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IMPACT BEHAVIOUR OF REINFORCED LUFFA AND PALMYRA PALM FIBERS POLYESTER COMPOSITES

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ABSTRACT

This paper presents analysis on the effects of type of fiber loading on the impact characteristics of composite materials reinforced with luffa and palmyra palm fibers. The loading of 10 wt%, 20 wt% and 30 wt% were used for luffa and palmyra palm fiber respectively. The specimens for Charpy impact test were cut from the composite plates. The impact test was conducted according to ASTM D256 using the charpy V-notch impact testing machine. The paper presents and analyses the results of the Charpy impact tests (failure energy (U) and resilience (K)) for the composite materials tested. Some important remarks concerning the areas of failure are presented. Finally, the paper graphically shows the effects of fiber loading on the dynamic characteristics obtained in Charpy impact test.

Keywords: *Composite, Charpy impact test, failure energy, resilience.*

1. INTRODUCTION

Currently, the resin-based composite material, also known as Fiber Reinforced Polymer (FRP) which generally consists of continuous fibers and a matrix material, is the most widely used in auto-mobile industries due to their improved properties over other metallic based materials. The continuous fibers provide the required strength and stiffness, and loading capability of the material, while the matrix system provides a continuous medium, not only aligning the fiber direction, but also transferring the load between different fibers, and allowing the fiber to undertake the shear and compressive loading.

Compared with the conventional metallic alloys, composite materials offer many advantages, especially where high specific properties are concerned. which is defined as the ratio between the ultimate tensile or compressive strength and the density of the materials. In addition, composite materials provide better fatigue properties and corrosion resistance, which makes the composite structures have a longer operational cycle and need little maintenance and enhance the safety[1, 12].

In spite of the advantages of composite materials referred above, the brittle behavior when loaded under fatigue conditions and limited impact resistance become their serious weaknesses. Their low impact strength makes it undergo significant damage in the form of damage modes when subjected to impact load. The damage mechanism includes fiber failure, matrix failure and debonding between fiber and matrix. The poor resistance of the composite materials to the impact load is a critical issue in the manufacturing industries [4, 8]. Therefore, investigating the impact toughness behavior of the composite materials is more critical and can avoid unnecessary losses when detecting the damage in time.

As a main failure type in auto-mobile and aircraft structures, impact damage has been an increasing concern, especially when nowadays the composite materials are widely used on the aircraft and automobile industries. It is reported that at least 13% of 688 repairs to 71 Boeing 747 fuselages and also car bumpers were related to the impact damages [5]. There are different sources causing the impact damage such as: road accident in cars, ballistic impact (for military aircraft), bird strike, hail, engine or runway debris, service cars colliding with the structure and the structure and dropped tools during the maintenance [11].

Charpy v-notch impact test has been employed in this work to determine the energy absorption, notch sensitivity, fracture toughness and fracture behavior of a laminate reinforced composite material, through information obtained from standardized pendulum type breaking standard specimens in a bending mode. The aim of this paper is to characterize the effects of fiber loading on the impact behavior of reinforced Palmyra palm and Luffa fiber reinforced polyester composite. Thus, 10 wt%, 20 wt% and 30 wt% each for Palmyra palm and Luffa fiber were used as reinforcement respectively in polyester resin.

2. EXPERIMENTAL METHODOLOGY

In this paper, *Palmyra palm and Luffa* fibers (10 wt%, 20 wt% and 30 wt%) respectively were used to reinforce polyester matrix: First of all, three composite plates were produced by using the hand lay-up technology. The average volume fiber ratio of the composite materials tested was equal to 28 %,while the percentage weight of fiber ratio was 10 wt%, 20 wt% and 30 wt%. The curing time was one hour at room temperature. The plates made of composite materials were cut to obtain the specimens whose dimensions are shown in (figure 1) according to ASTM D256 [3].

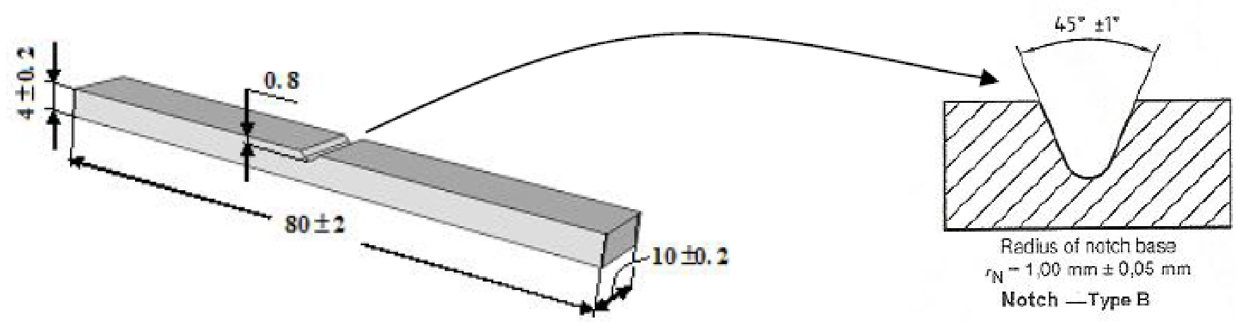
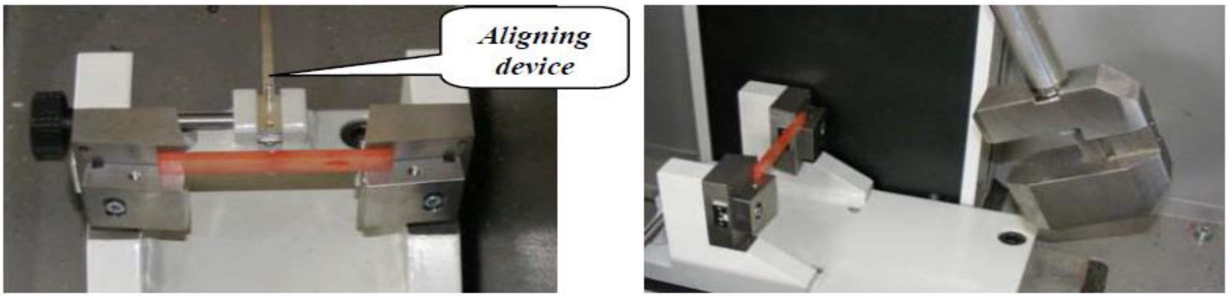


Figure 1: Shape and dimensions of the composite specimen used for Charpy impact test [2].

A total number of 7*specimens* were manufactured including the control specimen. The dimensions, gauge length and V-notch were chosen according to the standard. The specimen was placed between a special holder with the notch oriented vertically and towards the origin of impact as shown in figure 2a. The specimen was struck by a "tup" attached to a swinging pendulum. The specimen breaks at its notched cross-section upon impact, and the upward swing of the pendulum was used to determine the amount of energy absorbed in the process.



a. **b.**

Figure 2: Composite specimen supported on the Charpy impact pendulum:
a. aligning of the specimen with respect to the supports; **b.** specimen before impact [1].

The dimensions of the cross-section were recorded for each specimen before impact testing. Then, the specimens were subjected to Charpy impact test by using the experimental standard shown in the figure 2. The distance between the simple supports was 60 mm. The impact is produced by swinging the pendulum hammer against the test specimen from a height h_o. When it is released the hammer swings through an arc, hits the target specimen and after fracturing, it reaches a height h_1. The difference between the initial energy and the remaining energy represents a measure of the energy required to fracture the specimen. This quantity is called failure energy in Charpy impact test and it is denoted by U. The failure energy denoted by U, was recorded in case of each specimen tested. Finally, the resilience of each composite specimen was computed by using the following formula:

$$K = \frac{U}{A} \quad (1)$$

Where A represents the area of the specimen cross-section where the V-notch is manufactured.

3. RESULTS AND DISCUSSION

Table 1 shows the experimental results recorded during Charpy impact test. To easily analyze the values obtained for the resilience *K*, the last column of table 1 is graphically represented in figure 3.The scattering factor of the values of resilience *K* is quite small in case of each composite material tested. The greater values of the failure energy (table 1) were measured for the composite materials made of luffa reinforced polyester composites. On the other hand, one may note that the composite made from palmyra palm fiber has a lower resilience but higher than that of polyester unreinforced composite.

Table 1: Experimental results recorded for all specimens tested for Charpy impact test

Composite material	No of Specimen	Dimensions of the specimen		Remaining thickness at notch h_n (mm)	Area of the cross section A (mm)	Failure energy U (J)	Resistance $\frac{U}{A}$ (kj/m^2)	Average Resistance (kj/m^2)
		b(mm)	h(mm)					
0 wt% fiber	1	10.00	10.00	9.2	92.00	3.05	33.15	36.23
	2	10.00	10.00	9.2	92.00	3.20	34.78	
	3	10.00	10.00	9.2	92.00	3.75	40.76	
10 wt% luffa fiber	1	10.00	10.00	9.2	92.00	4.10	44.57	44.34
	2	10.10	10.00	9.2	92.92	4.20	45.20	
	3	10.20	10.00	9.2	93.84	4.06	43.27	
20 wt% luffa fiber	1	10.10	10.00	9.2	92.92	4.04	43.48	42.92
	2	10.00	10.00	9.2	93.84	3.79	40.39	
	3	10.20	10.00	9.2	92.00	4.13	44.89	
30 wt% luffa fiber	1	10.10	10.00	9.2	92.92	4.13	44.45	42.42
	2	10.00	10.00	9.2	92.00	4.04	43.91	
	3	10.20	10.00	9.2	93.84	3.65	38.90	
10 wt% Palmyra Palm fiber	1	10.00	10.00	9.2	92.00	3.91	42.50	38.65
	2	10.10	10.00	9.2	93.84	3.34	35.94	
	3	10.10	10.00	9.2	92.00	3.45	37.50	
20 wt% Palmyra Palm fiber	1	10.00	10.00	9.2	93.84	3.75	39.96	39.82
	2	10.00	10.00	9.2	92.00	3.70	40.22	
	3	10.10	10.00	9.2	92.92	3.65	39.28	
30 wt% Palmyra Palm fiber	1	10.00	10.00	9.2	92.00	2.70	29.35	31.98
	2	9.75	10.00	9.2	89.70	2.90	32.33	
	3	9.50	10.00	9.2	87.40	3.00	34.33	

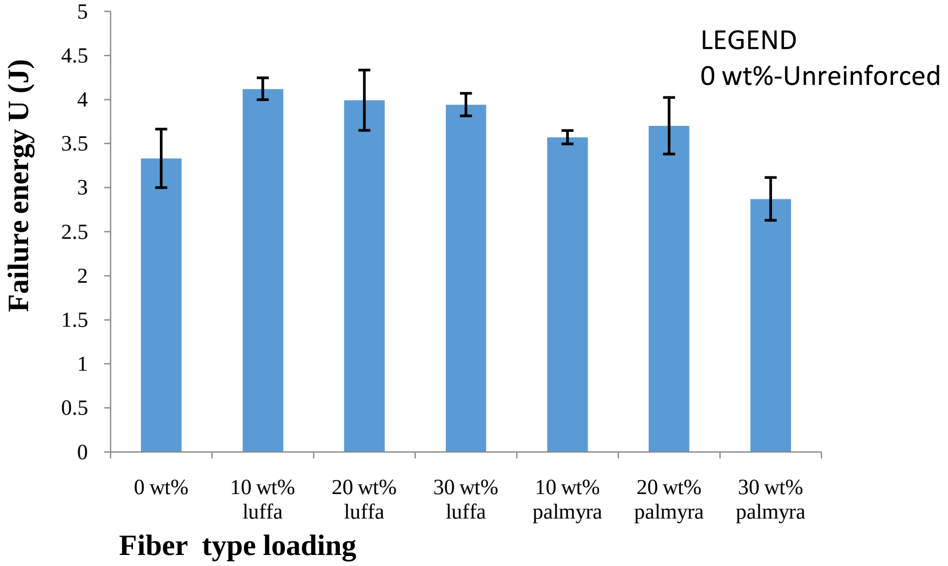


Figure 3: Mean values of the failure energy (U) of the composite materials tested

It can be seen from Figure 3 that the failure energy decreased in terms of Palmyra palm fiber, the failure is lower compared to that of luffa reinforced polyester composite. The maximum failure energy of 4.12 J obtained at 10 wt% luffa fiber reinforcement is higher than the maximum value obtained at 20 wt% Palmyra palm fiber reinforcement.

The highest failure energy of 4.12 J obtained on reinforcing with 10 wt% fibre content is higher when compared favourably with the optimal value of 3.50 J at 10 wt% fibre loading for PALF-polyethylene composite[4, 8, 11]. [5, 7] reported 3.50 J at 20 wt% fibre content for palm-epoxy composite and 3.6 J at 20 wt% fibre loading in jute-coir fibre reinforced hybrid polypropylene composite, which were all lower than 3.7 J obtained at 20 wt% Palmyra palm fiber. These could be as a result of the difference in the strength of the fibres or the matrix used.

The overlap in the error bar between 10 wt%, 20 wt% and 30 wt% fibre content, suggest that there was no significant difference in the failure energy of the three composites.

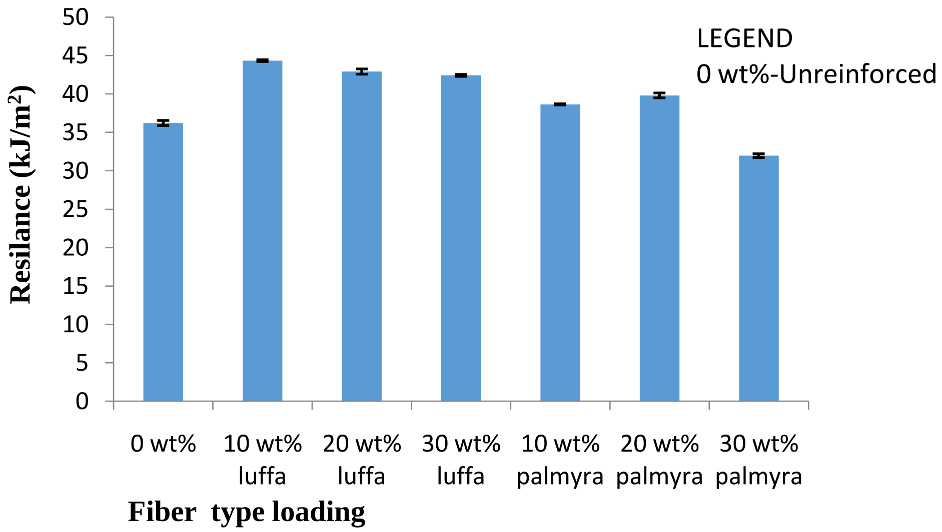


Figure 4: Mean values of the resilience U/A of the composite materials tested

The average values of the resilience *K* were computed (fig. 4). It may be observed that in case of the composites made of luffa/polyester resins, the resilience *K* is greater than the corresponding value obtained in case of the composite made of palmyra palm/polyeter resins. The difference might be due to the fact that woven fibers have better mechanical properties compare to non woven fibers [6, 9, 10]. But all the resistance of the reinforced composites are higher than the unreinforced polyester composite.

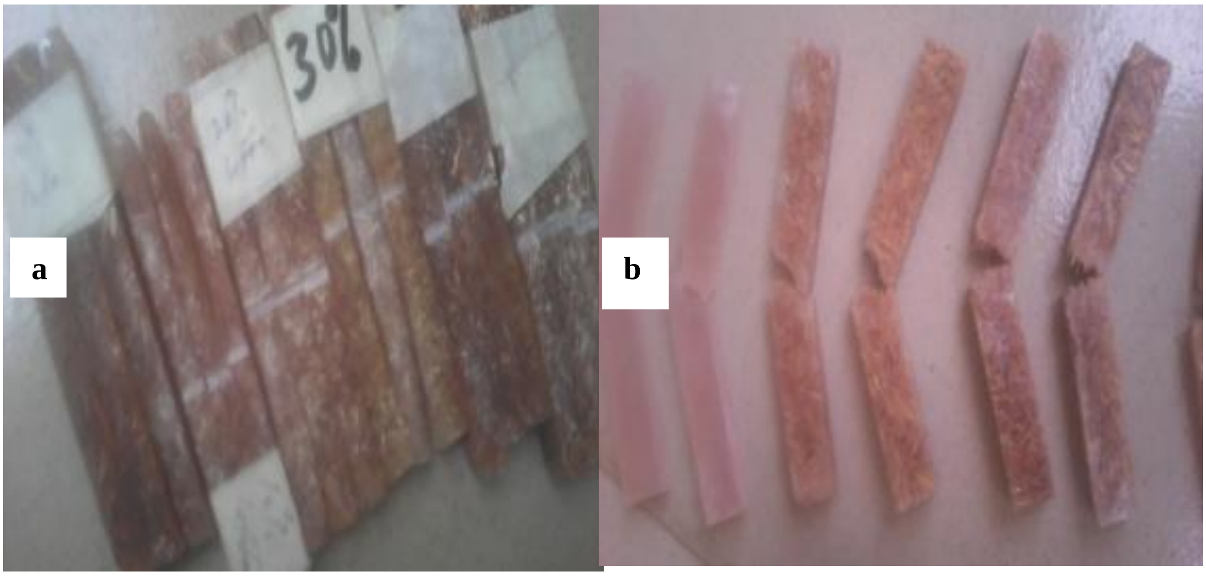


Figure 5: Composite specimens before and after Charpy impact test.

A photo of the composite specimens before and after Charpy impact test is shown in the figure 5. All specimens tested were broken during the impact test. This happened because the composite specimen was ruptured immediately it was hit by the pendulum.

4. CONCLUSIONS

The impact behaviors of the composite materials were mainly investigated by experimental studies in this work by varying the fiber loading from 10 to 30 wt%. From the experimental results, the following be drawn to conclusion:

Luffa and palmyra palm fiber were successfully used as reinforcement for polyester composite. The impact behaviors of both luffa and palmyra palm fiber composites are better than the unreinforced polyester composite. 10 wt% luffa polyester composite exhibits the best impact resistance of 44.34 Kj/m^2 greater than 38.89 Kj/m2 obtained by palmyra palm polyester composite at 20 wt% fiber loading.

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