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Mechanical Behaviour of Natural Fibre Reinforced Polyester Composite Material under Different Environmental Conditions

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Abstract- The composite materials are extensively in automobile industry for various applications. In the present study, the impact strength, tensile and flexural strength of Banana Empty Fruit Bunch composites have been calculated, after exposing to different environmental conditions i.e. high temperatures, low temperature and distilled water. The influence of alkali behaviour on the flexural, tensile and impact properties of composites has also been evaluated. Due to water aging, there was 10% reduction on impact properties and 50 % reduction in tensile, flexural properties. The water aging effects more Banana EFB composite compared to pure polyester. The elevated temperatures and low temperatures have degraded the mechanical properties varying from 10 – 20%. The failure is dominated by fiber-material interface debonding and brittle failure.

Index Terms – Tensile, flexural & Impact properties, water aging, Natural Fibre.

1. INTRODUCTION

In the past few years a huge development in the new composite materials with natural fibers reinforcement has been shown by important industries such as the automotive, marine, construction or packaging industry. Composite materials captured the attention of industries with the introduction of synthetic fiber reinforced polymeric based composite materials[1].The growth in composites usage also occurred because of the increasing awareness regarding product performance and increased demand in global markets for light weight components[2]. Natural fiber composites usage in the industry could ensure a sustainable development through utilization of renewable resources[3]. The primary goal is to substitute synthetic fibers like mineral fibers and glass. There are several kinds of natural fibers which are available in adequate in nature, including banana, sisal, jute, rice husk, bamboo and oil palm[4]. India occupies the largest area under banana cultivation. India involves the biggest region beneath banana development. In India we have around 5 lakh hectares of banana development and as it were 10% of the banana waste is extricated as fiber[5]. The banana natural product bunches (the upper side 'U' sort stem) is squandered as a by item and indeed ranchers frequently confront issues to clear it[6]. As of late, a light weight composite material has been arranged utilizing banana purge natural product bunch fiber (banana EFB) as support in polyester resin matrix, and its mechanical properties are studied[7]. Despite the attractiveness of natural fibers as reinforcement foe composites, the limitations imposed on mechanical performance include lower strength and lower modulus.

Other drawbacks include relatively high moisture absorption, poor dimensional stability (swelling), low thermal resistance, hence accompanying strength reduction[8].Considering the strength of materials in the adverse environmental conditions, is thus key to developing reliable automotive, aerospace and ocean engineering hardware. During service, polymeric composite material may be subjected to a variety of environmental conditions such as moisture, solvents, high temperature, low temperature, mechanical loads and radiation[9].The aim of present study is to evaluate the effects of various environments on tensile, flexural and impact properties of banana EFB reinforced composites as well as on pure polyester matrix At the end SEM studies have been carried out in order to identify the damage mechanism of banana EFB composites due to environmental effects.

2. MATERIALS AND METHODS

2.1 Materials

Unsaturated polyester resin of the grade ECMALON 4413 has 1233kg/m^3 density, 500-600cps viscosity at 25^{0}C, and 35% monometer content. Banana EFB natural fibers were extracted from empty banana bunch.

2.2 Extraction of banana EFB fiber

Banana empty fruit bunch fibers were extracted in laboratory using retting and mechanical extraction procedure. The banana rachis was taken for extricating fiber and made into four strips cutting them in longitudinal direction. These strips were doused in water for a period of almost 10 days. After this handle the strips were subjected to a mechanical process, by beating them delicately with a plastic mallet in arrange to extricate and partitioned the fiber. The resulting fiber bundle was scrapped with sharp knife and combed until individual fibers were obtained as shown in figure 1.

2.3 Fabrication of composites

Hand lay-up process was adopted within the arrangement of unidirectional composites. The amount of accelerator and catalyst included to tar at room temperature for curing was1.5% by volume of resin each. The shape was filled with an fitting sum of polyester tar blend and unidirectional fibers, beginning and finishing with layers of resin. Fiber deformation and development should be minimized to abdicate great quality, unidirectional fiber composites. In this manner at the time of curing, a compressive weight of 0.05MPa was connected on the shape and the composite examples were cured for 24 h.

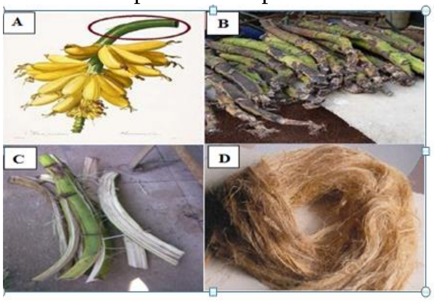

Fig. 1 - Extraction of Banana EFB fiber

2.4 Tensile testing of the composite

The ductile properties of the composites were measured as per the standard test strategy ASTM D638-89. The test examples with 160 mm long, 12.5 mm wide and 3 mm thick were arranged. Five identical examples were tried for each sort of composite. Covering aluminum tabs were stuck to the closes of the example with epoxy gum filling the space at the tab cover to anticipate compression of the test conjointly for effective grasping within the jaws of the chuck. The examples were tried at a cross head speed of 2 mm/min, utilizing an electronic tensometer (Show METM 2000 ER-1).

2.5 Flexural testing of composites

Three-point twist tests were performed in agreement with ASTM D 790M test strategy I (strategy A) to degree flexural properties. The tests were 100mm long, 25 mm wide and 3mm thick. In three-point twisting test, the external rollers were 64mm separated and the tests were tried at a strain rate of 0.5mm/min. The flexural modulus and the most extreme composite push are calculated utilizing the relationships[10] given in prior paper.

2.6 Impact strength testing of the composite

Izod affect test scored examples were arranged in agreement with ASTM D256-88 to degree affect quality. The examples were 63.5 mm long, 12.7 mm profound and 10 mm wide. A sharp record with included point of 45○ was drawn over the center of the saw cut at 90○to the test hub to get a reliable starter break. The tests were broken in a plastic affect testing machine (capacity-21.68 J).

3. RESULTS AND DISCUSSIONS

3.1 Tensile properties

It has been observed that there is a decrease in tensile strength when banana EFB composites are subjected to 80^0 C temperature which is shown in figure 2. When the composites are exposed to high temperatures, fibers tend to shrink themselves and this will leave some spaces between matrix and fibers interfaces. Stress would concentrate at these sites and degrade the composite integrity. But there is a slight increase in tensile strength when composites are subjected to 130^0C. This may be due to the increased fibre/matrix adhesion from the softening of the polyester matrix. It has been reported that the short time ageing at high temperature improves the mechanical properties of thermoplastic composites. This can be explained by an additional process of annealing of the thermo pressed composites at the softening temperature. The enhancement in tensile strength may be attributed to the formation of transcrystallinity developed on the surface of fibre after treatment. There is a moderate reduction in tensile strength when the banana EFB specimens are subjected to cold temperature of -4^0C. When fiber/ lattice interface is available to dampness from the environment, the cellulose strands tend to swell. This is often since, the cellulosic strands are hydrophilic and so can assimilate water from the environment and can swell. This comes about in improvement of shear stretch at interface which leads to the extreme debonding of the strands. There's 50% decrease in ductile quality when the banana EFB examples are water matured for 25 days. Submersion in water may lead to quick debonding, delamination and misfortune of basic judgment. The assimilation of dampness will plasticize the framework and cause a decrease in pliable quality.

3.2 Flexural properties

The observations made earlier for the effect of heat treatment and water aged tensile strain/stress properties are also relevant here. There is a decrease in flexural strength with the increase in temperature which is presented in figure3. There is a decrease in flexural properties after water immersion which can be related to the weak fibre–matrix interface due to water absorption

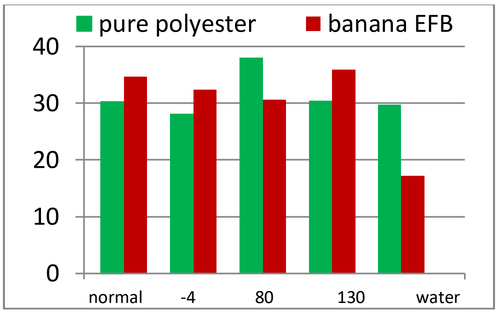

Fig. 2 – Tensile properties

3.3 Impact properties

It has been noticed as shown in the figure 4, that there is a slight increase in impact strength, nearly 1%, when the composites are subjected to 80^0C. This is due to interfacial gap between fiber and matrix, which is increased as the sample is subjected to elevated temperature. It is believed that a right gap is always beneficial for impact resistance. However the gap developed is more when the samples are subjected to 130^{0}C which results in decrease in impact strength. There is approximately 7% increase in impact strength when banana EFB subjected to -4^{0}C. This increase in impact strength of banana EFB composites could be due to the acceptable level of damage in the interface region because of moisture absorption. The swelling of fibers causes a strong mechanical interlock between the fiber and matrix. Therefore swelling is beneficial for impact strength to a certain extent. There is a decrease in impact strength when banana EFB are immersed in water for 25days.This is due to more swelling of fibers which increases the fiber matrix debonding thus decreasing the impact strength.

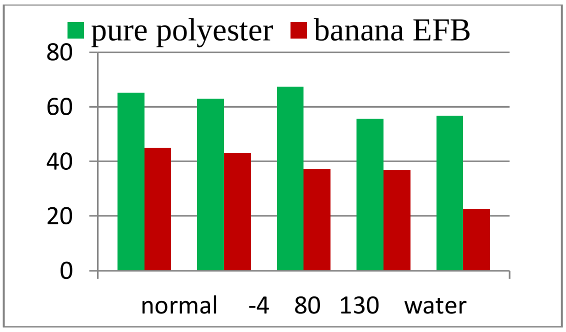

Fig. 3 – Flexural properties

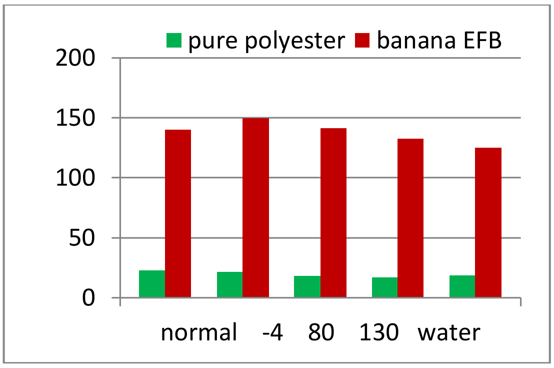

Fig. 4 – Impact properties

4. CONCLUSIONS

It has been noted that higher aging temperatures degraded both the tensile and flexural properties. Higher maturing temperatures quickened shrinkage handle that created a crevice at the interface between fiber and fabric, subsequently diminishing load-bearing capability of composites. The pliable modulus and flexural modulus of immaculate polyester gum are expanding with the increment in temperature. This uncovers that immaculate gums prolonged more at hoisted temperatures than at room temperatures. There is 50% reduction in both tensile and flexural strength, when composites are aged with water for 25 days. This is due to debonding of fibers due to water absorption. However the water aging and high temperatures have minimum effect on impact strength of composites. The weak fiber matrix region caused with elevated temperatures and water immersion is beneficial for impact energy to dissipate. As far as tensile, flexural properties are concern, this situation is not desired.

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