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EFFECT OF SAND AND TEMPERATURE ON THE MECHANICAL PROPERTIES OF JUTE FABRICS REINFORCED POLYPROPYLENE BASED COMPOSITE

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Abstract

Jute fabrics reinforced polypropylene based composites were prepared using compression molding technique and the fabrics percentage were kept constant at 20% (by weight) for all the prepared composites. Different percentages (0, 5, 10 and 15%) of sand were added with the jute fabrics to improve the mechanical properties. The highest tensile strength (TS) and tensile modulus (TM) were obtained at 15% sand containing composites and the improvement was 67-57%, respectively. The elongation at break was decreased 61% for 15% sand containing composites. Sand containing (15%) Jute/PP composites were treated for different temperature (-20°C, 40°C and 60°C) to investigate the change of mechanical properties. At low temperature (-20°C) the TS and TM were improved 22-27% respectively. On the other hand at low temperature (-20°C) the elongation at break was decreased 6%. At high temperature (60°C) the TS and TM were decreased 40-23%, respectively but elongation at break was improved 11%. The sand containing composite showed better fiber matrix adhesion in scanning electron microscopy (SEM).

Keywords: Sand, Jute Fabrics, Mechanical Properties, Compression Molding, Composites.

Introduction

Our prime research on to find some materials that should be bio-degradable and have sufficient mechanical properties for the design construction. Thus, natural fiber reinforced composites are chosen for the fabrication of bio-degradable composites.[1-2] Natural fibers are getting attention from researchers and academician to utilize in polymer composites due to their ecofriendly nature and sustainability.[3] Natural fiber is considered one of the environmentally friendly materials which have good properties compared to synthetic fiber.[4] A late current industry research identified that the worldwide natural fiber reinforced polymer composites industry sector reached U$2.1 billion in 2010. Current pointers are that interest in NFPCs industry will keep on growing quickly around the world. The utilization of NFPCs has expanded considerably in the shopper merchandise as developing industry sectors throughout the last few years. As indicated by evaluations, over 5 years (2011–2016), the NFPCs industry is estimated to grow 10% worldwide.[5]

Natural fibers in simple definition are fibers that are not synthetic or manmade. They can be sourced from plants or animals.[6] The use of natural fiber from both resources, renewable and nonrenewable such as oil palm, sisal, flax, and jute to produce composite materials, gained considerable attention in the last decades, so far. The plants, which produce cellulose fibers can be classified into bast fibers (jute, flax, ramie, hemp, and kenaf), seed fibers (cotton, coir, and kapok), leaf fibers (sisal, pineapple, and abaca), grass and reed fibers (rice, corn, and wheat), and core fibers (hemp, kenaf, and jute) as well as all other kinds (wood and roots).[7]

Natural fibers are not free from problems and they have notable deficits in properties. The natural fibers structure consists of (cellulose, hemicelluloses, lignin, pectin, and waxy substances) and permits moisture absorption from the surroundings which causes weak bindings between the fiber and polymer. Jute fiber is a natural fiber which is next to cotton fiber on the basis of industrial application. Jute fiber

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mainly composed of cellulose (61-71%), hemi-cellulose (13.6-20.4%), lignin (12-13%), ash (0.5-2%), pectin (0.2%), wax (0.5%) and moisture (12.6%).[8-11] Furthermore, the couplings between natural fiber and polymer are considered a challenge because the chemical structures of both fibers and matrix are various. These reasons for ineffectual stress transfer during the interface of the produced composites. Accordingly, natural fiber modifications using specific treatments are certainly necessary. These modifications are generally centered on the utilization of reagent functional groups which have ability for responding of the fiber structures and changing their composition. As a result, fiber modifications cause reduction of moisture absorption of the natural fibers which lead to an excellent enhancement incompatibility between the fiber and polymer matrix.[8] The wide applications of NFPCs are growing rapidly in numerous engineering fields. The different kinds of natural fibers reinforced polymer composite have received a great importance in different automotive applications by many automotive companies such as German auto companies (BMW, Audi Group, Ford, Opel, Volkswagen, Daimler Chrysler, and Mercedes), Proton company (Malaysian national carmaker), and Cambridge industry (an auto industry in USA). Beside the auto industry, the applications of natural fiber composites have also been found in building and construction industry, sports, aerospace, and others, for example, panels, window frame, decking, and bicycle frame.[11] In this work, we tried to find out the effect of sand on the jute fiber reinforced polypropylene based composite and tensile properties variation in different temperatue.

Experimental

Materials

Jute fabrics or hessian cloth (bleached commercial grade, Tossa Jute) was collected from Bangladesh Jute Research Institute (BJRI), Dhaka, Bangladesh. Polypropylene was purchased from Polyolefin Company, Pte. Ltd., Singapore. Sand was collected from the local area near Savar, Dhaka, Bangladesh.

Composite Fabrication

For making one PP (polypropylene) sheet, granules of PP (about 10 g) were placed in two steel plates and then into the heat press (Carver, INC, USA Model 3856). The press was operated at 200°C temperature and 5 tons consolidation pressure for 5 min. The plates were then cooled for 1 min in a separate press under 5 tons pressure. The resulting PP sheet was cut into desired size and so the jute fabrics for composite fabrication. Composites were prepared by sandwiching two layers of jute fabrics between three sheets of PP. The sandwich was then placed between two steel plates and heated at 200°C for 5 min at a pressure of 5 tons and cooled like PP sheet. The fiber weight fraction of the composites was calculated to be about 20%. Similar methodology was illustrated elsewhere.[12-18]

For the preparation of sand containing composites, two desired size jute fabrics were soak in 500 mL beaker. The water contained 0, 5, 10 and 15% sand. After soaking 15 min the jute fabrics were dried in an oven at 105°C for 6 hr. After removing moisture the sand percentage was measured 0, 5, 10 and 15%. Then composites were prepared containing different percentage of sand.

Thermal treatment

The composites were cut into desired size. Then they were taken in the refrigerator for 24 hours and in oven for 15 minutes. Then the samples were taken for mechanical test by UTM machine.

Mechanical Properties of the Composites

Tensile properties of the composites were evaluated by using the Hounseld series S testing machine (UK) with a cross-head speed of 1 mm/s. The dimension of the test specimen was (ISO 14125): 60 mm ×15 mm×2 mm. Composite samples were cut into the required dimension using a band saw.

Scanning Electron Microscopic Analysis

Jute fabrics reinforced polypropylene (Jute/PP) and sand containing jute fabrics reinforced composites were examined by Philips scanning electron microscope (SEM) at an accelerating voltage of 10 kV. Fracture sides of the composites (after tensile tests) were also observed using SEM.

Results and Discussion

Comparative Studies of the Mechanical Properties of the Composites

The mechanical properties of the Jute/PP based composites were measured. The TS, TM and Eb values were measured 30.38 MPa, 1030 MPa, and 14.46% respectively for 0% sand containing composites. The TS and TM were increased with the addition of sand and highest value was obtained for 15% sand containing composites. In the composites the sand was used as filler and thus the mechanical properties were improved. When sand was added the force transfer properties increased through the matrix to the fiber. Sand also increased the stiffer properties of the composites and thus reduced the elongation at break. That is why the TS and TM values increased in but the EB was decreased. The effect of mechanical properties of the composites is shown in Table-1 and illustrated in Fig-1, Fig-2 and Fig-3.

Table-1: The mechanical properties of composites

Composite	Tensile strength (TS), MPa	Tensile modulus (TM), MPa	Elongation at Break %
PP sheet	21	530	350
0% sand Jute/PP	30.38	1030	14.46
5% sand Jute/PP	40.68	1250	12.25
10% sand Jute/PP	45.90	1450	8.29
15% sand Jute/PP	50.6	1610	5.78

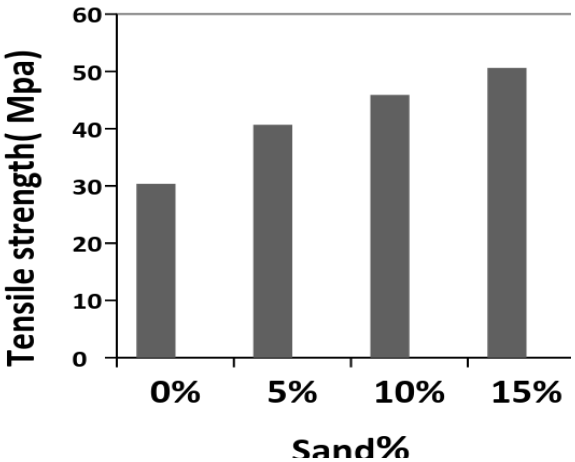

Fig-1: Tensile strength of different types of composites.

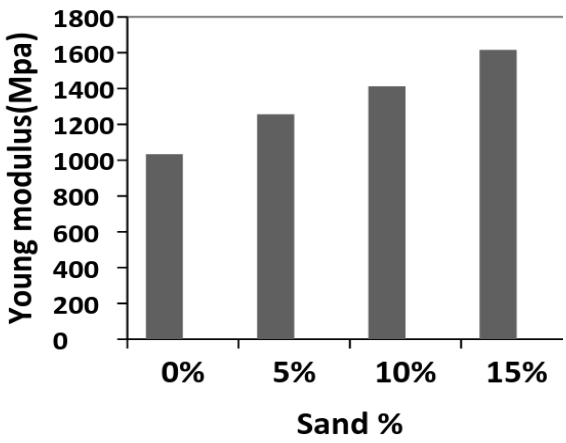

Fig-2: Tensile modulus of different types of composites

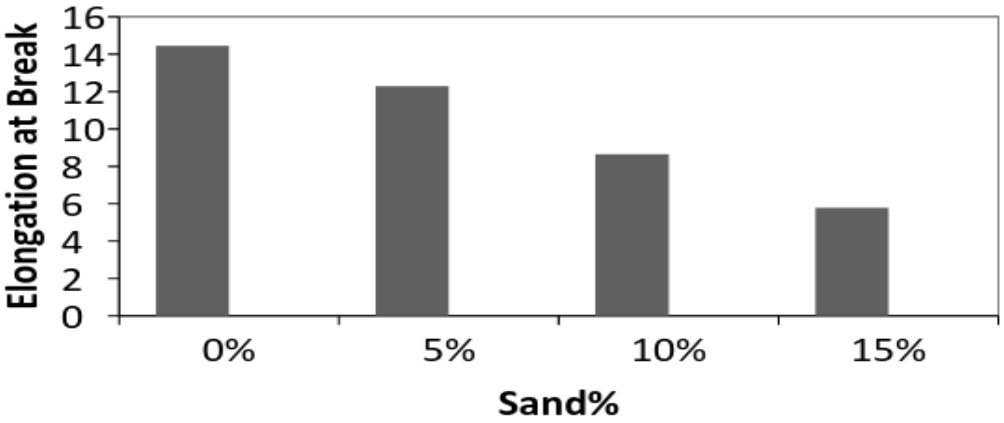

Fig-3: Effect of sand on the elongation at break

Thermal Effect

When the temperature of the composites was decreased (-20°C) the TS and TM values were increased up to 61.52 MPa and 2056 MPa respectively on counter the elongation at break was decreased to 5.69%. At high temperature (60°C) the TS and TM was 30.38 MPa and 1251 MPa respectively and the elongation at break was highest 10.17%.

At low temperature the vibrational movements of the composites molecules greatly decreased and thus increased inter molecular attraction force. As the attractive force increased at low temperature the mechanical properties (TS, TM) increased greatly. At low temperature the attractive force increased between the fiber and matrix and thus with each other. On the other hand at high temperature the attractive force decreased due to the improvement of molecular movements. As the attractive force decreased the TS and TM values decreased.

In case of elongation at break highest values were obtained at high temperature and lowest values were obtained at lowest temperature. The effect of temperature is given in the Table-2 and illustrated in Fig-4, Fig-5 and Fig-6.

Table-2: Effect of temperature on the mechanical properties.

Temperature	Tensile strength (TS), MPa	Tensile modulus (TM), MPa	Elongation at Break,%
-20°C	61.52	2056	5.69
40°C	42.75	1314	8.42
60°C	30.38	1251	10.17

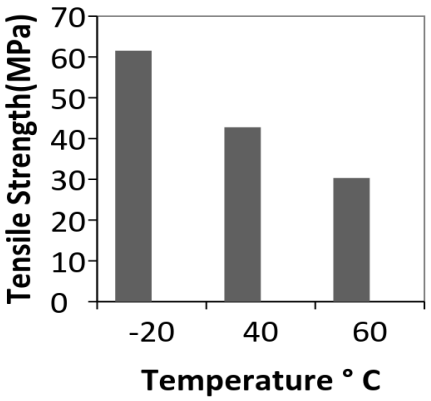

Fig-4: Effect of temperature on the TS

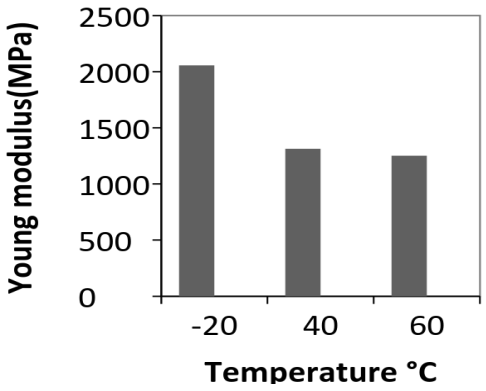

Fig-5: Effect of temperature on the TM

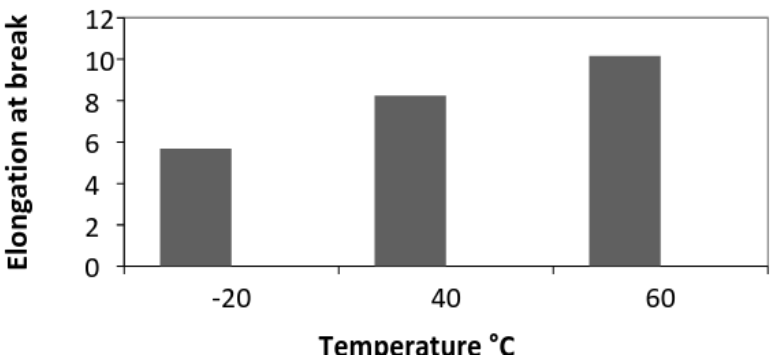

Fig-6: Effect of temperature on the EB%

Scanning Electron Microscopy Analysis

SEM images of the fracture surface of jute ber reinforced PP based composite and different percentage sand treated jute fiber reinforced PP based composites are given in Fig-7, Fig-8, Fig-9 and Fig-10. This is clearly observed that the bonding between jute and matrix is not so good. This is the main reason for slightly lower mechanical properties in jute ber reinforced PP based composites. The SEM image of the fracture surface explains that the jute ber pull-out is quite low in Jute/PP.

In case of sand treated Jute/PP based composites the fiber matrix adhesion image shows good bonding between the fiber and the matrix. From the image it is clear that the matrix adhesion is good and the fiber pull-out is also good relative to the without sand based composites. This may be the reasons of slightly good mechanical properties of sucrose treated Jute/PP based composites. Thus the mechanical properties increased in some extent. From the SEM analysis it is clear that the fiber matrix adhesion of the composites increased with the addition of sand.

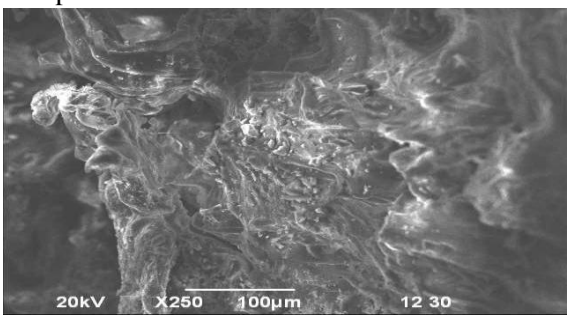

Fig-7: SEM image of the fracture side of the 20% jute fabrics+ PP composite.

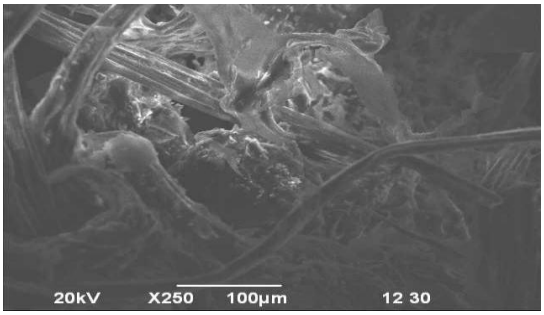

Fig-8: SEM image of the fracture side of the 20% jute fabrics+5% sand +PP composite.

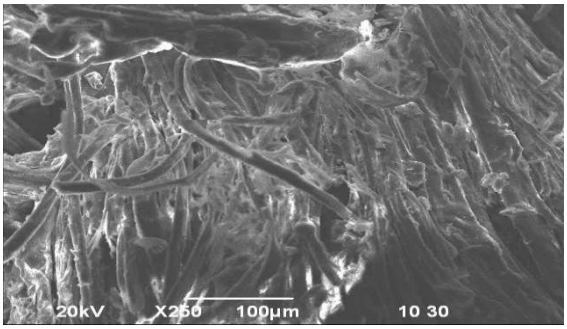

Fig-9: SEM image of the fracture side of the 20% jute fabrics+10% sand +PP composite

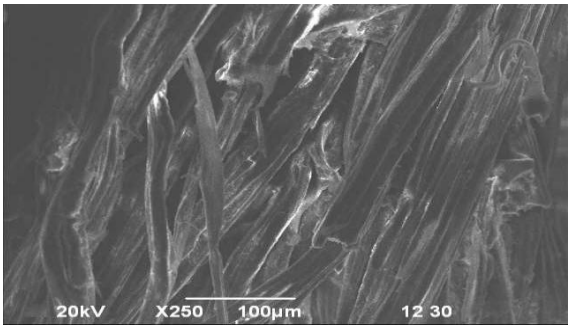

Fig-10: SEM image of the fracture side of the 20% jute fabrics+15% sand +PP composite..

Conclusion

Sand and jute fabrics reinforced polypropylene based composites were made by compression molding technique. Varying amount of sand used as filler, is important parameter of this fabrication process. A numbers of weight percentage of sand (5, 10 & 15%) and fixed amount of jute fabrics (20%) were used during fabrication process. Tensile strength and young's modulus of the jute fabrics+sand+ polypropylene composites were increased with the increasing sand percentage and Elongation at break of the composites were decreased with increasing sand percentage. It was seen that tensile strength and young modulus of the composites were decreased with the increasing temperature. Elongation at break was increased with increasing temperature. From the image of the Scanning Electron Microscopy it was obtained that, the morphology of the fracture sides of the composite's sample were not homogeneous which result in poor adhesion among jute fabrics, sand and polypropylene. For the light construction materials PP is a good polymer. When jute is used with the PP polymer the mechanical properties

increased in a great extent. Sand filler also increases the mechanical properties especially tensile properties. So sand treated PP/Jute composites can be a good replacement of PP/Jute based composites.

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