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TRIBOLOGICAL AND MECHANICAL PERFORMANCE OF POLYESTER COMPOSITES FILLED BY JASMINE DRY LEAVES

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ABSTRACT
Dry jasmine leaves represent one of the agricultural wastes that cannot be used again. This study investigates the possibility of using these residues as filling material for polyester composites in order to use these composites as a new engineering material for some industrial applications. This study focuses on tribological properties such as wear rates and friction coefficient of the proposed polyester composites, and also studies the mechanical behaviour of these composites. Test specimens were processed by mixing polyester resin by ground jasmine dry leaves ranging from 5 to 50% of the total weight of the sample divided into two categories (soft and coarse) depending on the size of granules of jasmine leaves. Test specimens prepared in the form of cylindrical pins of 5 mm diameter and 30 mm height so that they can be tested by means of pin-on-disc tribometer to measure the friction coefficient and wear rates. Samples underwent to compression test to study the mechanical properties. The results show that polyester composites filled by 5 % and 30 % jasmine dry leaves have relatively higher wear resistance and higher mechanical strength.

KEYWORDS
Tribology, jasmine wastes (J.W.), polyester composites.

INTRODUCTION
Polyester composites are commonly used nowadays in industrial applications such as bearing materials, brake pads materials, flooring materials and so on, [1]. Use of agricultural wastes (corn husk) can improve the mechanical and tribological behavior of polyester composites which can be used in industrial applications, [2]. Polyester composites reinforced with mango's dry leaves were recommended as low friction coefficient and high wear resistance material for industrial applications such as solid lubricants. Polyester composites reinforced with palm fronds were recommended as high friction and low wear rate material for industrial applications such as brake pads, [3]. Further approaches in designing polymeric composite in order to operate under low

friction and low wear against steel counterparts are described, [4]. Due to the great changes in technology that occurred in the last century, a larger number of components fabricated in engineering polymers and composites have been used; substituting the most traditional metals in diverse applications, attaining in many cases better advantages as reduction of maintenance costs, save in weight and higher freedom for designing. Some examples of applications can be cited as: self-lubricant bearings, linear guides, mechanical seals, bushings, bearings cages, transporting belts, gears, and pulleys. These components are in turn more required in the aspects of mechanical resistance, fatigue strength and resistance to wear, [5]. Analysis of the wear resistance of polymeric fibres requires a better understanding of their abrasive scratch behaviour and their frictional response, [6].

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, [7].

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, [8]. 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, [9]. 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, [10].

As polymers generally posses good self-lubricating abilities through the formation of a polymer transfer film or 'third body', they are also used in industry as sliding materials in gears, slides and bearings, [11]. Fibre-Reinforced-Polymer composites are used particularly in the automotive and aircraft industries and the manufacture of spaceships and sea vehicles, [12]. 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, [13]. Composite materials consist of a resin and reinforcement chosen according to desired mechanical properties and the application, [14].

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. 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, [15].

EXPERIMENTAL

For the purpose of conducting the experiments, a "Pin-on-Disc" test rig has been designed and manufactured, Fig. 1. It consists of (1) a steel disc of 150 mm diameter and 5 mm thickness driven by variable speed motor (2) specimen holder (3) load cell (4) load holder at which the normal loads were applied and (5) digital screen attached to the load cell. Test specimens were formed in shape of cylindrical pins of 10 mm diameter and 30 mm height, Fig. 2. Polyester was mixed with the agricultural waste by weight ratio from 0 to 50%.

The friction coefficient and wear rate are the two tribological properties that are subject to the study; beside the mechanical strength of proposed composites. The change in the friction coefficient and wear rate was traced with the change in the percent of the weight of the jasmine waste (J.W. %) from the two types under applied normal loads 2, 4, and 6 N.

Fig. 1 Pin-on-Disk test rig.

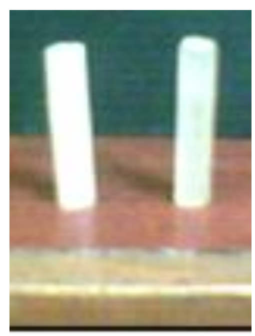

Fig. 2 Pins of polyester.

A compression test was carried out on the composite pins to indicate the effect of jasmine contents and jasmine leaves particle size on the ultimate strength of polyester. 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.

Tribological measurements were carried out at room temperature and normal level of humidity by means of "pin-on-disc" tribometer at 1700 rpm under 2, 4, and 6 N applied loads.

The following equations were applied in calculating the values of wear rate and friction coefficient.

Wear rate = $(W_1-W_2)/t$ g/min (1)
Friction coefficient = $\mu = F_f / F_n$. (2),
Where
W_1 = Specimen's weight before test, (g),

W_2 = Specimen's weight after test, (g),
T = Test duration, (min.),
F_f = Friction force N, and
F_n = Normal force N.

RESULTS AND DISCUSSION

The results of experimental work are divided into two groups:

1 Results of Tribological Tests.

Figure 3 shows that the increase of soft particles contents of jasmine leaves in polyester composite caused an increase in friction coefficient. For instant, friction coefficient increased from 0.7 for polyester free of agricultural wastes to 1.0 for composite containing 30 % jasmine leaves under the load of 4 N. This may be explained on the basis that the particles of jasmine leaves formed an abrasive layer that increased friction coefficient.

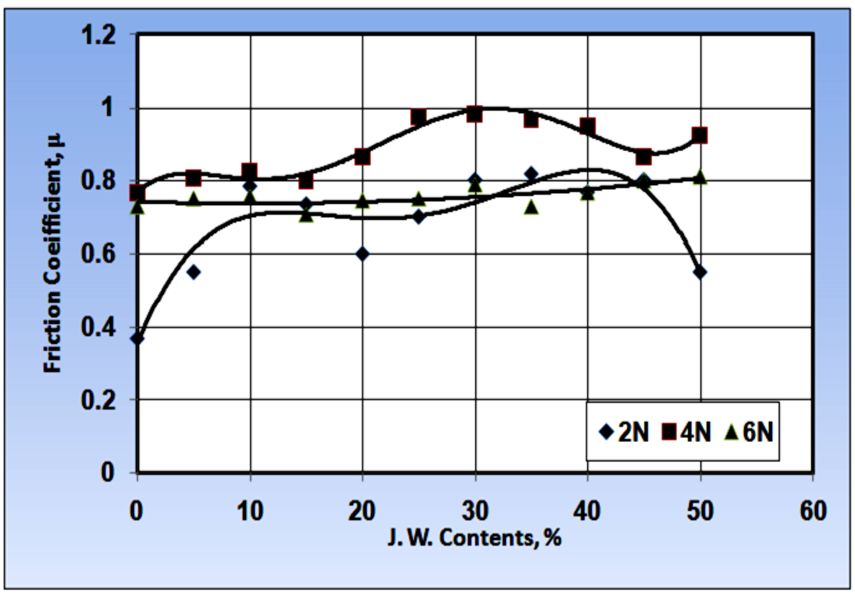

Fig. 3 Effects of soft particles of jasmine leaves on the friction coefficient of polyester composite.

Figure 4 shows that increase of coarse particles of jasmine leaves increased friction coefficient from 0.7 for polyester free of agricultural wastes to more than 1.55 for composite containing 50 % jasmine leaves under 2 N load.

Figure 5 shows that the increase of soft particles content of jasmine leaves in polyester composites decreased wear rate from 0.02 g/min to 0.008 g/min. It is shown that wear rate of polyester filled by coarse jasmine leaves slightly exceeded wear rate of composites filled by soft particles.

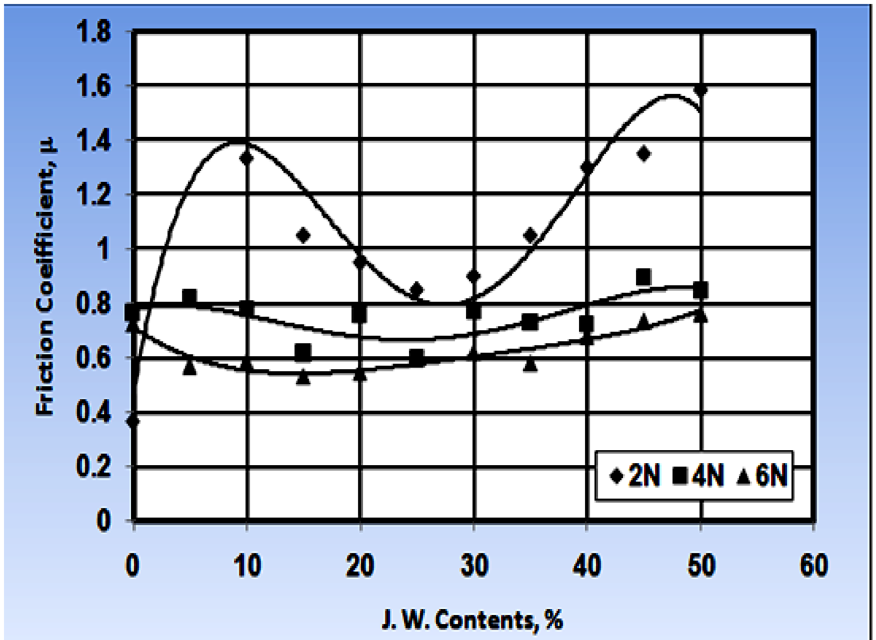

Fig. 4 Effects of coarse particles of jasmine leaves on the friction coefficient of polyester composite.

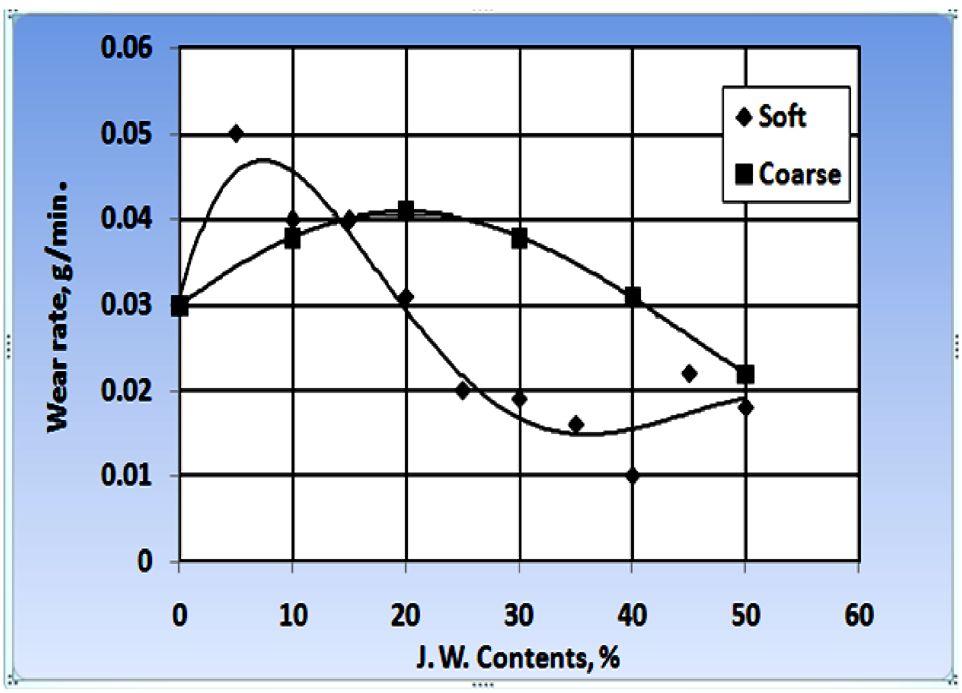

Fig. 5 Effects of jasmine leaves on wear rates of polyester composite.

2 Results of Mechanical Tests

Figure 6 shows the stress-strain curve for polyester free of agricultural wastes, as shown in this figure the ultimate stress of polyester is approximately 60 N/mm^2.

As represented in Fig. 7 increases of jasmine leaves in polyester composite increase the ultimate strength for polyester composite to more than 110 N/mm^2 for composite filled by 5% soft particles of jasmine leaves wastes; beside slightly increases of ultimate strength to 72 N/mm^2 for composite filled by 5 % coarse particles of jasmine leaves.

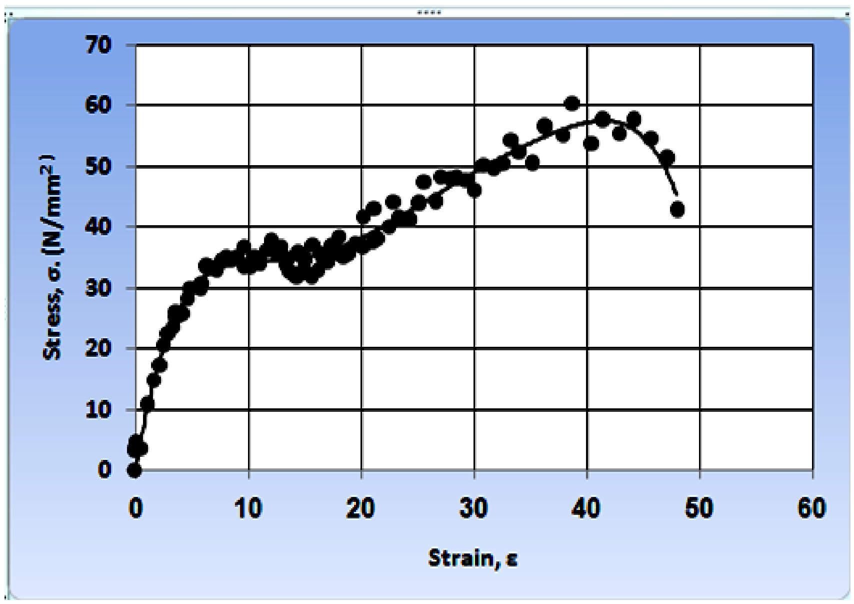

Fig. 6 Stress – strain curve for polyester free of jasmine leaves.

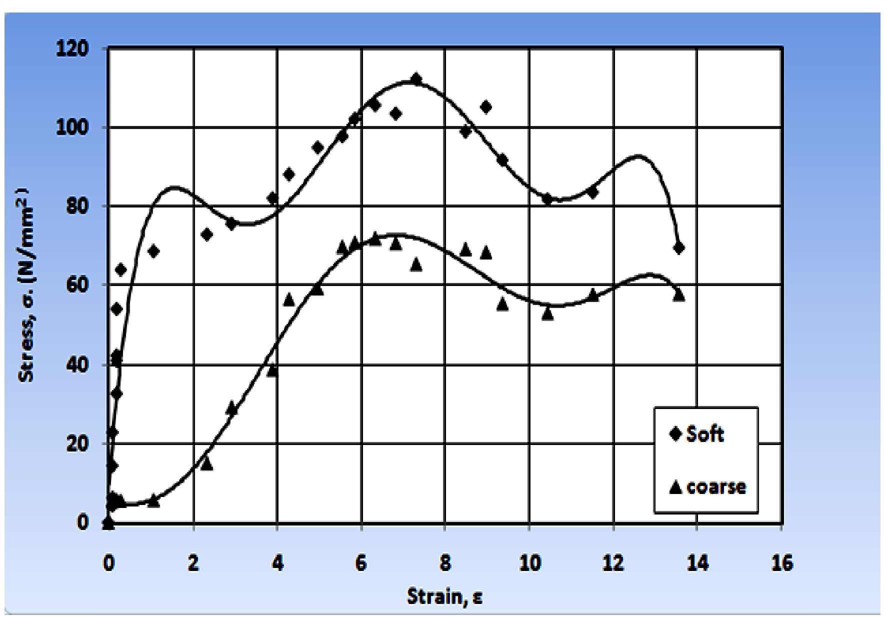

Fig. 7 Stress – strain curve for polyester composite filled by 5 wt. % jasmine leaves.

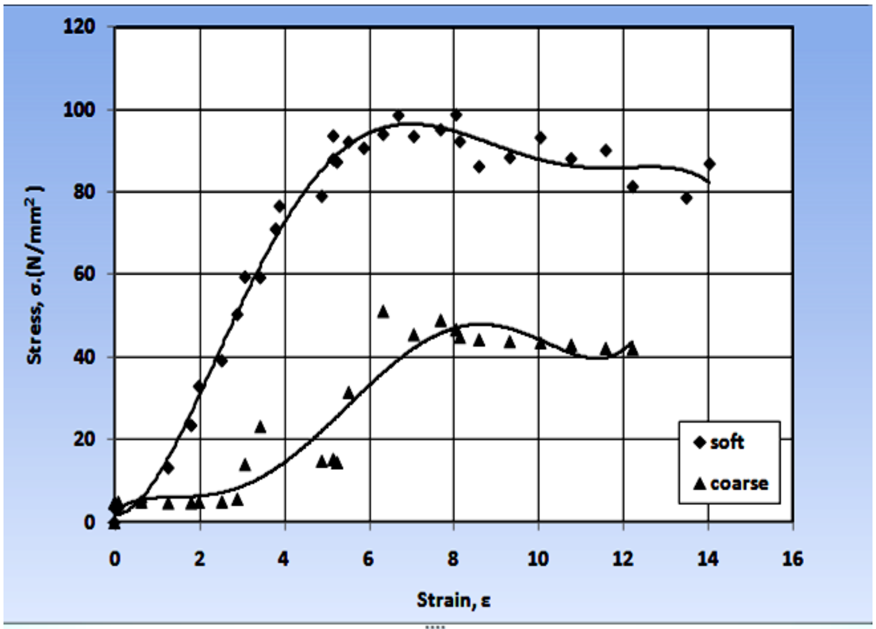

Fig. 8 Stress–strain curve for polyester composites filled by 30 wt. % jasmine. eaves.

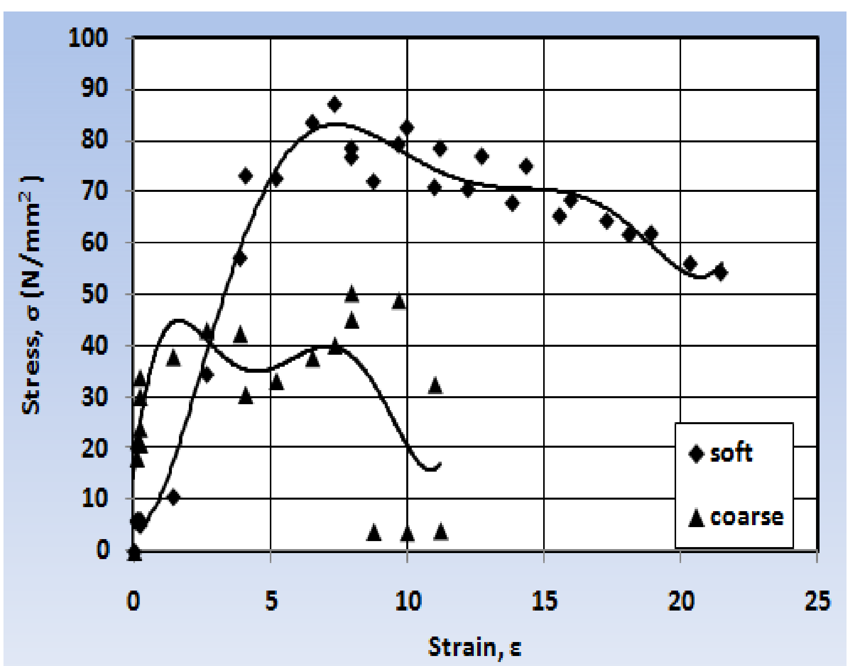

Fig. 9 Stress – strain curve for polyester composite filled by 50 wt. % jasmine leaves.

Figure 8 shows that increase of wastes to 30 % increases the ultimate strength of polyester composite from 60 N/mm^2 to more than 90 N/mm^2 for composite filled by soft particles of wastes. But on the other hand increase of coarse particles of jasmine leaves in polyester composite to 30 % decreases the ultimate strength to 48 N/mm^2, which mean that the composite become weaker than free polyester.

Polyester composites filled by 50% soft particles of jasmine wastes have ultimate strength of 85 N/mm^2; beside the increases of coarse particles of wastes in composites to 50% make the composite weaker than free polyester as shown in Fig. 9.

CONCLUSIONS

1. The friction coefficient of polyester composite increases with increasing the content of coarse particles of jasmine leaves in composites under low loads.
2. Increase of soft particles of jasmine leaves in polyester composites remarkably decreases the rates of wear for proposed composites.
3. Polyester composites filled with jasmine leaves were recommended as high friction and low wear rates material for industrial applications such as brake linings.
4. Addition of jasmine leaves improves the mechanical behavior of polyester composites.
5. Ultimate strength of polyester composites increases remarkably to 110 N/mm^2 and 90 N/mm^2 with increasing the content of soft particles of jasmine leaves in polyester composites to 5% and 30% respectively.
6. Increasing the content of coarse particles of jasmine leaves in composites to 50 % makes the composites weaker than free polyester.
7. Use of agricultural wastes (jasmine leaves) can improve the mechanical and tribological behavior of polyester composites which can be used in industrial applications.

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