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Investigation of Mechanical Properties of Agave Americana Fibre Reinforced Hybrid Composites

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Abstract: The growing environmental problems, the problem of waste disposal and the depletion of non-renewable resources have stimulated the use of green materials compatible with the environment to reduce environmental impacts. Therefore, there is a need to design products by using natural resources. Natural fibers seem to be a good alternative since they are abundantly available and there are a number of possibilities to use all the components of a fiber-yielding crop; one such fiber-yielding plant is Agave Americana. The leaves of this plant yield fibers and all the parts of this plant can be utilized in many applications. The "zero-waste" utilization of the plant would enable its production and processing to be translated into a viable and sustainable industry. Agave Americana fibers are characterized by low density, high tenacity and high moisture absorbency in comparison with other leaf fibers. These fibers are long and biodegradable. Therefore, we can look this fiber as a sustainable resource for manufacturing and technical applications. Detailed discussion is carried out on extraction, characterization and applications of Agave Americana fiber and evolution of mechanical properties agave Americana hybrid composites by varying percentage of fiber and placing fiber in different orientation.
Keywords: Natural fiber reinforced hybrid composites, Agave americana fibers, rice husk, Alkali treatment,polyester, Mechanical properties.

I. INTRODUCTION

The availability of natural fibers is abundance and also they are very inexpensive when compared to other advanced man-made fibers. These natural fibers are used as a suitable reinforcing material environmental concern and they are now emerging as a potential alternative for glass fibers in engineering composites [1]. The natural fibers are used as reinforcements for composite materials due to its various advantages compared to conventional man-made fibers [2, 3]. The primary advantages of natural fibers are low density, low cost, biodegradability, acceptable specific properties, less wear during processing and low energy consumption during extracting as well as manufacturing composites and wide varieties of natural fibers are locally available. "Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics". Kelly [4] very clearly stresses that the composite should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. Beghezan [5] defines as "The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not their short comings", in order to obtain improved materials. The advantages of composites over their conventional counterparts are the ability to meet diverse requirements with significant weight savings as well as strength-weight ratio.

The use of composites filled with particles in polyester system has gained significant importance in the development of thermosetting composites. One of the most important focuses in achieving this goal is to develop a new material, which possesses a strength-to-weight ratio that far exceeds any of the present materials. polyester is the most important matrix used in the high-performance transportation systems. When polyester combines with glass/carbon fibers, it results in advanced composites, which have sound-specific properties such as impact, hardness, tensile, strength, modulus, and tri-bological properties. The new found properties make this material very attractive for use in aerospace applications. A rough estimation has it that for every unit of weight reproduction in an aircraft, there is a considerably less consumption of fuel or higher load capacity, and hence materials offer load saving [6-9]. Hybrid composites are materials are made by combining two or more different types of fibers in a common matrix. Hybridization of two types of short fibers having different lengths and diameters offers some advantages over the use of either of the fibers alone in a single polymer matrix. The combination of bio-fibers like oil palm, kenaf, industrial hemp, flax, jute, henequen, pineapple leaf fiber, sisal, wood and various grasses with polymer matrices from both non-renewable (petroleum based) and renewable resources to produce composite materials that are competitive with synthetic composites such as glass–polypropylene, glass epoxies, etc., is gaining attention over the last decade. Available data in literature usually covers hybrid composites made of natural fibers/synthetic fibers and remembering that plant-based fibers have been selected as suitable reinforcements for composites due to their good mechanical performances and environmental advantages. Hybrid composites reinforced with natural fibers, very often combined with synthetic fibers such as glass fibers, can also demonstrate good mechanical performance [10–12]. Polymer composites with hybrid reinforcement solely constituted of natural fibers are less common, but these are also potentially useful materials with respect to environmental concerns [13]. Investigations of lingo-cellulosic fibers have shown that the properties of fibers can be better used in hybrid composites [14]. The main parameters which affect the mechanical properties of the composites are fiber length, weight ratio, fiber orientation and interfacial adhesion between fiber and matrix. In the present investigation, the Tensile Strength, Flexural strength and impact strength of hybrid-biological fiber reinforced composite material was found out experimentally. The natural fiber used is fibers from agave americana and rice husk.

II. MATERIALS AND METHODS

A. Agave Americana Fibers

Agave americana is a natural fiber of yields a stiff fiber traditionally used in making twine and rope. Agave americana is fully biodegradable and highly renewable resource of energy. Agave americana fiber is exceptionally durable and a low maintenance with minimal wear and tear. Agave americana fiber is extracted by a process known as decortication, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers will remain.

B. Fiber Surface Treatment

Washed and dried Agave Americana fiber taken in separate tray and 10% NaOH solution was added, and the fibers were soaked in the solution for 10 hours. The fibers were then washed thoroughly with water to remove the excess of NaOH sticking to the fibers. The Agave americana fibers were chopped into short fiber length for molding the composites.

C. Rice Husk

Rice hulls are the coatings of seeds, or grains, of rice. The husk protects the seed during the growing season, since it is formed from hard materials, including opaline silica and lignin. The hull is mostly indigestible to humans. Winnowing, used to separate the rice from hulls, is to put the whole rice into a pan and throw it into the air while the wind blows. The light hulls are blown away while the heavy rice fall back into the pan. Later pestles and a simple machine called a rice pounder were developed to remove hulls. In 1885 the modern rice hulling machine was invented in Brazil. During the milling processes, the hulls are removed from the raw grain to reveal whole brown rice, which may then sometimes be milled further to remove the bran layer, resulting in white rice.

D. Polyester

Polyester is a term often defined as ―long-chain polymers chemically composed of at least 85% by weight of an ester and a dihydric alcohol and a terephthalic acid‖. In other words, it means the linking of several esters within the fibers. Reaction of alcohol with carboxylic acid results in the formation of esters.

Polyester can also be classified as saturated and unsaturated polyesters. Saturated polyesters refer to that family of polyesters in which the polyester backbones are saturated. They are thus not as reactive as unsaturated polyesters. They consist of low molecular weight liquids used as plasticizers and as reactants in forming urethane polymers, and linear, high molecular weight thermoplastics such as polyethylene terephthalate (Dacron and Mylar). Usual reactants for the saturated polyesters are a glycol and an acid or anhydride.

Unsaturated polyesters refer to that family of polyesters in which the backbone consists of alkyl thermosetting resins characterized by vinyl unsaturation. They are mostly used in reinforced plastics. These are the most widely used and economical family of resins.

E. Preparation of Hybrid Composite

A GI Sheet mould with required dimensions was used for making the sample as per ASTM standards. The mould was coated with a mould releasing agent for the easy removal of the sample. The resin and hardener were taken in the ratio of 10: 1 parts by weight, respectively and 5% of rice husk is added and stirred contuniously for 3minutes until homogenous mixture was observed. Then, a pre-calculated amount of hardener was mixed with the polyester and stirred for 20 minutes before pouring into the mold. The hand lay-up technique was used to impregnate the composite structures. In this technique, the Agave americana fibers was wetted by a thin layer of polyester suspension in a mold. A stack of hybrid fibers were carefully arranged in a unidirectional manner after pouring some amount of resin in to the mold. The remaining mixture was poured over the hybrid fibers. Brush and roller were used to impregnate fiber. The closed mold was kept under pressure for 24 h at room temperature. Test specimens of required size were cut out composite manufactured after curing. The percentages of fibers used are 1%, 2% and 3% by weight.

F. Mechanical Testing

Three important mechanical properties, tensile strength and impact strength were tested. All test specimen dimensions were according to the respective ASTM standards. All tests were performed at room temperature. Nine specimens of each type were tested.

G. Tensile Strength

Tensile strength indicates the ability of a composite material to withstand forces that pull it apart as well as the capability of the material to stretch prior to failure. The commonly used specimens for tensile test are the dog-bone type and the straight side type with24end tabs. During the test a uni-axial load is applied through both the ends of the specimen. The tensile strength were conducted according to the ASTM D638 standard on computerized universal testing machine Test for tensile properties were carried out as described in American Standard Testing and Measurement (ASTM) method D638, using the Instronuniversal testing machine at crosshead speed of 10mm/min using dumbbell test piece. Each tensile specimen was positioned in the Instron universal tester and then subjected to tensile load, as the specimen stretched the computer generated the graph as well as all the desired parameters until the specimen fractured. A graph of tensile stress versus tensile strain was plotted automatically by the computer.

H. Impact Test

The Pendulum is mounted on antifriction bearings. It has two starting positions, the upper one for Charpy & the lower one for Izod testing. On release, the pendulum swings down to brake the specimen and the energy absorbed in doing so is measured as the difference between the height of drop before rupture of the test specimen and is read from the maximum pointer position on the dial scale.

I. Izod Test

The Izod test is clamped vertically in Izod support fitted on the base of the machine. The support is provided with a machined vertical groove to suit the test piece size. The front clamp piece and the Allen screw enable clamping of the test piece in correct height with the help of Izod setting gauge supplied.

III. RESULTS AND DISCUSSION

Development of hybrid composites made from natural fibers with increased strength, stiffness and durability requires necessary understanding of mechanical behaviors. The mechanical properties of hybrid composites depend on the fiber strength, fiber modulus, fiber length, fiber orientation, and fiber–matrix interfacial bond strength. A strong fiber–matrix interface bond plays a vital role in establishing high mechanical properties of composites. A good interfacial bond is required for effective stress transfer from the matrix to the fiber by which maximum utilization of the fiber strength in the composite can be obtained. The analysis of mechanical properties of composites is important for understanding the behavior of composite materials. It is a well-known fact that the mechanical properties of fiber-reinforced composites depend on the nature of matrix material, the distribution and orientation of the reinforcing fibers and the nature of the fiber-matrix interfaces. A change in the physical and chemical structure of the fiber for a given matrix will result in drastic changes in the overal .

A. Tensile Strength

The effect of weight fraction of fiber in the composite on tensile strength as shown in below bar charts. According to result shows that effect of tensile strength by weight fraction and orientation of fiber in composites.tensile strength is increases fiber percentage by 1%,2%,3% and best sutable orientation is combination of both parallel and perpendicular to the axies i.e (combination of 0 degrees and 90 degrees orientation).

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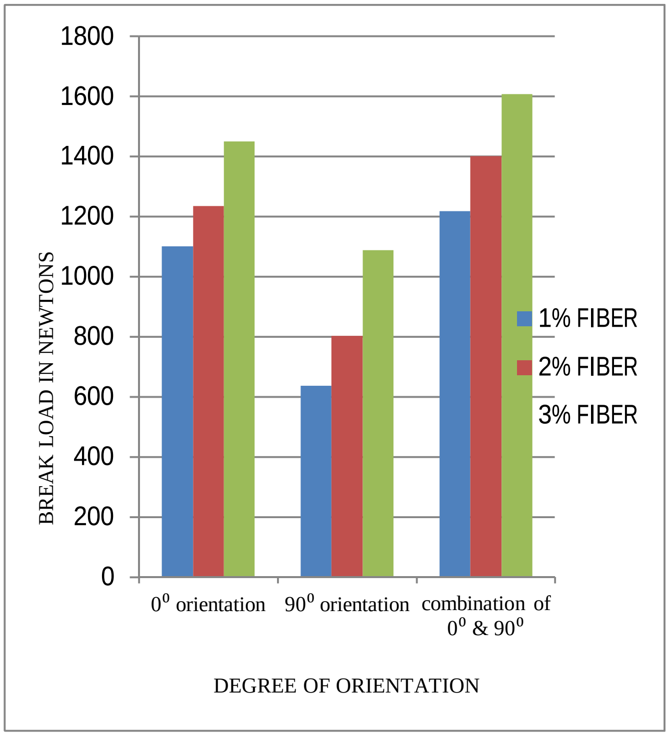

Fig1: Variation of break load in newton with fiber loading

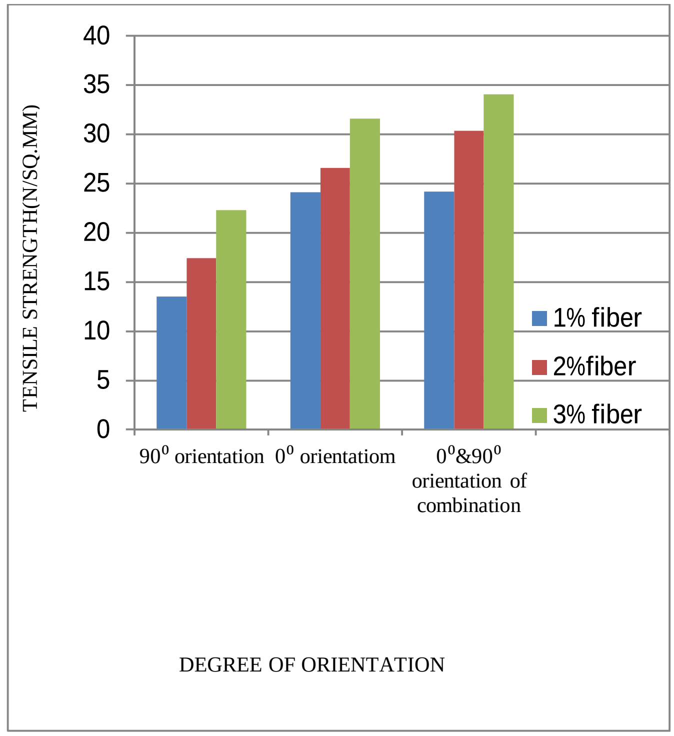

Fig2: Variation tensile strength(N/Sq.mm) with fiber loading

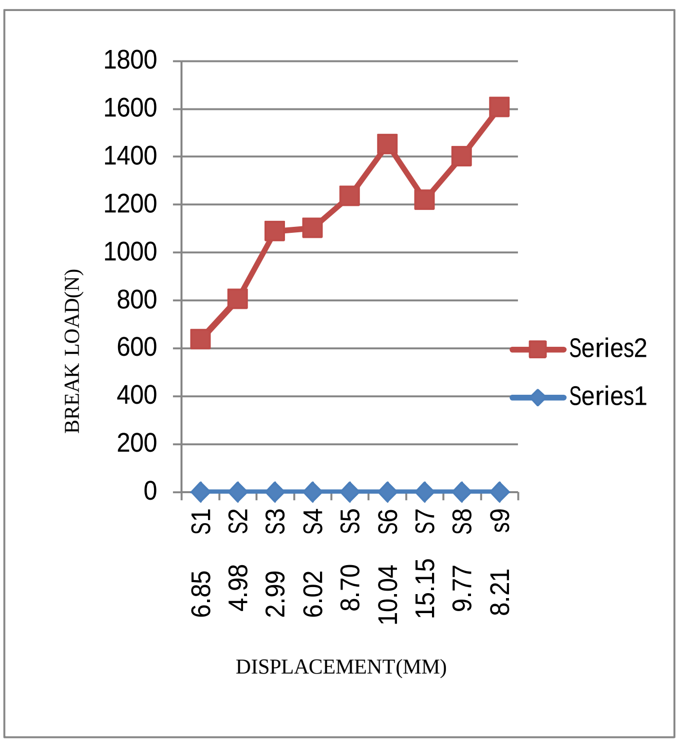

Fig3: Variation of Displacement and Break load

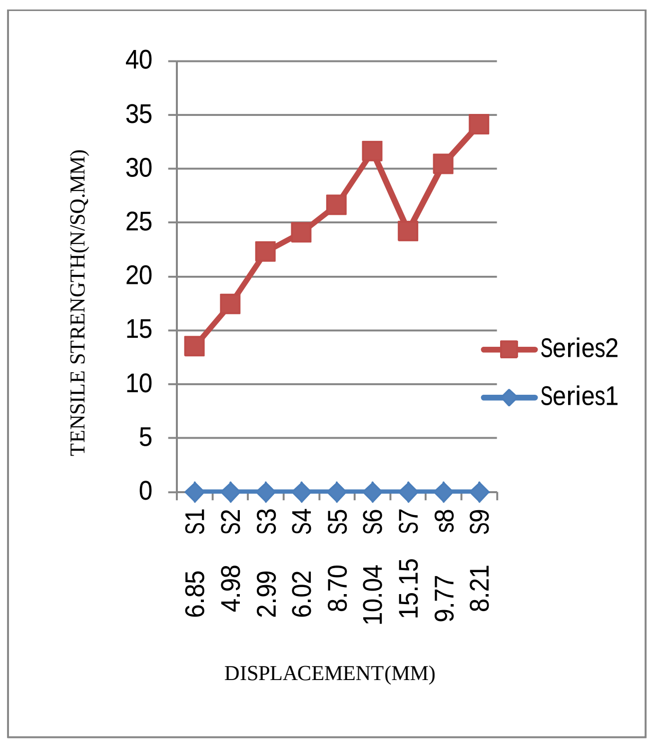

Fig4: Variation of Displacement and tensile strength

B. Impact Strength

Impact strength is the ability of a material to absorb energy under a shock load or the ability to resist the fracture under load applied at high speed. Impact behavior is one of the most widely specified mechanical properties of the Engineering materials. The variations of impact strength with respect to fiber loading (weight fraction) is as shown in Figure below for Izod method of impact test.

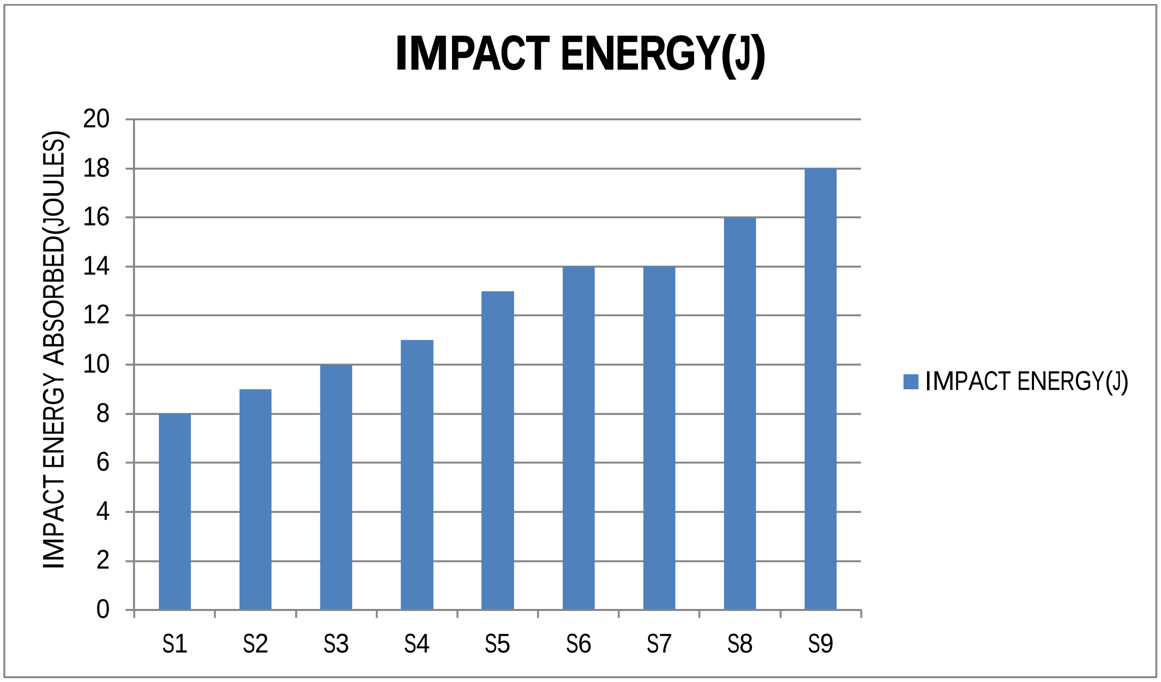

Fig 5:Impact energy absorbed

The ability of a material to absorb energy under a shock load is increased by increasing percentage of fiber and energy absoebed is high when fibers are palced combination of both parallel and perpendicular to the axies.

IV. CONCLUSIONS

In the present work, investigation was carried out on the Agave Americana fibre reinforced hybrid composites. The investigation includes manufacturing of composites produced through hand lay-up technique and evaluation of mechanical properties according to experimental plan. The major contributions drawn from the investigation are summarized as below: Hand lay-up technique was successfully adopted in the fabrication of Agave Americana fibre reinforced hybrid composites. The fiber percentage increases the tensile strength increases. The best orientation of fiber is both combination of parallel and perpendicular to the axies. The ultimate tensile strength of polyester composite increases with fiber because of formation of proper adhesion between fiber and matrix is improved due to addition of rice husk . The ability of a material to absorb energy under a shock load is increased by increasing percentage of fiber and energy absoebed is high when fibers are palced combination of both parallel and perpendicular to the axies.

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