Study of the Effect of Nano Particles on Poly Tetra Fluoro Ethylene for Structural Applications

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Abstract
The design and structural reliability of advanced materials like composites and sandwich materials require a better understanding of the fracture process initiates and progresses to final failure. The science and technology provides an overview of research activities on the application of fiber-reinforced composite materials in the design of wind turbine blades. Unique emphasis was given to the work of scientists, researchers and industrialists who are active in the field and to the latest improvements achieved in new materials, manufacturing processes, architectures, aerodynamics, optimum design, testing techniques.

Keywords
Composite Material, Impact Test, Charpy Impact Test,Compression Test, Microstructure Study, Poly Tetra Fluoro Ethylene (PTFE).

I. Introduction
The composite materials are the multifunction material system that gives characteristics obtainable from any different material. By joining more than 2 different characteristics composite material, we can get strong structures physically." Here classification of the composite materials are such as wood, bones, shell etc, some are man-made materials such as powder metallurgy components, electrical insulators, magnetic components, paper laminates etc. There are two different divisions of composites manufacturing processes: First is open molding and second is closed molding. In open molding, laminate, the gel coats are placed in the atmosphere during fabrication process. The closed molding process uses 2-part molding set and vacuum bag for composite material. In open molding and closed molding process there are different types of methods.

- **Open Molding Method:** Hand Lay-Up, Spray-Up, Filament Winding.
- **Closed Molding Method:** Compression molding, Resin Transfer Molding.

II. Objectives of Composite Material
In this project, "study of the effect of Nano Particles on Poly Tetra Fluoro Ethylene for structural application" is determined. We should know how initiation of composites material fracture takes place and also know the composite material final fracture process.
The composite material mainly consists of sandwich structural concept mainly consists of two or more thin, stiff, strong and relatively dense faces sheets. The density and thick cores are bonded in composite material. The composite material structure gives good strength and flexible stiffness
Here advanced composite sandwich structures have been widely used in automobile industry, marine industry, aerospace industry, wind turbine blades, pipelines, etc. Due to their strong structural ability in carrying transverse loads with less weight penalty. If the core material is good quality, it will have less deflection and high stiffness in composite material. Due to this process the wind turbine blades can carry high loads

III. Components of Composite Material
The composite material mainly consists of the following two major materials:
0.1% of C.N.F.-Carbon Nano Fiber.
P.T.F.E.-Poly Tetra Fluoro Ethylene.

IV. Literature Review
Here the literature survey is carried out as a part of the research and development work to have an overview of the material properties, production processes, and wear behavior of polymer matrix composites. In this chapter we study polymer composites behavior of abrasive wear. This all reports explain and published various literatures on composite materials.
Li and Liang [3] studied the fracture property of PA-66 and its nano composites filled with PTFE nano particles. Here, fractography analysis of fractured specimens is done. The effect of nano particles on the fracture behaviour and also the toughening different mechanisms in nano composites are discussed. Here, the measured wear volume loss increases with increase in distance/abrasive particle size. However, the specific wear rate decreases with increase in distance and decrease in abrasive particle size.

Shao Yun Fu et al. [4] investigated the influence of particulate fillers on the mechanical properties-stiffness, strength and fracture toughness of polymers. It is shown that dramatic developments in mechanical properties can be achieved by bonding of a few weight percentages of inorganic minerals in polymer matrices. This focuses on how nano composite materials are caused by particle size, particle content and how these factors influence the mechanical behavior of polymer nano composites. Here the research tells that the composite strength/toughness is strongly affected by particle size, and particle content, especially the particle/matrix adhesion. This is because strength depends on stress transfer between filler and matrix, and toughness or brittleness is mainly controlled by adhesion.

Further, kurahatti et al. [5] explains the friction and dry sliding wear behaviour of nano-zirconia filled bis maleim ides (BMI) composites. Nano-ZrO_2 filled with BMI composites containing 0.5, 1, 5 and 10 wt. % are prepared using very high shear mixer. The particles influence on the micro hardness, friction and dry sliding wear behaviour were measured with micro hardness tester and pin-on-disc wear apparatus.

Xin-Rui et al. [6] studied the polyimide composites filled with small carbon fibbers, graphite particles, and micro Si-02 are prepared by means of hot press moulding technique. The friction and its other wear properties of the resulting composites mainly sliding against GCr15 steel and are investigated on a model ring-on-block test rig. Here experimental results revealed that incorporation of graphite and SCF significantly improve the tribo logical PI-composites material properties. Here micro Si-02 will effect on the improvement of the friction and wear properties of the PI composite. Here a combinative addition of Gr, SCF and micro Si-02 was the effective in the friction-reducing and anti-wear strengths of the PI-composites.

V. Methodology

Problem Definition and Need Analysis

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Literature Review

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Procurement of Composite Material
C.N.F. & P.T.F.E

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Molding of 0.1% C.N.F. and P.T.F.E.

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Preparation of Specimen as Per
ASTM Standards

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Testing of Specimens

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Microstructure Study of Specimens

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Results and Discussion

Fig. 1: Project Methodology

In step-1 problem definition is selected based on research papers and references. After problem definition the literature review is done to select suitable composite material required for this application In this step two materials CNF and PTFE undergo the procurement process which is required as the raw material for next step With the C.N.F and P.T.F.E molding of these two materials is done based on some standard methods.

This step is followed by the preparation of specimen according to ASTM standards. With this step each specimen is tested by different methods. In this existing step microstructure of different specimens is done by compression testing, 3 point bending testing and impact testing.

At the end, the application is concluded by results and discussions based on reports included in annexure.

VI. Experimental Work

A. Static Compression Tests of Rigid PTFE Foam

This study gives the determination of the mechanical properties of polyurethane foam in static compression. The influence of density, loading speed effects and forming plane mechanical properties were investigated.

The specimens used for compression tests were in the cubes form with size: 25mm x 25mm x 25mm. used specimens shapes are shown in figure 2 . Comparisons between the (before test) initial shapes and (after test) final shapes of the specimen are presented in the fig. 2 and fig. 3 respectively.

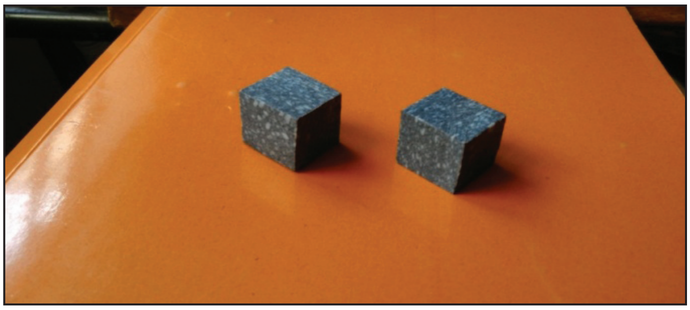

Fig. 2: Before Compression Test

Fig. 3: After Compression Test

This test is performed in UTM60T as per ASTM-A-370-13. With load application of 6,255.959 Kgs and 5,108.778 Kgs compression strength of 98.16 N/mm² and 80.16 N/mm² is achieved.

B. Impact Tests

A. Izode Impact Testing

It is an ASTM standard method of determining the materials impact resistance. An arm held at a constant potential energy is released. Here arm hits the sample specimen. The specimen either breaks or the weight rests on the specimen. Further from energy absorbed by the sample specimen and finally its impact energy is determined.

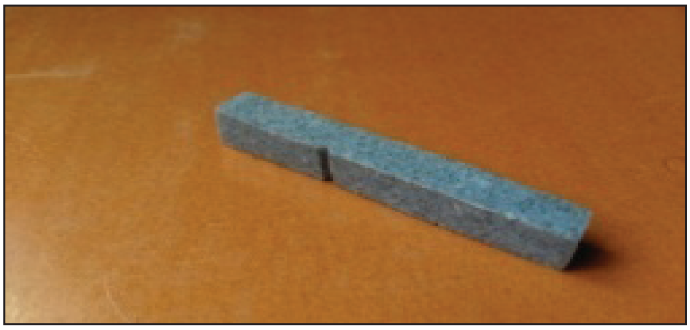

Fig. 4: Before Izode Impact Test

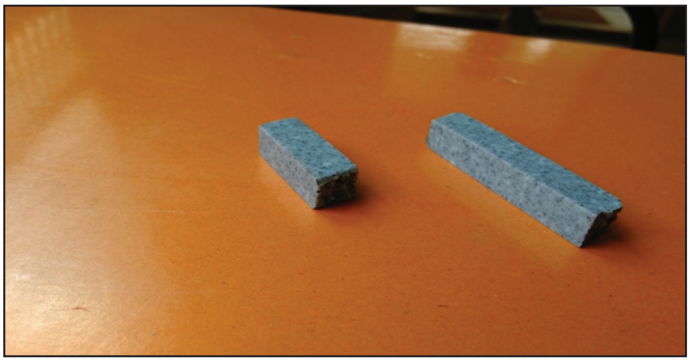

Fig. 5: After Izode Impact Test

C. Charpy Impact Testing

The Charpy impact test is also called as the Charpy V-notch impact test. It is a standardized strain-rate test which finds the amount of energy absorbed by a material during fracture.The figure 6 and fig. 7 represent before and after charpy impact test.

Fig. 6: Before Charpy Impact Test

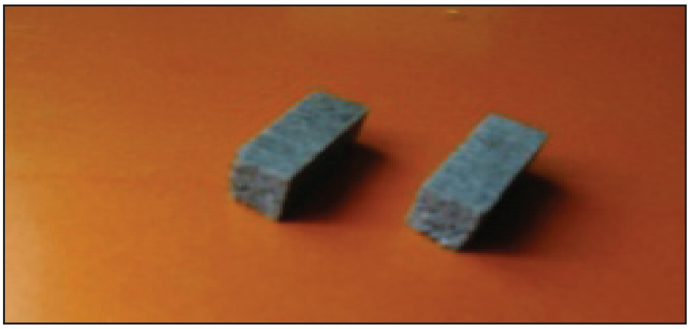

Fig. 7: After Charpy Impact Test

VII. Microstructure Study

Microstructure is the very small scale structure of a material, defined as the structure of a prepared surface of composite material which strongly influences physical properties such as strength, toughness, hardness etc. These properties in turn govern the application of these materials in industrial practice.

The methods used for microstructure study for all compression tests, 3-point bending test, impact test materials were according to ASTM-E562 with testing device is metallurgical microscope, having test details volume fraction 100X-MAG.

VII. A. Compression Test

Fig. 8 and Fig 9 shows cell shapes before and after compression tests for given specimen with load applied 6,255.959 Kgs and 5,108.778 Kgs. After compression tests the given specimen shows a total destruction of cells, which increases the stress with to an almost constant strain (called as densification). In the densification moment process, due to the gaps filling in the given specimens, this one acts almost like a solid material.

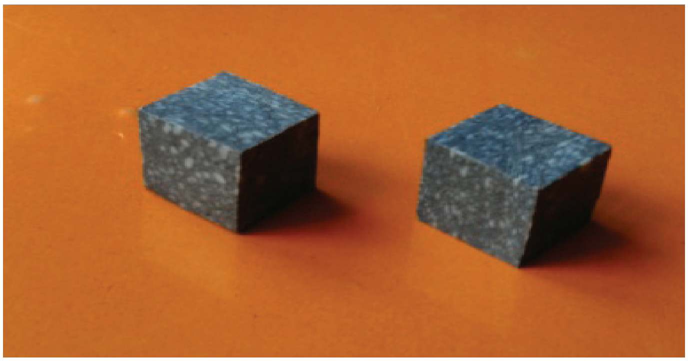

Fig. 8: Before Compression Test

Fig. 9: After Compression Test

VIII. Results And Discussions

A. Mechanical Property:- Compression, Tensile, Impact and Hardness test

The influences of rigid particulate fillers on the stress-strain behavior of polymers will be known, at least for fillers in the size of micrometers and larger. Here micro fillers commonly increase the stiffness at one end and on the other end they may have a detrimental effect on the flexural strain to break. The flexural strength of micro particle filled composites is known to be reduced with rising filler content.

Table 1: Results

S.no.	Test Name	Specimen Size	Observed Values	Astm Standard
1	Compression Test	12mm x 12mm x 25mm	*Compression strength = 134.58 N/mm^2 *Load applied = 1,976.210 Kgs	ASTM-A-370-13
		25mm x 25mm x 25mm	*Compression strength = 98.16 N/mm^2 *Load applied = 6,255.959 Kgs	ASTM-A-370-13
	Microstructure study	Before compression test	*Phase1 = 35.51 Phase2 = 64.49	ASTM-E562
		After compression test	*Phase1% = 33.15 Phase2% = 66.85	ASTM-E562
3	Impact test			
	*IZOD ‘V’ notch	10mm x 10mm x 75mm	*Energy observed in joules = 1.50 J	ASTM-A-370-13
	*CHARPY ‘V’ notch	10mm x 10mm x 55mm	*Energy observed in joules = 2.50 J	ASTM-A-370-13

The results measured for the nano composites in this study offer an apparent conflict with the given behavior. Further, the flexural modulus increases nearly linearly with the filler content as expected. Here the flexural strength behaves in the same way. Here important characteristics of composites have taken in order explaining this process.

The interface quality in composites is the static adhesion strength and the interfacial stiffness. It is very important role in the materials' capability to transfer stresses and elastic deformation from matrix to fillers. Further, this is especially true for nano composites, because they select a large portion of interface. Therefore, if filler matrix interaction is very poor, the particles are unable to carry any part of the external load. That case, the strength of the composite cannot be larger than that of the neat polymer matrix.

As mentioned above, the strain at break falls with rising filler content. Further, low filler loadings can already cause a dramatic drop in the fracture strain. Here one has to study that the composite is part matrix-part filler. Therefore, due to the rigid nature of the fillers, most of the deformation comes from the polymer. Now the actual deformation by the polymer matrix is much higher than the measured deformation of the sample. Further, with this result, the polymer reaches the failure strain limit at a lower total deformation. Now the total composite strain-to-break decreases finally.

IX. Conclusion and Future Scope

Here this experimental investigation into the mechanical testing and bodies' behavior of nano filled composites like carbon nano fibre (CNF + PTFE) leads to the following conclusions:

1. This work shows that successful fabrication of composites (CNF + PTFE) with and without filler by using compression mould technique.
2. The filler morphology, size, particle amount and also the dispersion homogeneity influence extensively the composite's performance. Therefore, composite toughness and strength are strongly affected by three factors – particle size, particle/matrix adhesion and particle loading.
3. The addition of nano particles increases the mechanical properties of composites (CNF + PTFE).
4. Composites (CNF + PTFE) filled with nano composites strongly depends on the experimental test parameters like as temperature and loading direction.
5. Behavior of composites under different operating speeds can be successfully tested by the compression test, 3-point bending test, impact test, hardness test.
6. Based on the microscopic observations of the surfaces, a positive rolling effect of the debris (nano particles and matrix) between the sample and the counter face, which led to remarkable reduction of particle size. This effect becomes more when the filler concentrations is wt. %.
7. Further, the nano filled composites (CNF + PTFE) show indication of mild hard particles.
8. These composites (CNF + PTFE) have adequate potential for tribo logical applications. Further, with the fillers reinforcement, they exhibit significantly improved resistance.

X. Future Scope

1. Vary the different compassion of C.N.F (carbon nano fiber) and P.T.F.E (poly tetra fluoro ethylene)
2. Using of FEM analysis to find out different mechanical property at different loads.
3. In the study the size of the abrading substance was 50 -70 microns. This work can be further extended to other particle size and types of particle like glass bead etc, to study the effect of particle size and type of particles on behavior of the composite.
4. In the current study the fillers were added separately and fabricated and was found that at 2 and 4% filler concentration, the composite performs optimally. This can be extended by fabricating hybrid composites by mixing the two fillers together and analyzing the results.
5. In this study the filler materials were used in the increment of 2%, this can be increased to a variation increment of 10%, so that addition of filler materials can be studied to a greater extent.

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