Evaluation of Mechanical Properties of E-Glass Fiber Reinforced Polyurethane for Wind Mill Blades

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ABSTRACT

Polymer composite materials have been a part of the automotive, domestic, agriculture and aerospace industries for several decades. Polyurethane is one of the latest members of the rapidly growing thermoplastic polymer family which is capable of successfully competing currently with textile, chemical, automobile, aerospace applications, radar, marine applications, industrial products, building and packaging industries.

Polyurethane is the first member of a new group of polymers prepared by a mechanism defined as "Steriospecific" polymerization. From a simple monomer, this technique produces polyurethane with an exceptionally uniform molecular structure, which imparts outstanding engineering properties into the polymer.

Such structural regularity as well as low weight to strength ratio can be varied to tailor the properties of the polymer to satisfy a given requirement in the wind mill blades.

Keywords*:* *PU,*

1. INTRODUCTION

Modern technologies require materials with unusual combination of properties that cannot be met with conventional metals, alloys and ceramic materials. This is especially happened for materials that are needed for airplane, underwater submarines, energy production and transportation applications. For example, aerospace engineers are currently looking for structural materials that have low density, strong, stiff, abrasion and impact resistant and are anti corrosives. Material property combinations and ranges have been and are being extended by the development of composite materials.

A composite is considered any multiphase material that exhibits a significant proportion of the properties of both the constituent phases in such a way that a better combination of properties is realized. According to this *principle of combined action*, better property combinations are affected by the judicious combination of two or more distinct materials.

In practice, most of the composites consist of a bulk material (the 'matrix'), with some sort of reinforcement, added primarily to increase the strength and stiffness of the matrix. This reinforcement will usually be in fiber form. Most composites have been created to increase combinations of mechanical characteristics such as stiffness, ambient and high-temperature strength.

Many composite materials are composed of just two phases; one is termed the *matrix,* which is continuous and sounds the other phase, called the *dispersed phase.* The properties of composites are a combination of the properties of the constituent phases, their relative amounts, and the geometry of the dispersed phase. "Dispersed phase geometry" in this context means the shape of the particles their size, distribution and orientation.

2. LITERATURE REVIEW

Kishore et al. [1] Author concluded that Polymers with their composites are important alternative products to metal based goods in many common and advanced engineering applications. Ease of fabrication, availability of a good choice of materials from both thermoplastic and thermosetting varieties and their economic viability have made the advent of these newer materials for industries ranging from automobile to sports goods.

Femand Ellyin et. al. [2] Author studied that Polymer composites are increasingly gaining importance as substitute materials for metals in applications within the aerospace, automotive, marine, and electronic industries. Their lightweight and superior mechanical properties make them ideally suited for transportation and other applications. Polymer matrix composite materials offer many superior properties compared to with conventional materials, among them high strength to weight ratio, superior corrosion resistance and the ability to tailor the material system to a particular requirement.

George C Jaco et. al. [3] Composites have been mainly used for savings in secondary structures. With several advances made in understanding the behavior of composite materials, many fibre reinforced polymer composite materials are finding increasing use as primary load bearing structures and in a wide range of high technology engineering applications. The composites have the ability to tailor design, in addition to high stiffness-to-weight ratio, fatigue resistance, corrosion resistance, and low cost when compared with conventional metals. The main drawback of composite systems when compared to metallic systems is their inability to resist defect initiation and propagation.

Hou J. et. al. [4] Polymer composites with conducting carbon black, which may serve as polymer conductors or semi-conductors or the media for heat transfer, have found wide applications in electric and electronics industry. If Polymers designed and manufactured properly, glass/polymer and wood/epoxy rotor blades can provide tens of thousands of hours of operating time. The recent advances in composites technology, however, may provide an excellent opportunity to further improve the blade cost/performance.

3. EXPERIMENTAL ANALYSIS

3.1 Experimental Setup

3.1.1 Tensile test specimen

The test specimens for testing tensile strength were made as per ASTM D 638.

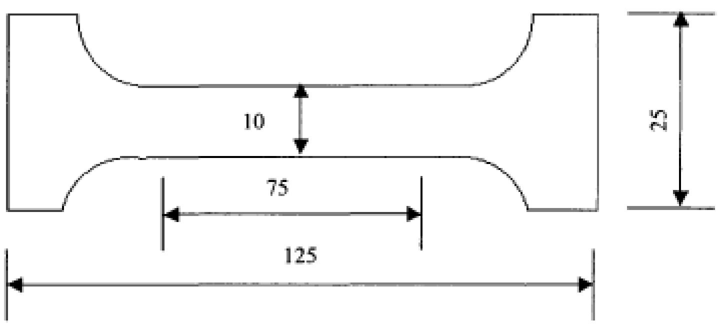

Fig. 3.1 Specifications of the tensile test specimen

3.1.2 Compression test specimen

The test specimens for compression test as per ASTM D 695 i.e., cylindrical specimen with diameter 20 mm and length of 25 mm were used for the measurements.

3.1.3 Flexural test specimen

The test specimen for flexural strength were made as per ASTM D 790 having the dimensions 50 X 20 X 2 mm with the gauge length of 48 mm as shown in Fig

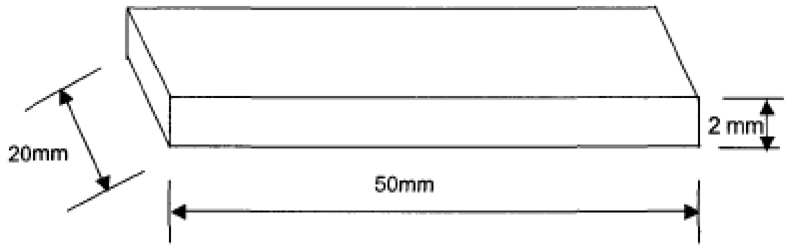

Fig.3.2 Specifications of the flexural test specimen

3.1.4 Impact test specimens

The size of the test specimen was 250 mm X 75 mm X 2 mm as shown in Fig 4.4

as per ASTM D 256. The depth under the notch of the specimen was 10.2 mm

(0.4 inches).

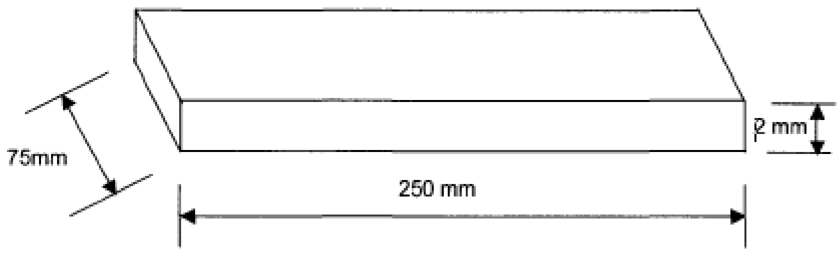

Fig. 3.3 Specifications of the Buckling/Impact test specimen

3.1.5 Shore hardness test specimens

The test specimens for shore hardness test as per ASTIVI D 2240 (cylindrical specimens with diameter 20 mm and length 25 mm) were used for the measurements.

ASTMD92–Standard test method used to calculate flash and fire points by Cleveland open cup tester. This analysis method shall be used to measure the properties of materials, products or assemblies in effect to heat and a test flame, under controlled laboratory conditions. The test cup filled to a specified level with the sample. The temperature of sample is increased rapidly at first and then slows at slow constant rate as the flash point is approached. At specified intervals a small test flame pass across the sample the lowest temperature at which the application of flame causes the vapors above the surface of liquid to ignite is taken as a flash point. To determine the fire point, the test continued until the application of test flame causes the oil to ignite and burn for five seconds.

4 RESULTS AND CONCLUSIONS

The tensile property that is ultimate tensile strength and stiffness of the PU/E-glass composites specimen showed significant improvement over the unreinforced PU specimen.

The Ultimate Tensile Strength and Young's modulus of the PU/E-glass specimen deviated very little at different strain rates except in case of the specimen with higher wt% of glass fibre. No effect of strain rate was observed in case of polyurethane specimen, which may be due to its ductile nature.

The similar trends of results are observed when subjected to compressive load. The failure mechanisms observed in unreinforced PU specimens were entirely different in nature from that corresponding to PU/E-glass composite.

The bending responses in PU specimens follow the three distinct aspects *viz.*, steep increase, steady state and steep decrease in deflection until failure.

In composite specimens steep increase, steep decrease and steady state until failure in sequence are observed.

The flexural strength in the composite specimens is higher than that of unreinforced PU specimens.

In PU specimens, at lower strain rates, ductile failure was observed whereas at higher strain rates, brittle failure with shallow dimples was observed.

In case of composite specimens, at lower strain rates, fibres slip individually and are scattered with fibre pull out. But, at higher strain rates, simultaneous failure of PU and glass was observed and this was indicated by the bundling of the fibres with PU adhering to them.

A modified instrumented impact tester was designed and developed with load cell, LVDT and the data acquisition system to capture the impact data and compute the impact properties of four types of laminates specimens.

The different types of PU/E-glass specimen only 48% PU/E- glass composite specimen showed superior performance in terms of energy absorbing properties and strength due to the higher stiffness of glass front layer and back layer.

Three modes of failures namely PL) layer failure, fibre failure and complete failure were observed predominantly.

Face layer failures are due to flexural and shear stress at the point of impact.

Specimen failure is due to shear strain and delamination between the fibre and the PU.

The PU/E-glass material was used to fabricate the components called braided tubes and these were tested for longitudinal and circumferential stresses. The results showed superior performance and hence recommended for high-pressure fluid transportation.

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