EFFECT OF NANOPARTICLES ON TENSILE, FLEXURAL, IMPACT AND FATIGUE PROPERTIES OF FRP POLYESTER COMPOSITES

D. Bino Prince Raja
Research scholar , Aeronautical Engineering
Noorul Islam Centre for Higher Education,
Kumaracoil, Tamilnadu
binoaero87@gmail.com

Stanly Jones Retnam.B
Associate professor in Automobile Engineering
Noorul Islam University, Kumaracoil .
Tamilnadu.

Abstract- Advanced PMCs,fibre reinforced polymer (FRP), has been used for many applications in various industries especially in aerospace structures. The most attention gained composites among them are polymer nanocomposites containing layered silicates. On comparison with polymer alone the nanocomposites have shown enhanced ionic conductivity, it shows decreased thermal expansion coefficient with increased modulus and solvent resistance. The mechanical properties of seven different combinations of composites FRP with Nano filler materials has been added. An increase in tensile strength, impact strength and fatigue life were greatly observed during measurement. A high increase of properties has been discussed in further processes.

Key words: *Tensile; impact; fatigue; Hybrid Bamboo/glass*

I. INTRODUCTION:

FRPs show enhanced properties such as high strength to weight ratios, resistance to electrochemical corrosion, ease and speed of application which are too advantageous over steel. To investigate the effects of fire on the mechanical and thermal properties of FRPs, reinforcing steel and various insulation materials used in fireproofing FRP, research is being conducted at Queen's university in conjunction with the National Research Council(NRC) of Canada and industry partners. To characterize the mechanical and thermal properties of these materials small scale tests have been conducted. 'Nano technology is the understanding and control of matter at dimensions roughly 1 to 100 nanometres, where unique phenomena enable novel applications'. With the use of these smart materials the dream of a near perfect feature will come true. Hence Nano technology is all set to prove that there are no limits for technological developments and is going to make our life easier than before.

Nano technology is building things atom by atom and molecule by molecule. One has to manipulate atoms precisely as when separated, it is a 'bottom up' manufacturing approach in which machines and mechanics are built with Nano scales.

Modelling of composite layered parts performance under load is necessary as, they are employed in functional parts. By the introduction of the reinforcing fibres, modification of the inherent mechanical properties of the matrix material is possible in fibre reinforced composite material. The material properties of the two consistent components of composite interface, along with the amount of reinforcing materials of its geometrical arrangement within the matrix determine the mechanical properties of the composite material. With the help of composite fabrication process (Zak et al 2000) determination of amount of reinforcements and their arrangement is done.

The mechanical properties (Yu et al 2000a,b; Li and Chou 2003; Thorsten's and Chou 2003) with a high aspect ratio and a high Young's modulus and tensile strength, in combination with electrical and thermal conductivity make them interesting materials for the use of nano fillers in polymers and open up new perspectives for multi-functional materials, e.g. conductive polymers with improved mechanical performance.

For tensile properties and impact properties due to large specific surface area and active groups on surface of nano SiO2 particles, modification of Nano SiO2 in epoxy resin-based composite was more effective than that of standard SiO2. Also, for the toughness of epoxy resin-based composites with nano SiO2 and standard SiO2 in SEM images (Lied al 2007) similar behaviour was observed.

FRPs with enhanced matrix dominated mechanical properties and an anisotropic electrical conductivity is achieved by Nano modification of the epoxy matrix.

II. EXPERIMENTAL DETAILS

Fabrication of composite is done by compression moulding process with polyester resin which gives the cost-efficient method. More components, like aerospace parts is suited for a low volume, labour intensive method. Polyester resin is used in matrix material and reinforcing material is used as bi-directional bamboo fibre in woven form. In the case of hybrid material, both woven bamboo and glass fibre are used as reinforcing material.

To find out how much the force it can withstand by the fabricated material by using tensile test according to ASTM standards. By using UTM machine the maximum specimen elongation can be determined.

Stress – displacement & load-displacement sketch can be calculated by using tensile test, which derives to determine the tensile modulus. From the tensile test readings, we can come to which material can be used to withstand the load and to design it in such a way that it can pass the quality check control of materials. High aspect ratio and young's modulus with Tensile strength, in mixture with an electrical and thermal Conductivity make them smart materials and open new thoughts for Smart materials.

The fabricated ASTM D 638 is kept in a UTM machine which is computerized. The specimen is kept at a proper spacing in the UTM and pulled till it fails at testing speed of 60 mm/min to calculate the elongation and strength of the material.

Table 1: shows the different mixture of Polyester resin, and natural woven bidirectional bamboo fibre in wt% Specimens. Specimens A, B, C, D, E. F and G were constructed. ASTM D criterion is used to organize the mould. Specimens were as per tested in computerized UTM, Charpy test machine and fatigue testing machine.

S.No	Specimens	Combinations	Volume (%)	Weight (gm)
1	A	Polyester resin	70	1080
		Bamboo	30	450
2	B	Polyester resin	75	1150
		E-glass fibre	25	425
3	C	Polyester resin	70	1100
		Bamboo	15	200
		E-Glass fibre	15	200
4	D	Polyester resin	70	1125
		Bamboo	10	150
		E-Glass	20	300
5	E	Polyester resin	70	1125
		Bamboo fibre	20	300
		E-Glass	10	150
6	F	Polyester resin	70	1125
		Bamboo	27	280
		Coconut shell powder in micro	3	12
7	G	Polyester resin	70	1125
		Bamboo	27	280
		Coconut shell powder in Nano size	3	10

III. RESULTS AND DISCUSSION

3.1 Specimen Vs UTS

Figure 1 shows the graph of Ultimate tensile strength (UTS) in MPa versus specimens of all seven various combinations plot. It is observed that the specimen G yielded 630.86 MPa of UTS for the increment Nano particles as coconut shell powder.

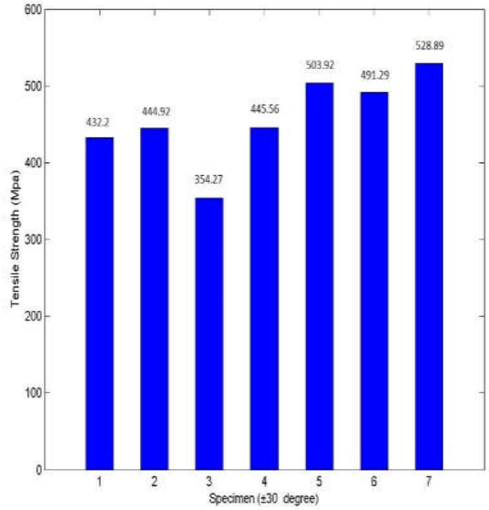

Figure 1 Type of composites Vs UTS

3.2 Specimen Vs Flexural Strength:

Figure 2 shows the graph of Ultimate flexural strength (UFS) in MPa versus specimens of all seven various combinations plot. It is observed that the specimen G yielded 77.368 MPa of FS for the increment by addingNano particles as coconut shell powder.

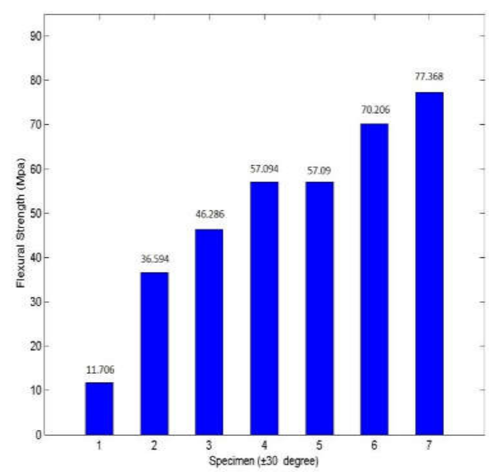

Figure 2 Type of composites Vs Flexural Strength

3.3 Specimen Vs Impact strength

. Figure 3 shows the graph of impactstrength in MPa versus specimens of all seven various combinations plot. It is observed that the specimen G yielded 0.502 J/mm^2 of maximum strength for the increment Nano particles as coconut shell powder

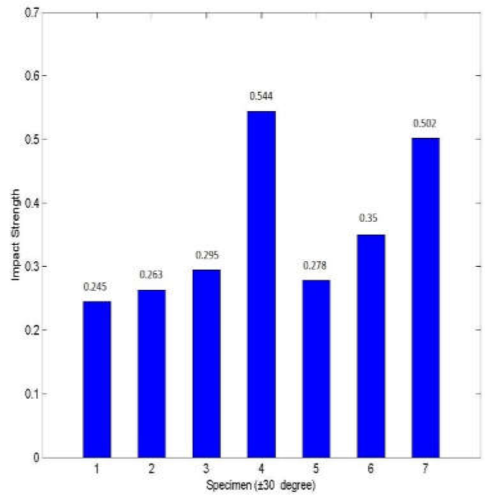

Figure 3 Type of composites Vs Impact Strength

3.4 Fatigue test

Figure 5 represents the S-N Curve for different types of specimens

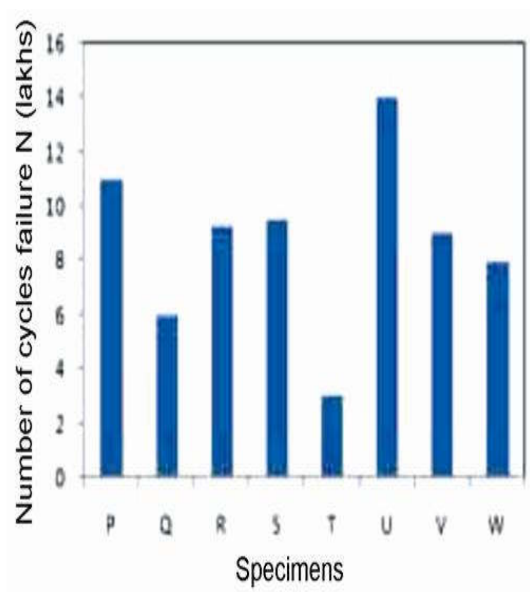

Figure 4. Fatigue life for various specimens at stress range(S)

Figure 4 illustrates the plots of fatigue life vs different unnotched specimens in the stress range of 80% of tensilestrength. For specimenP(A) yielded 11×10^5 cycles and Q(B) yielded 6×10^5 cycles. For the addition of fibre and 3wt% of Nano powder yielded$9{\cdot}3 \times 10^5$ cyclesfor SpecimenF yielded9·5

$\times 10^5$ cycles. Further hybrid composites have reducedfatiguelifeto3 $\times 10^5$ cycles. Fatigue life greatly increased to 14 × 10^5 cycles in specimen F for the increment of hybrid bamboo/glass and reduction in SpecimenF yielded 9 × 10^5 cycles and G yielded 8 × 10^5 cycles. It shows that 3wt% of nanopowder and 27wt% of fibre will greatly increase the fatigue life.

IV. CONCLUSIONS

Under this methodology, the woven bamboo bidirectional FRP composites which are produced by intermixing of bamboo and glass fiber was tested under the room temperature conditions. The results are shown as follows.

- PMC, has rich Ultimate tensile strength when Nano materials is added, the Yield Strength rises up to 630.86 MPa compared to other combinations.
- PMC, has rich high tensile strength when Nano materials is added, thetensile strength Strength rises to 77.386MPacompared to other combinations.
- PMC has high impact strength, when Nano materials is added, the Yield Strength rises up toyielded 0.502 J/mm^{2}compared to other combinations.
- Fatigue test resembles that addition of micro materials and hybrid specimens posses increases to 14 × 10^5 cycles an an increment compared to Nano powder.

The above four parameters of this work which can conclude the effect of nanoparticleson tensile, flexural, impact and fatigue properties posses high strength compared to all other combinations.

REFERENCES

[1]. K. P. Ashik and Ramesh S. Sharma, “A Review on Mechanical Properties of Natural Fiber Reinforced Hybrid Polymer Composites,” 21 September 2015.

[2]. M. R. Sanjay, G. R. Arpitha and B.Yogesha, “Investigation on Mechanical Property Evaluation of Jute - Glass Fiber Reinforced Polyester,” IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), vol. 11, Issue 4, Ver. V, Jul- Aug. 2014.

[3]. Tara Sen and H. N. Jagannatha Reddy, “Pretreatment of Woven Jute FRP Composite and Its Use in Strengthening of Reinforced Concrete Beams in Flexure,” Advances in Materials Science and Engineering, vol. 2013, Article ID-128158, 15 pages, 27 August 2013.

[4]. E. T. Thostenson and T. W. Chou, “On the elastic properties of carbon nanotube-based composites: modeling and characterization,” J Phys D: Appl Phys 2003; 36:573-82

[5]. Yu MF, Lourie O, Dyer MJ, Moloni K, Kelly TF, Ruoff RS, “Strength and breaking mechanism of multiwalled carbon nanotubes under tensile load,” Science 2000; 287:637-40

[6]. Yu MF, Files BS, Arepalli S Ruoff RS, “Strength and breaking mechanism of multiwalled carbon nanotubes under tensile load,”Phy Rev Lett 2000; 84:5552-5

[7]. Li C, Chou TW, “Elastic moduli of multiwalled carbon nanotubes and the effect of van der Waals forces,” Compos SciTechnol 2003; 63:1571-24.