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EFFECT OF CORN HUSK ON THE MECHANICAL AND FRICTIONAL BEHAVIOR OF POLYESTER COMPOSITES

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ABSTRACT
Polyester composites are commonly used nowadays in industrial applications such as bearing materials, brake pads materials and flooring materials. In this work, polyester composites reinforced with Corn Husk Waste (CHW) are proposed to be used as new engineering materials with improved mechanical and frictional behavior. Cylindrical pins with 10 mm diameter and 30 mm height were prepared as test specimens. Two factors have been taken into consideration when designing the experiment; the size and weight of the added particles. A Pin-on-disk tribometer has been designed and constructed to perform measurements of the friction coefficient for proposed composites. WP300.20 universal testing device was used to investigate the mechanical properties of polyester composite. Results show that agricultural wastes (corn husk) can improve the mechanical and tribological behavior of polyester composites which can be used in industrial applications.

KEYWORDS
Corn Husk Waste (CHW), Polyester Composite, Friction, Mechanical Properties.

INTRODUCTION
Short fiber reinforced polymer composites are nowadays used in numerous tribological applications. In spite of this fact, new developments are still under way to explore other fields of application for these materials and to tailor their properties for more extreme loading conditions, [1]. Polyester composites are commonly used nowadays in industrial applications such as bearing materials, brake pads materials and flooring materials, [2]. Fiber Reinforced Plastics (FRP) are widely used as structural materials in the manufacture of, for example, marine boats, automobiles and bathtubs due to their light weight, high degree of rigidity and superior moldability, [3]. There are the two main characteristics which make these materials attractive compared to conventional metallic designs. They are of relatively low density and they can be tailored to have stacking sequences to provide high strength and stiffness in directions of high loading, [4].Composite materials consist of a resin and reinforcement chosen according to desired mechanical properties and the application, [5]. Polyesters are also commonly used as matrix materials, particularly with glass-fibre-reinforcement. Polyester is an economic material that has high chemical resistance and is resistant to environmental effects. It

has high dimensional stability and low moisture absorption. The production technologies for thermoset glass/polyester composites are easier and cheaper than those for other glass/resin materials. Glass-fibre-reinforced polymer with thermosetting polyester resin is an attractive material that is economically desirable. Its application at low temperatures and under service terms is easy when this material is compared to advanced polymer composites with a complex molecule structure, high strength and working under terms of difficult service, [6]. Fibre-Reinforced-Polymer composites are used particularly in the automotive and aircraft industries and the manufacture of spaceships and sea vehicles, [7]. In industrial applications, the increase in the use of composite materials means that it is necessary to know their behaviour under working conditions. Wear is an important parameter and its experimental behaviour must be known, [8]. Polymers are frequently used in tribological applications because of their self-lubricating ability and loadability. However, most research on their friction and wear mechanisms is performed on small-scale test samples under relatively low normal loads, [9]. Polymers have been favorably introduced as sliding materials in offshore structures for over ten years because of good wear resistance. Mainly under high loads, surface plasticity contributes to low friction, which is favorable for a reduction in dissipated sliding energy, [10].

In the present work, polyester composites reinforced with Corn Husk Waste (CHW) are proposed to be used as new engineering materials with improved mechanical and frictional behavior.

EXPERIMENTAL

The investigation was carried out to examine the effect of adding corn husks on the mechanical and frictional properties of polyester.

Raw Materials

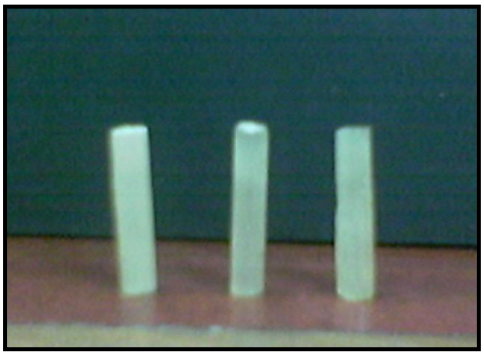
Corn husks, Fig. 1, were supplied as agricultural waste from the corn plants, these wastes cleaned from any other contaminates and grinded into two types of particle size; soft particles with 0.5 mm particle size and hard type with 3 mm particle size. Polyester resin was used as polymer matrix for the proposed composite.

a b

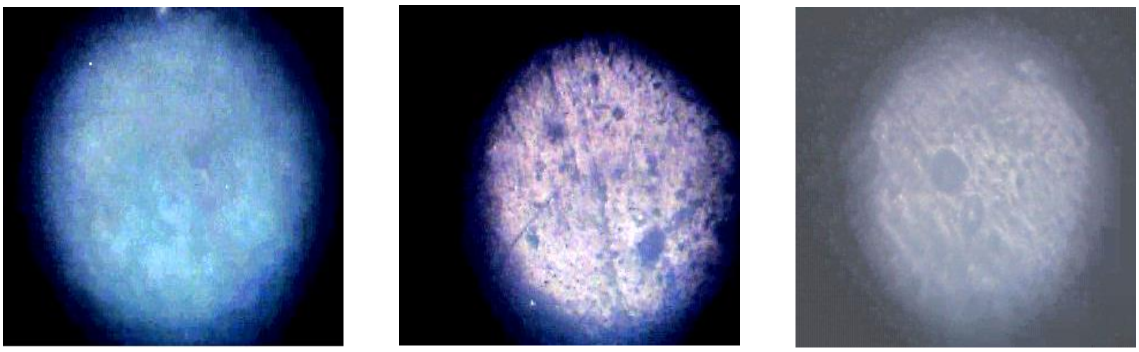
Fig. 1 Corn Husks a) soft and b) hard particles.

Preparation of Test Specimens

Test specimens were formed in shape of cylindrical pins of 10 mm diameter and 30 mm height, Fig.2.2. Polyester was mixed with grinded corn husk in weight ratio from 0 to 50% then molded into a paper mold then left it for two days for solidification before tests.



a



b c d

Fig. 2 a) Test specimens b) unfilled polyester, c) polyester reinforced by soft particles and d) polyester reinforced by hard particles.

A compression test was carried out on the composite pins to indicate the effect of corn fibers upon the stress-strain behaviour of the proposed composite. Mechanical investigations performed by means of WP 300.20 universal testing machine under load range from 0 to 5 KN. A stress-strain curve has been plotted directly by the testing device for each test sample.

Friction Coefficient Measurement

Description of test rig

Experiments were carried out using "pin-on-disc" test rig, Fig. 3. It consists of

1- Steel base 80 cm width and 100 cm long,
2- Steel disc of 170 mm diameter and 5 mm thickness,
3- Electric motor,
4- Worm gearbox,

5- Specimen holder,
6- Load cell,
7- Loading plat at which the normal loads were applied, and
8- Digital screen attached to the load cell.

Fig. 3 Pin-on-Disk Tribometer.

Tests were carried out at room temperature and normal level of humidity by means of "pin-on-disc" tribometer. Polyester composites were held in specimen holder and loaded against the rotating steel counterface; the friction force was monitored by the digital screen which attached with the load cell. These forces measured at 190 rpm (0.696 m/s) under variable normal loads 2, 4, and 6 N. Friction coefficient calculated by dividing the friction force by the applied load, eq.(1).

$$\mu = F_f / F_n \qquad (1)$$

where,

μ = friction coefficient F_f = Friction force N, and F_n = Normal force N

RESULTS AND DISCUSSION

The results of experimental work divided into two groups:

Results of Tribological Tests

Figure 4 shows that increase of hard particles of corn husk contents decreases slightly the friction coefficient of polyester composite from 0.75 for free specimen under 6 N applied load to 0.51 for composite reinforced by 15 % hard particle corn husk, then the friction coefficient increase to 0.58 with increases of corn husk contents to 50 %. The friction reduction may be explained as a result of the contact between the counter face material and corn husk particles which come to the contact zone. But the friction coefficient increases for composite with high corn husk contents which may be a result of the contact between the composite surface and transferred layer from the composite surface to the counter face.

Figure 5 shows that increase of soft particles of corn husk contents decreases slightly the friction coefficient of polyester composite from 1.02, 0.79 and 0.75 for free specimen under 2, 4 and 6 N applied load respectively to 0.9, 0.58 and 0.48 for composite reinforced by 15 % soft particle corn husk under 2, 4 and 6 N respectively, then the friction coefficient increase under all loads with increases of corn husk contents to 45 %.

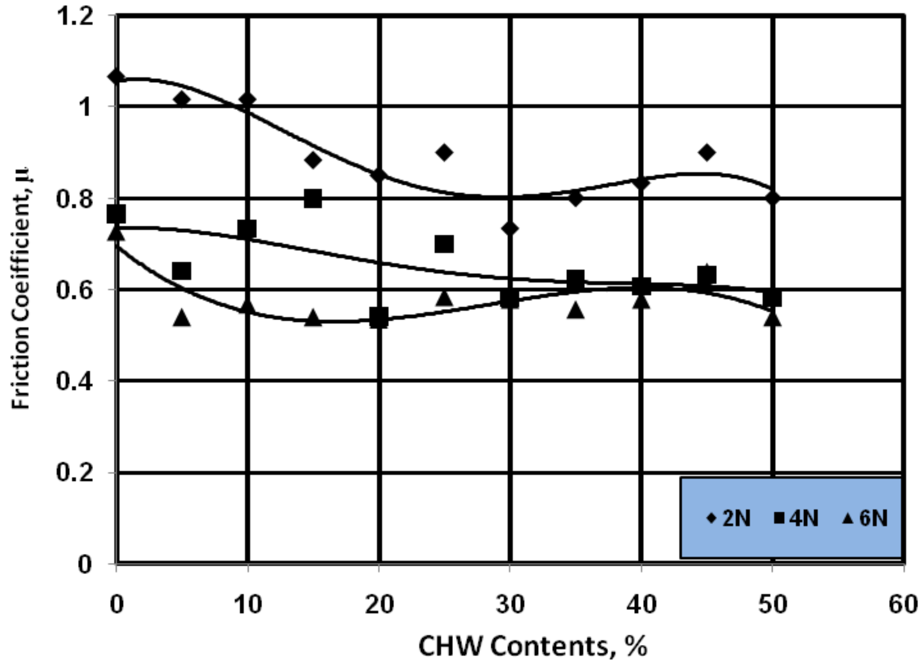


Fig. 4 Effect of hard particles corn husk content on the friction coefficient of polyester composites.

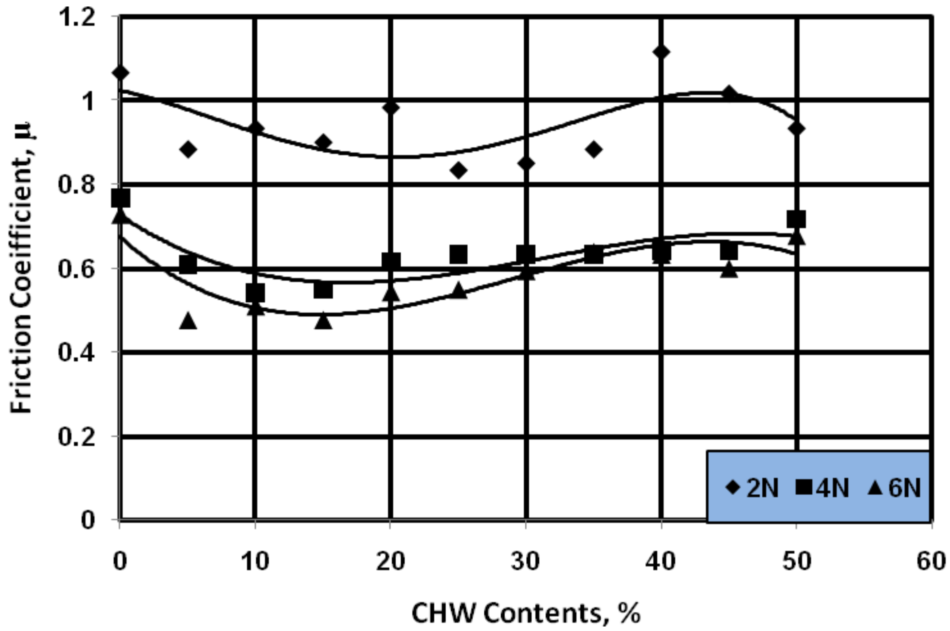


Figure 5 Effect of soft particles corn husk content on the friction coefficient of polyester composites.

It seems that there is an elastic deformation occurred on the composite surface under high loads which may be responsible for the friction reduction. And it can be concluded

that the transferred layer responsible for the increase of friction for composite with high corn husk contents. These results show that there is no significant effect for the particle size on the friction coefficient of proposed composite.

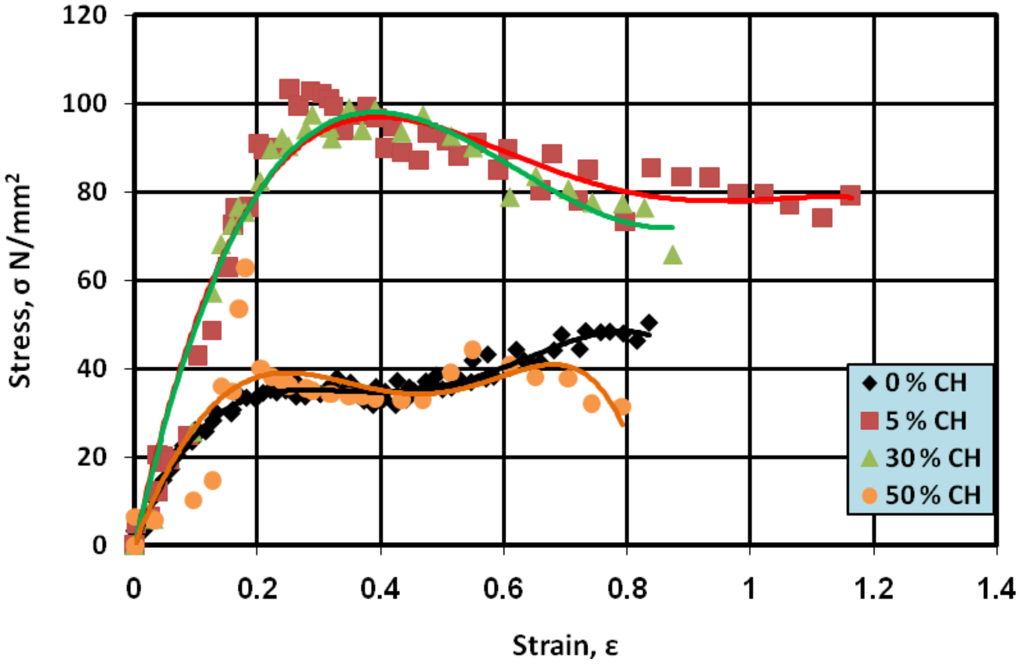


Figure 6 Effect of hard particles corn husk content on the stress-strain curve of polyester composites.

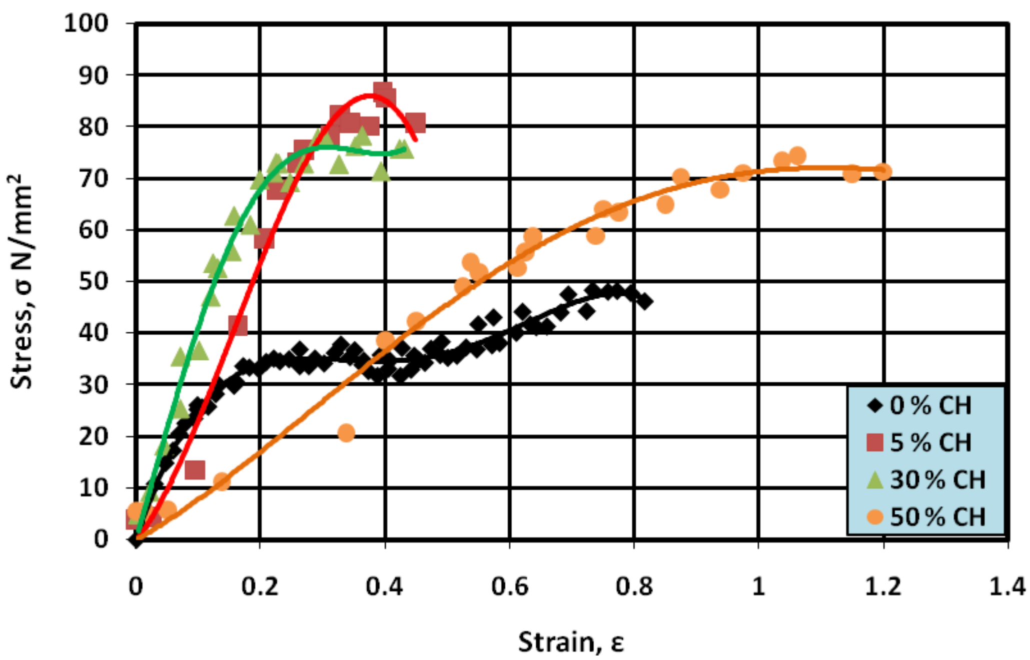


Figure 7 Effect of soft particles corn husk content on the stress-strain curve of polyester composites.

Results of Mechanical Tests

Figure 6 discusses the relation between stress and strain for the polyester composite reinforced by hard particles of corn husk. As shown in the figure the ultimate strength of polyester composite increases from 48 N/mm^2 for free polyester to 100 N/mm^2 for polyester containing 5 % and 30 % corn husk particles, on the other hand the fracture strain of polyester increases from 0.8 for free specimen to 1.2 for polyester composite reinforced by 5 % corn husk. Continuous increasing of corn husk in polyester composites to 50 % decreases the strength of composite less than 40 N/mm^2 and also decreases the fracture strain to less than 0.8 which may be a result of decreasing the bonding between the composite contents. Figure 7 shows that increase of soft particles of corn husk in polyester composite to 50% increases the ultimate strength to more than 70 N/mm^2 and increases the fracture strain to 1.2. From these results it can be seen that the optimum composites of polyester reinforced by corn husk is that composite which contains 5% hard particles of corn husk and the composite which have 50% soft particles of corn husk, these two percentage improved the mechanical behavior of polyester composite.

CONCLUSIONS

From this work it can be concluded that:

1. The friction coefficient of polyester can be decreased with the increase of corn husk content in the polyester composites.

2. The mechanical behavior of polyester can be improved by adding corn husk particles to polyester in form of hard particles by 5 % of the composite weight.

3. Use of agricultural wastes (corn husk) can improve the mechanical and tribological behavior of polyester composites which can be used in industrial applications.

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