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Fabrication and Investigation on Tensile and Flexural Properties of Short Sisal and Glass fibre Reinforced Hybrid Thermoplastic Composites

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ABSTRACT

Hybridization with small amounts of synthetic fibers makes these natural fiber composites more suitable for technical applications such as automotive interior parts. New eco-friendly material and products based on sustainability principles. Fibres material as low cost low density, Non –toxicity comparable strength and minimum waste problem. In the present work, sisal fiber is incorporated in polypropylene resin matrix hybridized with glass fiber for preparing composite specimens at various fiber weight percentages. The developed sisal fiber, glass reinforced hybrid polypropylene composites (SGPP) were then tested for their tensile and flexural properties. It was found that the increase in fiber content increased the Tensile and Flexural Properties of Sisal glass-PP composite. Hybrid composite were fabricated by injection modeling technique using an automatic injection molding machine JSW 180H with 100 ton clamping pressure at 200^0 C and an injection pressure of 1200 psi. After molding, the test specimens were conditioned at 23^0 C according to ASTM D 618 before testing.

Keywords- Hybrid composite , Injection Moulding, ASTM standard , SGPP

I. INTRODUCTION

Natural Fibre composites combine plant-derived Fibres with a plastic binder. The natural Fibre components may be wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, banana leaf Fibres, bamboo, wheat straw or other fibrous material. The advantages of natural Fibre composites include lightweight, low-energy production, and environmental friendly to name a few. The use of natural Fibres reduces weight by 10% and lowers the energy needed for production by 80%, while the cost of the component is 5% lower than the comparable Fibre glass-reinforced component.[1]. In the past, composites of coconut Fibre/natural rubber latex were extensively used by the automotive industry. However, during the seventies and eighties, newly developed synthetic Fibres due to better performance gradually substituted cellulose Fibres. For the past few years, there has been a renewed interest in using these Fibres as reinforcement materials, to some extent in the plastic industry. This resurgence of interest may be attributed to the increasing cost of plastics and the environmental aspects associated with using renewable and biodegradable materials[2]. Natural Fibre and glass Fibre improve the tensile strength and these composite are used for medium strength application. The sisal Fibre is traditionally used for rope and twine, and has many other uses, including paper cloth, footwear, hats, bags, carpet, and dartboards. The sisal plant has a 7–10 year life-span and typically produces 200–250 commercially usable leaves. Each leaf contains an average of around 1000 Fibres. The Fibres account for only about 4% of the plant by weight. Sisal is considered a plant of the tropics and subtropics, since production benefits from temperatures above 25 degrees Celsius and sunshine.It is well known that hybrid composite can be fabricated using two or more kinds of reinforcement material with a single matrix material or a single reinforcing material with multiple matrix materials. Hybridization of natural Fibre with synthetic Fibre (glass or carbon) is widely developed and used in various applications such as wind power generation, helmet, aerospace, orthopedic aids and automobile or transportation sector [3]. Since the 1990s, natural fiber composites are emerging as realistic alternatives to glass reinforced composites in many applications. Natural fiber composites such as hemp fiber-epoxy, flax fiber-polypropylene (PP), and china reed fiber-PP are particularly attractive in automotive applications because of lower cost and lower density. Glass fibers used for composites have density of 2.6 g/cm3 and cost between $1.30 and $2.00/kg. In comparison, flax fibers have a density of 1.5 g/cm3 and cost between $0.22 and $1.10/kg [4] Hybridization of natural fibre with high corrosion and stronger resistance synthetic fibres like glass, carbon, aramid etc. can improve the various properties such as strength, stiffness etc. It helps us to achieve a better combination of properties than fibre reinforced composites. Thus banana fiber in combination with glass has proved to be excellent for making cost effective composite materials. Uses of hybrid composites are aeronautical applications (pilot's cabin door), marine applications (ship hulls), wind power generation (blades), telecom applications (hybrid aerial, underground cable)[5] Hybridization with small amounts of synthetic fibers makes these natural fiber composites more suitable for technical applications such as automotive interior parts. Performance of injection-molded short hemp fiber and hemp/glass fiber hybrid polypropylene composites were analyzed [6] Water absorption behavior indicated that hybrid composites offer better resistance to water absorption.A hybrid composite materials using Wood Powder, Groundnut Husk and Cashew nut Husk have been developed [7]. The behavior of composites and hybrid composites of short bamboo and glass fibers in a polypropylene (PP) matrix under hydrothermal aging and under tensile–tensile cyclic load were studied and this hybrid showed better fatigue resistance [8]. Mechanical and physical properties of oil palm empty fruit bunch/glass hybrid reinforced polyester composites were studied and showed hybrid composites exhibited good properties [9]. Different composites based on polypropylene and reinforced with flax and glass fibers have been made and their mechanical properties are measured together with the distribution of the fiber size and the fiber diameter [10]. Natural fibres have many remarkable advantages over synthetic fibres. Nowadays, various types of natural fibres have been investigated for use in composites including flax, hemp, jute straw, wood, rice husk, wheat, barley, oats, rye, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm, sisal, coir, water hyacinth, pennywort, kapok, paper mulberry, banana fibre. [11] Sisal fibre has the characteristics of ideal substitute of asbestos for brake composites Biwa's et al. studied with coir reinforced epoxy composite and observed that mechanical properties dependent on the length of reinforcement fibre[12]. The Chemical and physical treatments of sisal fibre increases fibre strength and the adhesion between the fibre bundles and the matrix resulting in the improvement of mechanical properties, especially tensile properties of sisal laminates[13]. This study presents life cycle assessments of a side panel for Audi A3 car made from ABS co-polymer and an alternative design made from hemp fibre epoxy resin composite[14].

II. EXPERIMENTAL

Polyproplene

Polypropylene (PP), also known as polypropylene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene polypropylene belongs to the group of polyolefin's and is partially crystalline and non-polar with density of 0.90 g/cc and a melt flow index (MFI) of 11 g/10min (230^0 C/2.16 kg).

Sisal Fibre

Plant Fibres - Sisal (Agave sisal Ana) Sisal is a hard fibre extracted from the leaves of sisal plants which are perennial succulents that grow best in hot and dry areas. Sisal is an environmentally friendly fibre as it is biodegradable and almost no pesticides or fertilizers are used in its cultivation. We purchasing sisal fibre from, Matlock Sisal Fibre Company Ltn have made a name for itself in the list of top suppliers of Paper & Paper Boards. We used 80 gm sisal fibre in mixture of hemp and banana. The length of sisal fibre is between 1.0 and 1.5 m and the diameter is about 100–300 μm. The fibre is actually a bundle of hollow sub-fibres. Their cell walls are reinforced with spirally oriented cellulose in a hemi-cellulose and lignin matrix.

Glass Fibre

Glass Fibre is a material consisting numerous extremely fine Fibres of glass.Glassmakers throughout history have experimented with glass Fibres, but mass manufacture of glass Fibre was only made possible with the invention of finer machine tooling. Glass Fibre has roughly comparable mechanical properties to other Fibres such as polymers and carbon Fibre. Although not as rigid as carbon Fibre, it is much cheaper and significantly less brittle when used in composites. Glass Fibres are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight Fibre reinforced (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "Fibreglass". This material contains little or no air or gas, is more dense, and is a much poorer thermal insulator than is glass wool.

Fig 1- Sisal Fibre

Fig 2 - Glass Fibre

III. Compounding and Specimen Preparation

The ground SCB Fibre was mixed with PP granules in a high-speed mixer (Model FM 10 LB; Henschel, Germany). The mixed material was extruded in a twin screw extruder (Berstorff, Germany) with an L/D ratio of 33 with a temperature profile of 190, 190, 180, 180, and 1908C. Two levels of filler loading(10, 5 wt %) were designed in sample preparation. Tensile and flexural specimens were prepared using an automatic injection molding machine JSW 180H with 100 ton clamping pressure at 200^0 C and an injection pressure of 1200 psi. After molding, the test specimens were conditioned at 23^0 C according to ASTM D 618 before testing.

Fig 3 - Injection Moulding Machine

Fig 4 - Injection Moulding Die

Fig 5 –Instron Universal Machine

Fig 6 (a)- Tensile specimen before fracture (Batch 1)

Fig 7(a)-Tensile specimen before fracture (Batch 2)

IV. RESULTS AND DISCUSSION

Tensile Testing

The Tensile test is carried out in universal testing machine accordance with ASTM D-638 standard. The testing out carried out in Central Institute Of Plastic Engineering And Technology Lucknow , Universal Testing Machine code no. PTC/083/ME having maximum working ranges 100 kN and accuracy ± 0.06%. Through this testing the ultimate tensile strength, modulus value and strain determined. The specimen is hold by the grip and load applied until the failure occurs.

Fig 6(b)- Tensile specimen after fracture (Batch 1)

Fig 7(b)-Tensile specimen after fracture (Batch 2)

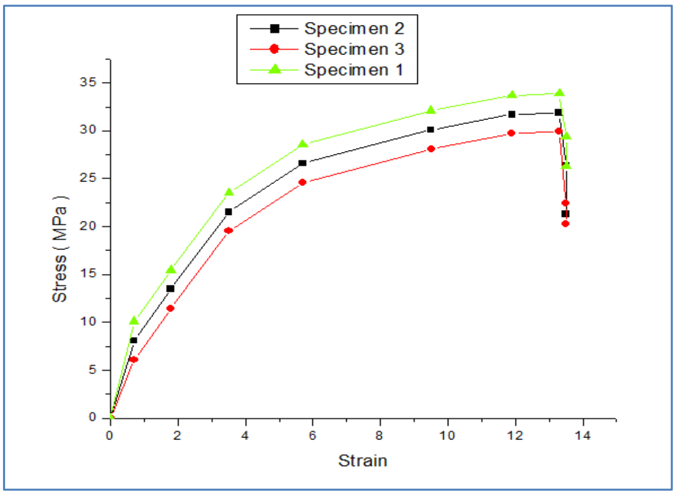

Fig 8-Stress vs Strain (Batch 1)

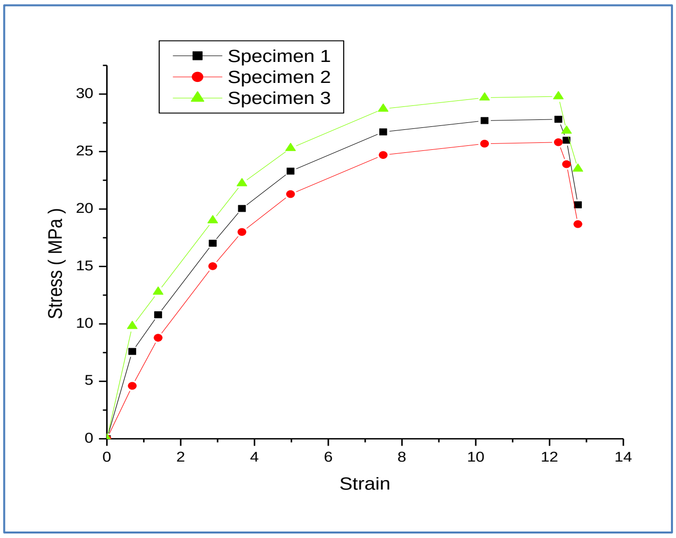

Fig 9-Stress vs Strain (Batch 2)

Obtained value from above curves

Ultimate Tensile Strength for Batch 1 – 31.33 MPa

Young Modulus for Batch 1 – 538.37 MPa

Ultimate Tensile Strength for Batch 2 – 27 MPa

Young Modulus for Batch 2 – 477.88 MPa

Flexural Testing

The flexural test is carried out in a Universal Testing Machine and it is made by INSTRON, USA and there is a code no. PTC/083/ME. There is a working range maximum 100 kN and accuracy is ±0.066%. It is used for mechanical property. The Flexural test is carried out in a UMT no samples cut in accordance with ASTM D-790 standard the testing procedure is as per the three-point bending test by placing the specimen on the Universal Testing Machine and applying load till the specimen fracture and break. Result is compared and flexural strength of the material is identified.

Fig 10(a)-Flexural specimen before fracture (Batch 1)

Fig 11(a)-Flexural specimen before fracture (Batch 2)

Fig 10(b)-Flexural specimen after fracture (Batch 1)

Fig 11(b)-Flexural specimen after fracture (Batch 2

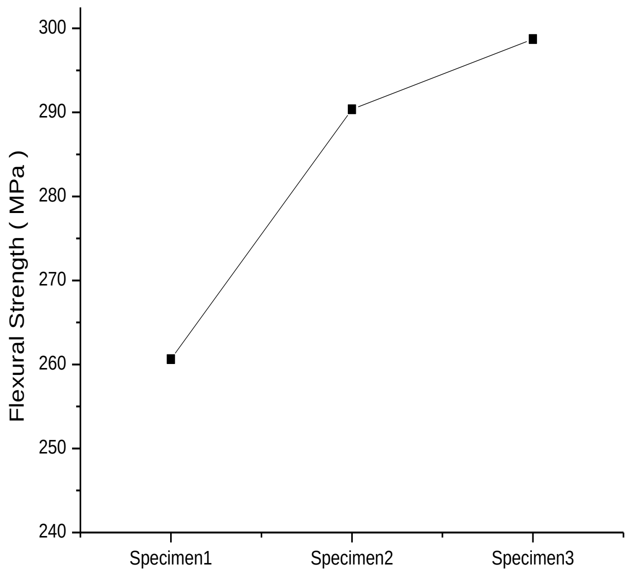

Fig 12-Flexural Strength (Batch 1)

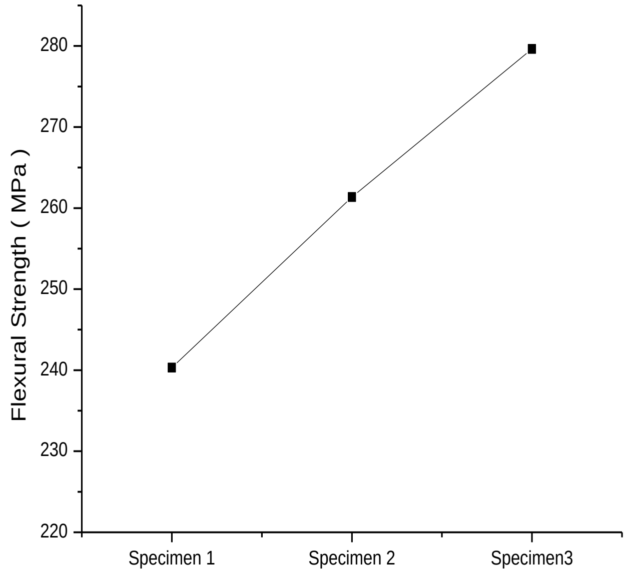

Fig 13-Flexural Strength (Batch 2)

Summary of Results

Tensile Strength for Batch 1 (10% Sisal , 2.5% Glass + PP)	31.33 MPa
Tensile Strength for Batch 2 (5% Sisal , 2.5% Glass + PP)	27 MPa
Flexural Strength for Batch 1 (10% Sisal , 2.5% Glass + PP)	283 MPa
Flexural Strength for Batch 2 (5% Sisal , 2.5% Glass + PP)	260 MPa

V. CONCLUSION

1. The incorporation of sisal fiber hybridized with glass fiber into the polypropylene matrix has shown an improvement in the tensile and flexural properties of the composite.
2. The tensile and flexural strength for batch 1 is higher than batch 2 , which clearly indicates that the mechanical properties are increased with increasing percentage of sisal fibre in the composite.
3. The tensile strength of SGPP is 31.33 MPa which is higher as compared to BGPP composite which has a tensile strength of 24.59 MPa .
4. The flexural strength of SGPP is 283 MPa which is higher as compared to BGPP composite which has a flexural strength of 270.86 MPa .

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