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Tensile Test for Environmental Effect On Glass Fiber Composite Materials

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ABSTRACT

The basic reason for working on this area arises from the fact that composites are vulnerable to environmental degradation. A moist environment, coupled with high or low temperature conditions is extremely detrimental for composites. There have been several efforts made by researchers in the last few years to establish the much needed correlation between the mechanical properties of the material and the moist environment or similar hydrothermal conditions, subjected to thermal shocks, spikes, ambient & sub ambient temperatures. But most research has been on the mechanical aspects rather than the physical & chemical interface and how this brings change in the internal mechanical properties and affects a variety of other morphological changes. The focus of our research has been to understand the physical changes that take place at the bonding interface between the fibers and the matrix, as it is of prime importance due to its link to the stress transfer, distribution of load and it also governs the damage accumulation & propagation. This has wide significance in aerospace applications, because the aircraft components are exposed to harsh moist environment. Hence our project work aims at the characterization of the hybrid GFRP'S by DSC/SEM and to analyze the variation of Tg and flexural strength along with the mode of failure due to variation in moisture and temperature gradient.

KEYWORDS : *Glass fiber reinforced polymer composite, Hydrothermal, Environmental conditioning, Resin.*

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I. INTRODUCTION

Over 95% of the fibers used in reinforced plastics are glass fibers, as they are inexpensive, easy to manufacture and possess high strength and stiffness with respect to the plastics with which they are reinforced. Their low density, resistance to chemicals, insulation capacity are other bonus characteristics, although the one major disadvantage in glass is that it is prone to break when subjected to high tensile stress for a long time. Therefore, data on the effects of moisture on retention of the mechanical properties of GFRP during long term environmental exposure are crucial for them to be utilized in outdoor applications. The environmental stress cracking characteristics of GFRP were studied using fracture mechanics samples under constant tensile load and water environment. For GFRP the characteristics of crack length as a function of exposure time. Ductile aramid fibers seemed to project the glass fiber reinforcement from stress cracking due to higher chemical resistance and complex failure mechanisms.

In addition to the prediction of load transfer in the joint stress analysis was conducted to investigate the effect of bonded on the peel and shear stress distribution in the adhesive. The main objective of this work is to investigate the effects on flexural strength of GFRP composite materials subjected to hydrothermal aging and its life predication by mathematical modelling. In this work, the effects of environmental ageing on retention of flexural properties of GFRP are studied and qualitative correlation to between results from ageing and accelerated ageing is discussed.

II. LITERATURE REVIEW

Glass transition temperature (Tg) of thermo set matrix in composites is very important property because it defines the critical service temperature of the component and consequently their applications. For practical applications they are used at a temperature below their Tg i.e. in the glass state.

When materials are exposed to hydrothermal environment, the Tg usually decreases and therefore, the service temperature of the material changes. Moisture absorption by epoxy matrix composites has plasticizer effect, as reduction of Tg of the matrix. This effect is usually reversible when water is removed but exposure to high temperature can produce irreversible effects, which is attributed to the chemical degradation of the matrix and attack on the fiber/matrix interface. This causes increase of internal voids of the entangling polymer chain, promoting chain expansion and the microcracks formation into the polymer matrix. There are many factors on which moisture absorption depends such as temperature, fiber volume fraction, reinforcement orientation, fiber nature, and area of exposed surfaces, diffusivity and surface protection [1, 2].With the constant necessity of the development of light weight structures, the advancements of science and technology in several areas has contributed to the improvement of aviation parts. Structural components of aircraft for civilian and military purposes, such as flaps, rudders, fairings, aileron, fuel tanks, elevator, tail cone and others that were previously made of metal alloys are recently being manufactured in laminated structures of advanced polymeric composites (Kim and Ye, 2005). Currently, several companies are already introducing these parts in their aircraft, among which may be cited as Airbus, Boeing and Embraer (Botelho and Rezende, 2000).Thermoplastic composite materials have several advantages over traditional thermoset composites in the manufacture of lightweight structures, among them the fact that these materials can be reprocessable, have good cost effectiveness and solidify in a short time compared with slow curing of the thermoset resins, which facilitate their use (Botelho et al., 2003). Between the thermoplastic matrix, the poly (ether-imide) (PEI) is a polymer of high performance with good properties, such as strength and stiffness at elevated temperatures, good electrical properties, ample chemical resistance, besides low cost. Furthermore, its glass transition temperature Tg is high compared to other engineering polymers and can be used in aeronautical applications (Oliveira et al., 2009; Zenasni et al., 2006; Viña et al., 2008; Chevali et al., 2010). Fiber-reinforced thermoplastic composites in outdoor applications encounter ambient moisture, variation of temperature, salinity and ultraviolet (UV) radiation in addition to stress and temperature, which affects mechanical properties (White and Shyichuk, 2007). These materials are used for long periods of time on airplanes, so it is necessary to know exactly which influence of such factors ensure its safe operation, preserving their properties for the period desired (Yakimets et al., 2004).So, in addition to mechanical properties (tensile, compression, shear etc.), it is important that the maximum service temperature be verified making sure the aircraft flight envelope, based on knowledge of Tg and melting temperature (Tm)..

III. EXPERIMENTAL METHOD

3.1 Tensile test for polymer matrix composite materials using UTM (ASTM D3039/D3039M-OO)

To perform mechanical testing some type force application device is required, along with grips or other fixtures to transfer the applied loading to the test specimen while special purpose load frames can be and are used, general purpose load frames, termed universal testing machines, of the most common. These are either electro mechanical or hydraulic devices.

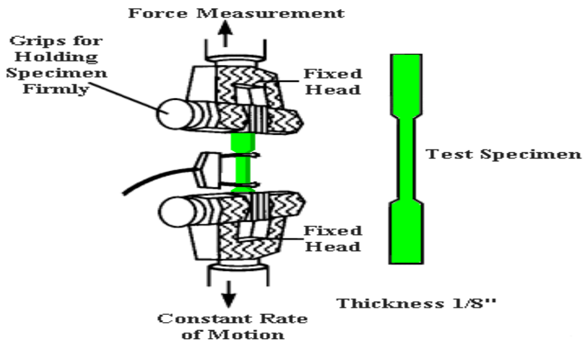

Fig. 1 Test specimen in UTM

Current generation electro mechanical testing machines typically have moving cross head which moves up and down, on two rotating screws driven by electric motor. Load is monitored by an electronic load cell connected to a strip chart recorder and/or personal computer. The more versatile of these machines can operate in load, displacement or strain control. In load control, as specified rate loading can be applied to the test specimen via electronic feedback from the load cell to the driving motor.

3.1.1 Summary of Test Method

A thin flat strip of material having a constant rectangular cross section is mounted in the grips of a mechanical testing machine (Figure 1) and monotonically loaded in tension while recording load. The ultimate strength of the material can be determined, from the maximum load carried before failure. If the coupon strain is monitored, then the stress response of the material can be determined from which the ultimate tensile strain, tensile modulus of elasticity, poisson ratio can be derived.

3.1.2 Significance and Work

This test method is designed to produce tensile property data for material specification, research and development quality assurance, and structural design and analysis.

3.1.3 Testing Machine Heads

The test machine shall have both essential stationary head and a movable head.

3.1.4 Drive Mechanism

The testing machine drive mechanism shall be capable imparting to the movable head a controlled velocity with respect to the stationary head. The velocity of the movable head shall be capable of being regulated.

3.1.5 Load Indicator

The testing machine load sensing device shall be capable of indicating the load being carried by the test specimen.

3.1.6 Grips

Each head of the testing machine shall carry one grip for holding the test specimen so that the direction of load applied to the specimen is coincident with the longitudinal axis of the specimen.

3.2 Tensile strength

Tensile strength is indicated by the maximam of a stress-strain curve and, in general, indicates when necking will occur. As it is an intensive property, its value does not depend on the size of the test specimen. It is, however, dependent on the preparation of the specimen and the temperature of the test environment and material. Tensile strength, along with elastic modulus and corrosion resistance, is an important parameter of engineering materials used in structures and mechanical devices. It is specified for materials such as alloys, composite materials, ceramics, plastics and wood.

3.3 Explanation

There are three definitions of tensile strength:

Yield strength

The stress at which material strain changes from elastic deformation to plastic deformation, causing it to deform permanently.

Ultimate strength

The maximum stress a material can withstand when subjected to tension, compression or shearing. It is the maximum stress on the stress-strain curve.

Breaking strength

The stress coordinate on the stress-strain curve at the point of rupture.

IV. SETTING PROPERTIES FOR THE MESH

4.1 Width Thickness Length

Select the specimen width and thickness to promote failure in the gage section. Keep the gauge section as far from the gribs as reasonable possible and provide a significant amount of material under stress therefore produce a more statistically significant result.

4.2 Use of Tabs

Tabs are strongly recommended to failure the specimen in the fiber direction.

Fiber orientation	Width mm (in)	Overall length mm(in)	Thickness mm(in)
Balanced and symmetric	25 (1.0)	250 (10.0)	2.5 (0.1)

4.3 Specimen Overview

The prepared slabs of the composite materials were taken from the mold and then specimens were prepared from composite slabs for different thermal and fire resistance tests according to ASTM standards (Figure 2). The test specimens were cut by laminate by using different tools. Three identical test specimens were prepared for different tests.

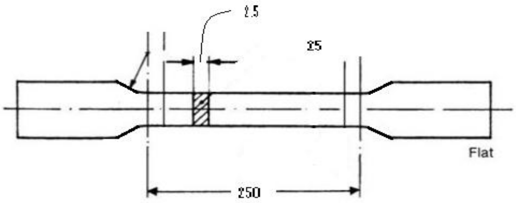

Fig. 2 Test Specimen

4.4 Tensile Test Specimen

Tensile test specimen before test (Fig. 3) section of universal test machine. After the test section tensile changed (Fig. 4).

Fig. 3 Tensile Test Specimen before Test

Fig. 4 Tensile Test Specimen after Test

V. RESULTS AND DISCUSSION OF MECHANICAL PROPERTIES

Different values got from tensile test is tabulated and discussed.

From tensile test, the values of ultimate tensile (Breaking) load, Ultimate Tensile Stress are calculated.

Test Specimen (Glass fiber/Epoxy)	Ultimate tensile (Breaking) load(KN)	Ultimate Stress (KN/mm^2)
Specimen 1	11.87	0.371
Specimen 2	11.90	0.372
Specimen 3	12.03	0.376
Specimen 4	12.02	0.375
Specimen 5	11.86	0.370
Average	11.93	0.372

VI. CONCLUSION

In this Project We have Fabricated Glass Fiber laminated plate using Epoxy resin and Hardner. We were make this Glass fiber laminates by Hand layup Method and cured process under Room temperature. After making Laminated plate, We have cut the laminates into Standard Test specimen using ASTM (American society of Testing Materials) table. Totally Five test specimens are drawn from that Glass fiber laminate, After that test specimens are tested in the Universal Testing Machine (UTM), Each test specimen tested separately, and found out Ultimate tensile load of specimen each Specimen, then the ultimate tensile stress calculated using following formulaUltimate Tensile stress= Ultimate tensile load/Cross sectional area Thus average Ultimate tensile stress value calculated for that Glass fiber/Epoxy laminate. Then the study about application of Glass fiber laminates in aircraft construction is carried out successfully.

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