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An Experimental Investigation on Tensile and Impact Properties of Bagasse/ Polypropylene Natural Composite

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ABSTRACT: Sugarcane bagasse is one of the most abundant types of natural fibers which can be utilized to fabricate natural composite materials. Since bagasse is one of the wastes of Khuzestan province sugarcane factories, recycling might be an opportunity to enjoy its economic and environmental benefits. In the present study, the mechanical and microstructural properties of Bagasse/Polypropylene natural composite fabricated by the injection molding method were investigated. Bagasse fibers after the drying process were mixed up to polypropylene with 10, 30, 40 and 50% weight fraction of bagasse. In order to investigate the mechanical properties, experimental tests consist of tensile test and Charpy impact tests were carried out. The results showed that the maximum material strength was obtained from the sample made of 40% weight fraction of bagasse. The strength of 40% bagasse was found about 10%more than 50% bagasse. The microstructural analysis indicated that the failure mechanism of 40% bagasse was mainly affected by fiber breakage. However, the main failure mechanism of 50% bagasse was changed to fiber pull out. Additionally, impact absorbed energy was significantly decreased by increasing the bagasse weight fraction.

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1- Introduction

The major advantages of wood-plastic composites could be considered as the low fabrication cost and high mechanical strength [1]. Several sources of wood pulp are available. Sugarcane bagasse is one of the most abundant types of natural fibers which can be utilized to fabricate natural composite materials.

Kuriakose et. al. [2] investigated the impact resistance of notched specimens made of natural fibrous composite. They found that fiber surface treatment is enhanced the impact resistance up to 51% compared with virgin material. Kazemi Najafi et. al. [3] studied the mechanical properties of a natural composite made of pericarp and plastic. The results showed that the improvement in tensile strength of the fabricated specimen made of recycled plastics is negligible. Samariha et. al. [4] reported the mechanical properties of bagasse natural composite. They found that by increasing the bagasse mass fraction percentage (wt%), the tensile strength is improved, while the impact of energy absorption is reduced.

In the present study, the mechanical properties of bagasse/ polypropylene natural composite are investigated experimentally using the injection molding method. The specimens are fabricated at four bagasse weight percent levels. Eventually, tensile strength, failure strain and impact resistance of prepared specimens are studied.

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2- Methodology

A granule shape polypropylene was utilized as a composite matrix material to fabricate the specimens. Bagasse was obtained from Karoon sugar cane industry. The fresh bagasse was first placed at 40 ° C near fresh air for 5 days. It was then moved to the oven at 70 °C to cure for 24 hours.

In order to investigate the effect of different bagasse wt% on specimen tensile strength and impact resistance, the mixture of bagasse/polypropylene was prepaid at 4 levels. Moreover, 3 grams of pigment was added to the mixture using in a high-speed mixer. Next, the prepared specimens were transformed into granules using an extrusion machine.

ASTM D638 and ASTM D6110 standards were employed to prepare test samples needed for tensile strength and impact resistance experiments. Double-cavities injection mold was utilized to ensure that the same environmental conditions of tensile and impact specimens were achieved. A unique code was assigned to each specimen based on its wt% composition as shown in Table 1.

Table 1: Specimen codes used in experiments

Description	Defined code
10% weight bagasse	PP0/B0
30% weight bagasse	PP1/B1
40% weight bagasse	PP2/B2
50% weight bagasse	PP3/B3

3- Experiments

A tensile test was carried out using Santam tensile test machine in accordance with ASTM-D638 standard. The major differences are determined for the failure strength and strain of specimens.

The 7045-GTMPX machine and ASTM-D6110 standard were utilized to perform the impact test. According to the standard, required specimens for this test were prepaid in a rectangular shape in the dimensions of 126×12.6 mm. Since the fabricated specimens were produced without notch, according to ASTM-D6110, a V-shape notch with 45-degree opening and depth of 2.54 mm was milled at the center of specimens.

4- Results and Discussion

4- 1- Tensile strength

The results of the quasi-static tensile test are shown in Fig. 1. As the figure illustrates, the highest strength is related to PP2/B2 code. The strength of this specimen was improved by 3.9%, 8.47%, and 14.9% compared with PP0/B0, PP1/B1, and PP3/B3 codes, respectively.

By increasing the bagasse wt%, two factors play an important role in the mechanical properties of specimens. The first factor is bagasse wt%. As Fig. 1 shows, by increasing the reinforced phase (bagasse) the overall tensile strength of the fabricated composite is improved [5]. However, the increase of bagasse wt% has increased the possibility of material defect during the fabrication process. Additionally, the bonding between matrix and the reinforcing phase is reduced [6].

As shown in Fig. 2, by increasing the bagasse wt%, the fracture strain is decreased. If wt% is increased more than 10%, the amount of fracture strain is significantly reduced (from 25% to 20%). As the results demonstrate, up to 50 wt% of bagasse, the fracture strain remains unchanged near 20% with the reasonable approximation.

4- 2- Specimen absorbed energy up to failure

The absorbed energy of the specimen up to failure is shown in Fig. 3. As it is seen, PP0/B0 specimen shows the highest energy absorption compared with other specimens.

By increasing bagasse wt% from 10 to 50, the impact resistance is reduced by 11.33%. As it is seen, the decreasing trend is significantly increased from 10 to 20 wt%, while from 20 to 50 wt%, the reduction trend is slightly decreased.

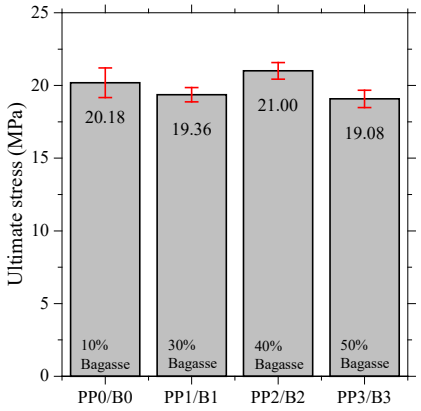

Fig 1: The influence of bagasse weight percentage on the specimen ultimate stress

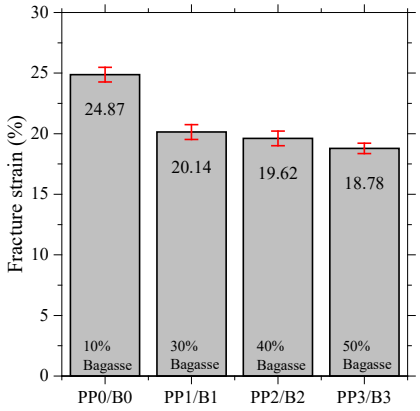

Fig. 2: The influence of bagasse weight percentage on the specimen fracture strain

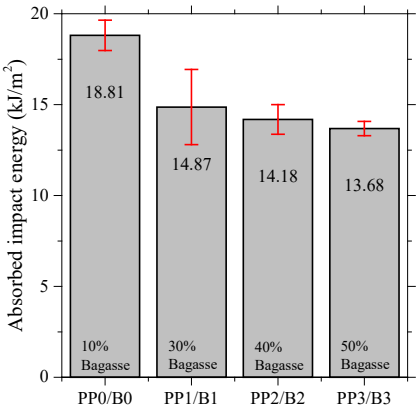

Fig. 3: The influence of bagasse weight percentage on the specimen absorbed impact energy

4- 3- Microstructural observations

It is observed that PP3/B3 contains more cavities compared with other specimens. Due to the high percentage of bagasse, the failure mechanism of bagasse fibers is transformed from fiber breakage to fiber pull out which is reduced the material strength and impact resistance.

5- Conclusion

The findings of this work can be summarized as follows:

1. Results showed that by increasing bagasse up to 30 wt% the tensile strength is reduced.
2. The impact resistance is significantly reduced by increasing more than 30 wt%
3. Microstructural observations show that from 40 to 50 wt% the failure mechanism of the composite is changed from fiber breakage to fiber pull out.

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