Evaluation of Sugarcane Bagasse Polymer Composite for Structural Applications

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Abstract - *Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated products and applications. Research is going on to develop newer natural fibre-reinforced plastic composites in order to replace metal and plastic components. Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The present work has been undertaken to develop a matrix composite (epoxy resin) using bagasse fibre as reinforcement and to study its mechanical properties and performance for automobile (structural) applications. The composites are prepared with different volume fraction of bagasse fibre. Natural fibre-reinforced composites can be applied in the plastics, automobile and packaging industries at minimal material cost. Environmental awareness today motivates the researchers, worldwide on the studies of natural fibre reinforced polymer composite and cost effective option to synthetic fibre reinforced composites based on green composite material. Thus material scientists and engineers are always striving to produce either improved traditional materials or completely new materials. This present work has been under taken to develop a polymer matrix composite (epoxy resin) using sugarcane fibre and to study its mechanical behaviour. The bagasse was successively treated with 14% Toulene solution and then later with 1M Citric acid and was sun-dried. Composites having different percentage weight fraction of 0, 2.5, 5, 7.5 % of sugarcane bagasse fibre for different laminates were made. The interfacial behaviour of these composites was investigated by tensile test, flexural test, impact test and density test. The fabricated composite samples were cut according to the ASTM standards for different experiments and its mechanical properties like density, hardness, tensile strength and impact strength are performed.*

Key Words: Sugarcane Bagasse, Epoxy, polymer matrix composites, Automobile (structural) applications.

Introduction

In the past decade, lightweight materials made from natural fibres composites with thermoplastics and thermosets have been embraced by automakers and suppliers to achieve weight reduction in order to improve fuel economy of automobiles and reduction of greenhouse gas emission. [1]This is because natural fibres have many exceptional properties that are difficult or impossible to match with synthetic fibres. These advantages include renewable, environment friendly, low cost, low density, flexibility of usage and biodegradability. Studies on the use of natural fibres such as bagasse, as replacement to synthetic fibre in fibre-reinforced composites have increased and opened up further industrial possibilities. [2]Natural fibre-reinforced composites can be applied in the plastics, automobile and packaging industries at minimal material cost. The fabrication method of a natural fibre composite material influences the mechanical properties and is strongly related to parameters such as the length of fibre and the resin used. [3]To improve the average fuel economy of cars and light trucks industries need to renew their focus on lightweight materials to achieve weight reduction. This can be achieved in structural and non-structural components such as door panels, seatbacks, headliners, package trays, dash boards, front-end, and interior parts. [4]The usage of lightweight, low cost natural fibres such as bagasse, kenaf, jute, sisal, hemp, and flax are providing automobile makers benefits of reduction in CO2, less dependence of oil sources, recyclability, and they are renewable and sustainable resources.

ITEM	%
Moisture	49.0
Soluble Solids	2.3
Fiber	48.7
Cellulose	41.8
Hemicelluloses	28
Lignin	21.8

Table 1 : Average Bagasse

Raw materials:

Raw materials used in this experimental work are (a) Natural fibre (Bagasse) (b) Epoxy resin (c) Hardener

1. Bagasse fibre

The sugar cane bagasse is a residue widely generated in high proportions in the agro-industry. It is a fibrous residue of cane stalks left over after the crushing and extraction of juice from the sugar cane. The main chemical constituents of bagasse are cellulose, hemicellulose and lignin. In the present work volume fractions of bagasse fibres (0%, 2.5%, 5% and 7.5% by weight) have been taken as reinforcement in the polymer matrix.

2. Epoxy resin
Lapox L-12 made by Atul limited having the following outstanding properties has been used as the matrix material such as excellent adhesion to different materials, High resistance to chemical and atmospheric attack, High dimensional stability, Negligible shrinkage, Excellent mechanical and electrical properties, Odourless, tasteless and completely nontoxic.

3. Hardener
In the present work Hardener K6 is used. This has a viscosity of 10-20 MPa at 25℃

Procedures for Preparation of composites:

(a) Bagasse fibre preparation:-
Fresh bagasse fibres were collected after they were crushed for extracting juice by using a hand crushing machine. The bagasse samples were then cleaned via pressurized water for about one hour. This procedure removes fine bagasse particles, sugar residues and organic materials from the samples. Fresh bagasse fibres were collected, spread on a water proof sheet and sun-dried to remove or reduce the moisture content. The bagasse was cleaned with RO water, then it was successively treated with 14% Toulene solution and then later with 1M Citric acid and was sun-dried again.

Figure 1 : Sugarcane bagasse fibre

(b) Composite preparation:-
The sugarcane bagasse was powdered using a grinder. The first group of samples were manufactured with 0, 2.5, 5, 7.5 % weight fraction of fibres. For different weight fraction of fibres, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. For quick and easy removal of composite sheets, mould release sheet was put over the glass plate and a mould release spray was applied at the inner surface of the mould. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 48 hours. This procedure was adopted for preparation of 0, 2.5, 5, 7.5 % weight fraction of composites.

Figure 2 : Prepared mould and curing

After 48 hours the samples were taken out of the mould, cut into different sizes based on ASTM standards and kept in air tight container for further experimentation.

Determination of the tensile and flexural strength

Tensile and flexural strength tests of the sugarcane fibre composites were carried out following ASTM D638 and ASTM D790 using a universal testing machine (INSTRON 3382). The specimen was tested on a load cell 100KN, a crosshead speed of 5mm/min and 1.32mm/min with a gauge length of 80mm. The test was carried out at the CMR lab of our institute.

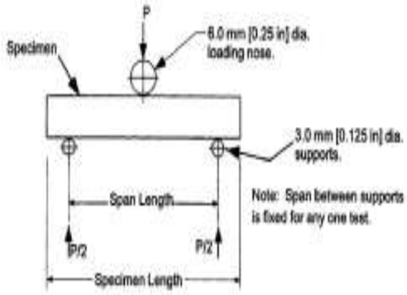

Image 1: ASTM

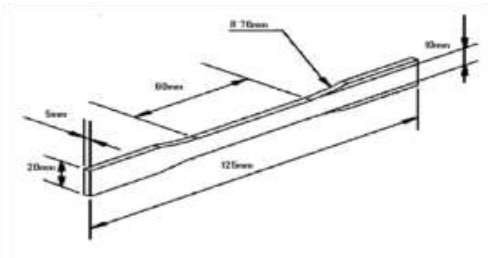

Image 2: Standard

Figure 3 : Specimens for testing

Testing and evaluation

Testing	Machine Used	Working Variables	No of Specimen	Standard Used
Tensile	INSTRON 3382 UTM	Load cell : 100 KN Rate : 5 mm/min	6×5=30	ASTM D638
Flexural	INSTRON 3382 UTM	Load cell : 100 KN Rate : 1.32 mm/min	6×5=30	ASTM D790

Table 2 : variables

The mould after curing was cut into specimens based on ASTM standards as shown below.

Tensile and flexural tests were carried out on INSTRON 3382,100 KN Universal Testing Machine at a temperature of 23±2˚C, and with relative humidity of 50±5%. Testing procedures were carried out in ASTM D638 for tensile tests and ASTM D790 for flexural tests. Summary of the entire test performed. It can be inferred from the above test results that the strength of the sugarcane fibre composite increases with the increase in the % weight fraction of sugarcane fibre as the fibres provide more binding for the epoxy. But after the concentration of 3.75% the strength the composites gradually decreases because of the fact that the fillers(sugarcane fibre) at a concentration above this does not optimally mix in the matrix and so the low strength of the fibres becomes directly prominent in the composites fabricated at such concentrations.

Results and Discussion

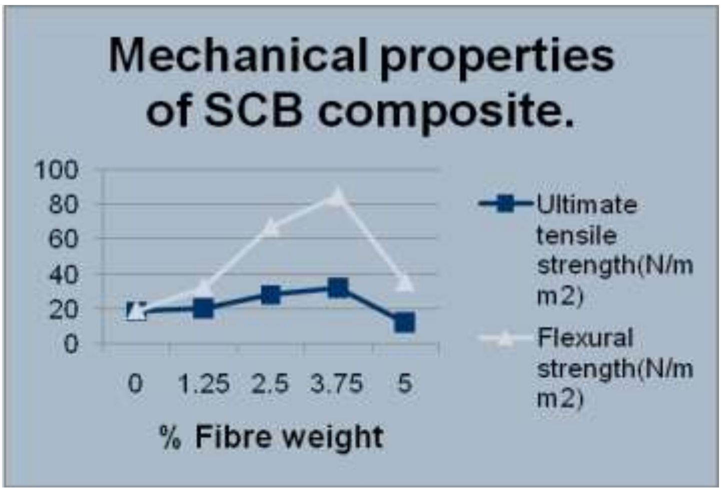

Table 3 : Results

This work shows the successful fabrication of a sugarcane fibre reinforced epoxy composites by simple open moulding technique. Also the results which we obtained are the suitable and comparable for the application of few automobile sectors. The sugar cane residue bagasse, an underutilized renewable agricultural material can successfully be utilized to produce composite by suitably bonding with resin for value added product(automobile applications). On increasing the fibre content, the strength and work of fracture increases and the best combination is found with 3.75% volume fraction of fibre in comparison with the matrix. The fibre surface modification by chemical treatments significantly improves the fibre matrix adhesion, which in turn improves the mechanical properties of composite. Maximum tensile and short-beam (flexural) strength value is observed for the composite prepared with sugarcane fibre of laminate with the weight percentage of the fibre being 3.75%.

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