirring

F. Stir Bar Magnet

This process is done on magnet stirrer the main aim of this process is to evaporate the ethanol present in the sample mixture in presence of heat and by continuous stirring, a bar magnet is placed in the solution whose continuous rotation causes the Epoxy and Nano tube mixture to mix well at the same time due to specified temperature the ethanol present in the mixture gets evaporated, this procedure is repeated for all the four beakers containing various carbon percentages, this process is continued for 50-60 minutes until the ethanol present in the solution gets evaporated by maintaining the temperatures up to 80 throughout the process.

g. Figure : Stir Bar Magnet



G. Fabrication Process

A plastic sheet of 0.3mm thickness is pasted on the bottom square plate on which a layer of glass reinforced fiber polymer is to be placed. Now the hardener is added to all the beakers containing the Epoxy, MWCNT mixer and immediately after adding the hardener it should be coated on the fiber layer if not the mixture becomes hard as solid in no time. A layer of glass reinforced fiber polymer is placed on the plastic cover which is pasted to the bottom square plate, then the beaker containing only Epoxy is coated on the glass fiber layer on which another glass fiber layer is placed on the previously applied coating one over the other and the process is repeated up to sixth layer and after the six layer the top square plate is placed and the whole arrangement is tightened is with screws and nuts. Now the same process is repeated with mixtures containing different percentages of MWCNT, the mixture is coated in between the adjustment layers up to sixth layer then it is covered with top square plate and the arrangement is tightened with screws and nuts and the same process is repeated for (0.6, 0.9, and 1.2) samples. After the completion of the process, with the help of hydraulic press the sampled arrangements are placed in between the hydraulic press and the pressure is applied from the both ends so that all the layers stick together and the samples are left under pressure for one day. Now the samples are taken out of the hydraulic press and after the removal of screws and nuts, top and bottom plates a square shaped material is obtained after which the material is heated in the oven for two to three days at a specific temperature. The obtained material has high strength.For fabricating the MNCNT-GRP Nano composites, DIGLYCIDYL ether of BISPHENOL-A type liquid Epoxy resin with TRIETHYLENETETRAAMINE as hardener was used which were supplied by ATUL INDUSTRIES. Thin MWCNTs produced via the catalytic chemical vapor deposition process were procured from NANOCYL Company, Belgium. The average diameter and average length of these Nano tubes were 10-20nm and 1-10 micrometer respectively and a special surface area of 250-300. The MWCNTs had 90% carbon purity and transition metal oxide of <0.1%.

III. RESULTS AND DISCUSSION

A. Tests Performed According To ASTM Standard

To evaluate the behavior the following tests are to be performed on the laminates to evaluate their properties, these tests are to be performed according to ASTM standards

TENSILE TESTING METHOD

This test method determines the in-plan tensile properties of polymer matrix composite material reinforced by high modulus fibers, the composite material forms are limited to continuous fiber (or) discontinuous FRP composites in which laminates are balanced and symmetrically with respect to the test direction. A thin plate flat strip of material having a constant rectangular cross section is mounted in the grips of mechanically testing machine and monotonically loaded in tension while recording the force. The ultimate strength of the material can be determined from the maximum force carried before failure, if the coupon strain is monitored with strain or displacement transducer then the stress-strain response of material can be determined, from which the ultimate tensile strain, tensile modulus of elasticity, poison ratio and transition strain can be determined.

a. Table Observation Table

s.no	Specimen label	Tensile strain at maximum load	load at break (KN)	Tensile stress at break	Comment
1	001	1.88420	178.05	178.05	GFRP-NEAT EPOXY
2	001	2.58121	209.69	209.69	0.3 WT% GFRP/MWCNT
3	001	2.57968	179.92	179.92	0.6 WT% GFRP/MWCNT
4	001	5.42618	9.69	242.22	0.9 WT% GFRP/MWCNT
5	001	4.44216	8.62	215.55	1.2 WT% GFRP/MWCNT
6	001	1.14378	5.43	135.80	GFRP-NEAT EPOXY
7	001	1.07102	4.80	119.88	0.3
8	001	1.98336	7.62	190.49	0.6
9	001	2.86569	7.95	198.74	0.9
10	001	1.79075	6.88	170.45	1.2
Maximum		5.42618	9.69	242.22	
Mean		2.57680	7.37	184.07	
minimum		1.07102	4.80	119.88	

FLEXURE TEST METHOD

This test method determines the flexural stiffness and strength properties of polymer matrix composites. a) Three point loading system utilizing center loading on a simply supported beam. b) A four point loading system utilizing two load points equally spaced from their adjacent support points, with a distance between load points of one-half of support span. For comparison purposes, tests may be conducted according to either test procedure, provided that the same procedure is used for all tests, since the two procedures generally give slightly different property values. The values stated in either SI units or inch-pound units are shown in brackets. The values stated in each systems are not exact equivalents therefore, each system must be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

b. Table Observation Table

S.NO	SPECIMEN LABEL	COMMENT	MAXIMUM LOAD	MAXIMUM FLEXURE STRESS
1	001	0.3WT% MWCNT/GFRP	503.96	232.59566
2	001	0.3WT% MWCNT/GFRP SAMPLE-2	678.90	313.33704
3	001	0.3WT% MWCNT/GFRP SAMPLE-3	720.50	332.53891
4	001	0.6WT% MWCNT/GFRP SAMPLE-1	461.12	212.82434
5	001	0.6WT% MWCNT/GFRP SAMPLE-2	183.16	222.99748
6	001	0.6WT% MWCNT/GFRP SAMPLE-3	574.64	265.21683
7	001	0.9WT% MWCNT/GFRP SAMPLE-1	553.47	255.44806
8	001	0.9WT% MWCNT/GFRP SAMPLE-2	631.65	291.53000
9	001	0.9%WT MWCNT/GFRP SAMPLE-3	559.83	258. 38339
10	001	1.2WT% MWCNT/GFRP SAMPLE-1	612.85	282.85614

IV. CONCLUSIONS

A. Tensile test

When compared to the neat Epoxy laminates, laminates with MWCNT are higher strength. When tested according to ASTM standards neat Epoxy laminates, tensile stress value at brake point was found to be (156.92), and where as laminates with MWCNT of various proportions (0.3%, 0.6%, 0.9%, and 1.2%) the tensile stress values at break point were found to be,

0.3% of MWCNT -163.285
0.6% of MWCNT -185.205
0.9% of MWCNT -220.48
1.2% of MWCNT -193.08

Whereas tensile strain values are recorded as for neat Epoxy 1.51,

0.3% of MWCNT -1.8261
0.6% of MWCNT -2.285
0.9% of MWCNT -4.149
1.2% of MWCNT -3.1965

Young's modulus values are recorded as neat Epoxy 15553.5805

0.3% of MWCNT -14745.03
0.6% of MWCNT -14023.83
0.9% of MWCNT -10666.14
1.2% of MWCNT -12540.19

So due to the inclusion of different proportions of MWCNT the strength of laminates found to be higher than neat Epoxy

B. Flexural test

When compared to the neat Epoxy laminates, laminates with MWCNT are higher strength. When tested according to ASTM standards neat Epoxy laminates, Flexural strain value at brake point was to be (248.98), and where as laminates with MWCNT of various proportions (0.3%, 0.6%, 0.9%, and 1.2%) the flexural strain values at break point were found to be

0.3% of MWCNT -0.02474
0.6% of MWCNT -0.02536
0.9% of MWCNT -0.02773
1.2% of MWCNT -0.10834

Whereas flexural young's modulus values are recorded as

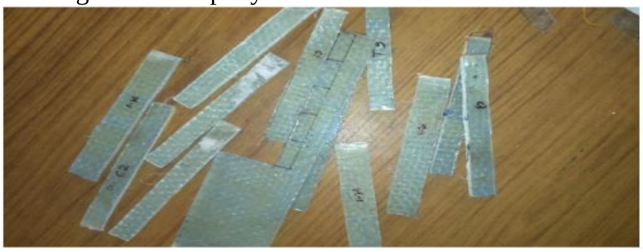
0.3% of MWCNT -15484.227
0.6% of MWCNT -13518.227
0.9% of MWCNT -14179.892
1.2% of MWCNT -13810.53

Whereas flexural stress values are

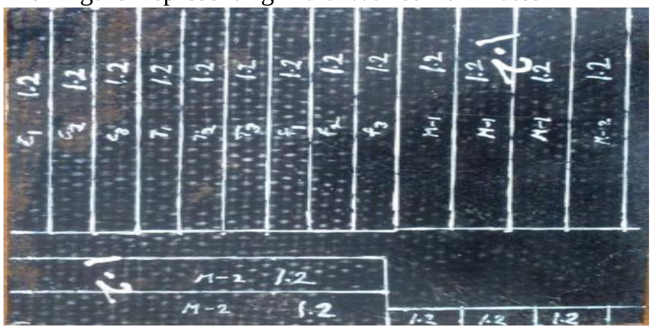
0.3% of MWCNT -1.8261
0.6% of MWCNT -2.285
0.9% of MWCNT -4.1459
1.2% of MWCNT –3.1965

So due to the inclusion of different proportions of MWCNT the strength of laminates found to be higher than neat Epoxy.

h. Figure :Neat Epoxy



i. Figure Representing Multi Walled Laminates



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