Journal of Manufacturing Engineering, 2009, Vol. 4, Issue 3, pp 192-196

WEAR RESISTANCE AND DIMENSIONAL ACCURACY OF DRILLED HOLES OF SHORT ROSELLE / SISAL FIBER HYBRID POLYESTER COMPOSITE

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ABSTRACT

In the present work, the effect of fiber length and content on the wear resistance and dimensional accuracy of drilled holes of short roselle and sisal fiber polyester hybrid composite were investigated. The composite with 30 wt% & 150 mm showed a good wear resistance compared to the composite with 30 wt% & 100 mm at maximum wear test time of 12 min. But the weight loss of the hybrid composite with all the fiber content and length during wear test was almost in same level at all wear test time. The composite with 20 wt% & 15cm show better dimensional accuracy compared to other composites. The dimensional accuracy of all drilled holes of all the hybrid composite specimens with all fiber content and length during drill hole analysis was also almost in same level. From this study, it is identified that the wear resistance and drill hole profile of short roselle and sisal fiber hybrid polyester composite is mainly dependent upon the fiber content of roselle and sisal fibers than that of the fiber length.

Keywords: *Hybrid composites, Polymer-matrix composite, Wear resistance, Dimensional accuracy of drilled holes.*

1. Introduction

Nowadays, as society begins to recognize the importance of utilizing renewable bioproducts that are beneficial to the environment, focus is beginning to return to natural fibers composite materials. Natural fibers such as flax, kenaf, hemp, jute, and sisal have the potential to act as replacements for glass fibers reinforcements in polymeric composites. They were emerging as realistic alternatives to glass-reinforced composites in many applications [1]. The advantages of the natural fibers were low density, high toughness, comparable specific strength properties, reduction in tool wear, ease of separation, decreased energy of fabrication, and carbon dioxide neutrality [2]. Natural fibers have many properties which make them an attractive alternative to traditional materials and have high specific properties [3-6]. In addition, they were available in large amounts [7], and were renewable and biodegradable. Other desirable properties include less skin and respiratory irritation [8], vibration damping [3, 4], and enhanced energy recovery [8, 2]. Mechanical Properties of injection-molded isotactic polypropylene and roselle Fiber Composites were investigated [9]. Even though a number of researches were going in the natural/glass hybrid composite materials, most of the researchers mentioned in the references suggest the replacement of the glass fibers with natural fibers due to environmental considerations. The long vegetable fibers like jute, mesta, roselle, flax, banana, and pineapple leaf fiber, ramie, sisal, manila etc. have wide textile uses. Mesta and roselle fibers were mainly used as substitutes for jute fiber to produce coarse type jute bag or twine. Sisal and manila fibers were very coarse in nature. High dry and wet strength, along with high flexural and torsional rigidity restrict their application to the cordage industry [10]. Both the strength and stiffness of short fiber composites mainly depends on fiber concentration, fiber lengths, fiber-matrix adhesion, as well as fiber orientation and dispersion [11]. Some hybrid composites with different types of natural fibers have been obtained as given in Table 1.

Though the fiber reinforced composites are produced as a commercial product by suitable fabricating technique, they further require certain machining operations like finishing, trimming, drilling, and grinding. In the recent years, the widespread use of composites and the need for joining them has meant that there is an increasing demand for machining of composites. Machining of fiber reinforced composites

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involves the removal of any extra or unwanted materials. The characteristics of the composites materials determine how they behave during machining. There are various new methods available for machining of fiber reinforced composites in various industries. The wear resistance and drill hole analysis was very essential to obtain the end product for any type of composite material. The drill hole was made in the fiber composite material by using 2 mm HSS drill bit. 30 holes were drilled on composite materials. One banana and a glass fiber composite, show better dimensional accuracy than other fiber composites [1]. The effects of increasing cutting speed ranging from 9550 up to 38650 rpm on hole quality, thrust force, torque and tool wear were studied for glass fiber-reinforced composite materials using both multifaceted drill and twist drill [18]. The quality of the drilled holes such as waviness and roughness of its wall surface, axial straightness and roundness of the hole cross-section can cause high stresses on the rivet, leading to its failure [19]. Wear tests were performed by applying a constant load of 0.5N on the composite specimen against a rotating abrasive wheel at dry sliding condition. It was concluded that the sisal fiber reinforced composite exhibits more wear resistance [20]. Wear test was performed by applying a constant load on the natural fiber composite specimen against a rotating abrasive wheel at dry sliding condition. The weight loss of the specimen at three intervals such as 3, 6 and 9 min were observed. Wear resistance of the banana and sisal hybrid composites were found to be good [21]. This investigation is started in roselle and sisal fiber hybrid polyester composite with aim of above mentioned. Besides, there is no previous report on the wear resistance and drill hole analysis of short roselle and sisal fiber filled polyester hybrid composite to the best of our knowledge. In the present work, short roselle and sisal fibers were used as reinforcements to polyester–based matrices. The effects of fiber content and length on the wear resistance and drill hole analysis of short roselle and sisal fiber reinforced hybrid polymer composite were investigated.

2. Experimental Details

2.1 Materials and processing

The commercially available roselle and sisal fibers with dry condition were taken as reinforcement fillers. The matrix material used in this investigation was based on commercially available polyester, Trade name Satyan Polymer supplied by GV Traders. Methyl ethyl ketone and Cobalt were used as accelerator and catalyst respectively. An accelerator of 20 drops was added along with 12 drops of catalyst for curing. In this work, the hybrid composite consisted of roselle and sisal fibers / polyester where the fibers content and length was varied. The fibers contents were set at 10%, 20% and 30% weight of the matrix. The fiber length is 10cm and 15cm respectively. The balance of the mixture was made up of the unsaturated polyester to give a total weight batch size of 100%. This fiber content and length was chosen to observe the effect of fiber content and length on the wear resistance and dimensional accuracy of drill hole. The roselle and sisal fiber were evenly arranged in a mould measuring 360 mm x 360 mm x 3 mm. The resin was degassed before pouring and air bubbles were removed carefully with a roller. The closed mould was kept under atmospheric pressure for 24 h. The samples were cured at room temperature for 24 h followed by a post curing in an oven at 30°C. The composites were fabricated in the form of flat sheets of thickness 3 mm. The physical appearance of short roselle/sisal fiber polyester hybrid composite material is shown in Fig. 1.

Table 1: Natural Fiber Hybrid Composites

S.No	Composites	References
1	Banana/sisal Polyester hybrid composites	[12]
2	Jute/cotton Novolac hybrid composites	[13]
3	Sisal/oil palm Natural rubber hybrid composites	[14]
4	Cotton/kapok Polyester hybrid composites	[15]
5	Ramie/Cotton Polyester hybrid composites	[16]
6	Kenaf fibers/wood flour hybrid polypropylene composite	[17]

2.2 Material characterization

For wear test, the rectangular specimen of 5.5 cm x 4.5 mm was slid against a rotating abrasive wheel at dry sliding condition. A constant load of 0.5 kg was applied during the wear test for all the samples. The weight loss was measured at the specified time intervals of 4, 8 and 12 minutes. In drill hole analysis, the holes are made on the composite materials using 8mm HSS drill bit. The magnified hole diameter was analyzed in different orientation. The holes were selected randomly and their average diameter was measured for both cases.

SEM studies were carried out in detail on the wear tested surfaces of roselle/sisal/polyester hybrid polyester composites using scanning electron microscope (SEM) (Model Hitachi S-3000N). The dimensional accuracy of drilled holes of the composites was studied using Profile Projector OPTO-MET VSS-24DP and Machine Vision Inspection System with RAPID I software.

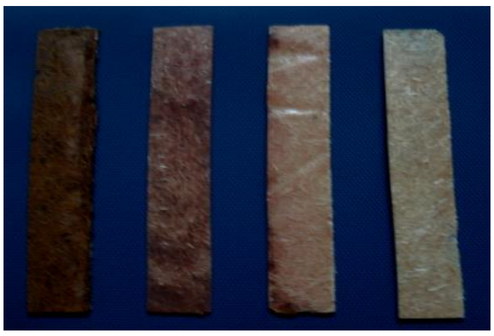

Fig.1 Physical Appearance of Short Roselle/Sisal Fiber Hybrid Polyester Composite

3. Result and Discussion

Fig. 2 and 3 shows the effect of fiber content and length on wear resistance of the roselle and sisal fiber hybrid polyester composite materials. The composites with 30 wt% fiber content are found to be better wear resistance in both 100 and 150 mm fiber length as shown in Fig. 2 and 3. Interestingly, the same level of weight loss was observed in the composite with 30 wt% & 100 mm and 30 wt% & 100 mm at the wear test time of 4 min. The composite with 10 wt%, 20 wt% and 30 wt% & 150 mm showed a better wear resistance compared to the composites with 10 wt%, 20 wt% and 30 wt% & 100 mm. Gradual weight loss was observed in all the cases. It was identified that the wear resistance of roselle and sisal fiber hybrid polyester composite mainly depends upon the fiber content of the roselle and the sisal fibers than that of the fiber length. There was no fiber pull-out from the surface of the composites during test as shown in SEM Fig. 5. It was also identified that the bonding strength between the fibers and matrix materials were in better condition. SEM image of the wear tested surface of the composite specimen is shown in Fig. 5.

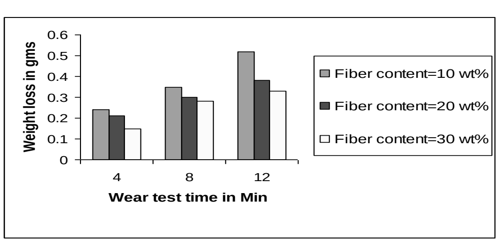

Fig. 2 Weight Loss of the Composites with 100 mm Fiber Length in Wear Test

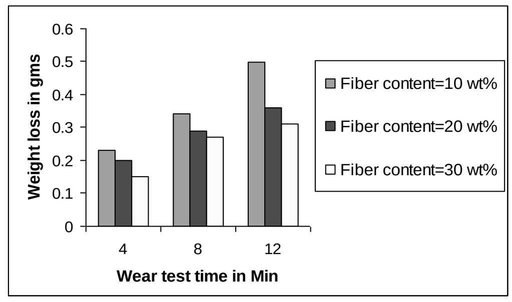

Fig. 3 Weight Loss of the Composites with 150 mm Fiber Length in Wear Test

In many industry applications, drilling operation is considered as a common machining process. In machinability study of the natural fiber composite materials, drilling is centrally a critical operation because the generated forces can lead to widespread damage. The major damage is certainly the delamination that can occur both on the entrance and exit sides of the work piece. This damage causes not only the aesthetic problems but also compromise of the mechanical properties of the finished part [22]. The damage level of delamination is mainly related to the machining parameters and the type of material drilled.

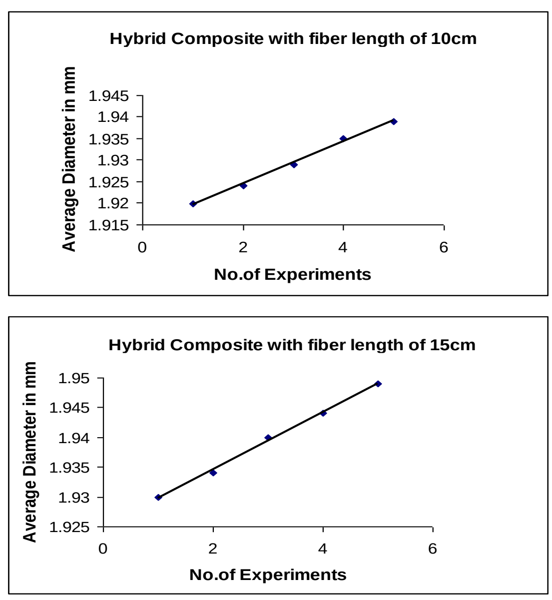

Fig. 4 Average Diameter of Drilled Holes of the Composites with 100 and 150 mm Fiber Length in Wear Test

The average diameter of the drilled holes of the roselle and sisal fiber hybrid polyester composite is shown as Fig. 4. The hybrid composite with 30 wt%

&100 mm re-bounces in small amount and the hole size gets reduced. The composites with 30 wt% & 150 mm show more elastic re-bounce than other composites. The hybrid composite specimen with 20 wt% &150 mm show better dimensional accuracy than other composites specimens. It is also identified that the dimensional accuracy of drilled hole of roselle and sisal fiber hybrid polyester composite is mainly depends upon the fiber content of the roselle and the sisal fibers than that of the fiber length. Machine vision image of drill hole profile of hybrid composite is shown as Fig. 6.

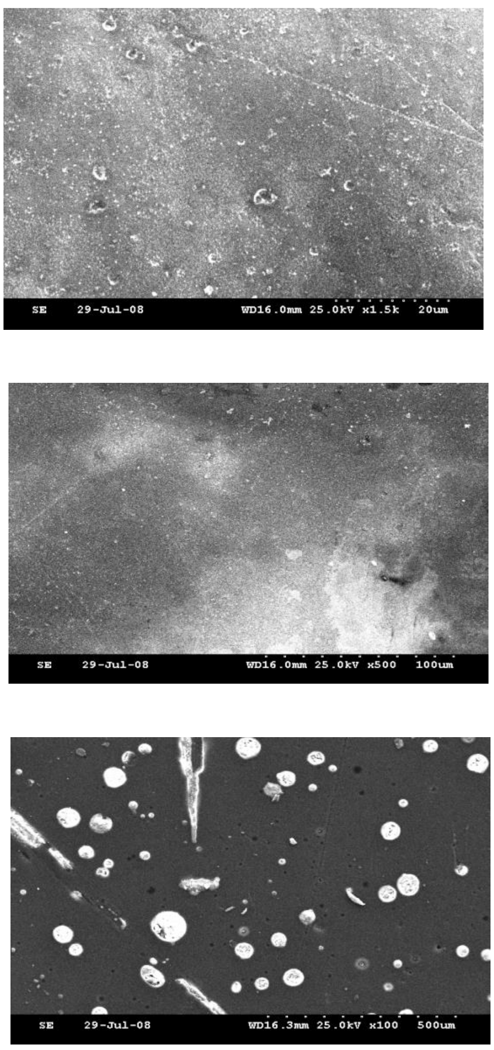

Fig. 5 SEM Image of the Wear Tested Image of the Surface of Roselle and Sisal Fiber Hybrid Polyester Composite with 30 Wt% & 10 cm and 30 Wt% & 15 cm

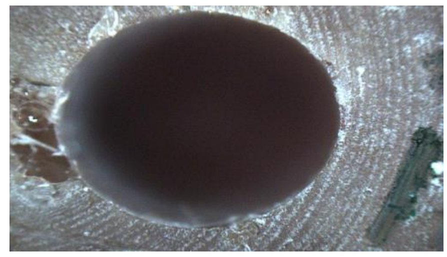

Fig. 6 Machine Vision Image of Drilled Hole of the Hybrid Composite Specimen with 20 wt% &10 cm

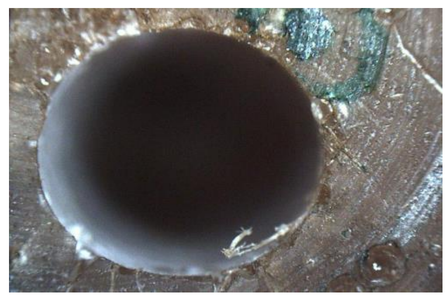

Fig. 7 Machine Vision Image of Drilled Hole of the Hybrid Composite Specimen with 20 wt% &15cm

4. Conclusion

In the present contribution reports that the composite with 30% fiber content composites showed good wear resistance in both cases. However, the composite specimen with fiber content 20% show better dimensional accuracy when compared to other fiber content composites in both cases. Finally, this study gives an conclusion that the wear resistance and drill hole profile of roselle and sisal fiber hybrid polyester composite is more depends upon the fiber content than the fiber length of roselle and sisal fibers.

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