Ilkogretim Online - Elementary Education Online, 2021; Vol 20 (Issue 4): pp.4322-4328
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.04.465

Experimental Analysis Of Hardness And Wear Behaviour Of Walnut Shell Filler, Chopped Glass Fiber Reinforced Polyester Composite

Lalit Ranakoti * , **Dr Rajesh Kumar Upadhyay****

*Department of Mechanical Engineering, Graphic Era deemed to be University, Dehradun, Uttarakhand, 248002lalitranakoti.me@geu.ac.in

**Professor, School of Management, Graphic Era Hill University Dehradun, Uttarakhand, 248002

Abstract

In order to analyses the reinforcing effect of walnut filler, the present article deals with the variable walnut filler loading in chopped glass fiber-polyester composite. Cleaning and removing of dirt from walnut was performed before reinforcing. Grinding of walnut shell was carried out in the grinder to transform it in required size. Hand lay-up method was employed in fabricating the composite samples The composite samples were characterized for Vickers hardness and specific wear. The obtained results were fruitful not only in increasing the hardness but also reducing the specific wear rate. The optimized walnut filler loading was obtained at 15 wt. %.

Introduction

The inclusion of two or more reinforcement in a common polymer is generally termed as hybrid composite. Various types of matrices are used to reinforced fiber/filler such as metal, polymer and ceramics. The reinforcement of the fillers can be executed in one or many forms for example one filler and fiber or may be more fibers or fillers [1]. The hybridization offers a wide range of advantages in the field of composite materials and opens a new space for advanced engineering applications. Most influential factors that play important role in deciding the resultant properties of composites are fiber matrix adhesion, types of fibers, surface treatment, matrix used and technique used in the manufacturing [2]. On the contrary, weak interfacial adhesion among the fillers, fibers and matrix leads to detachment of surface materials by the action of rubbing, abrasion, deformation and fatigue when subjected to external load [3].

Polymer composites are now being subjected to many applications for e.g., mechanical systems like gear, wind turbines equipments, automotive components etc. undergoing wear and abrasions [4-6]. The continuously contacting surfaces degraded the material and consequently leads to formation of cracks and fracture. In recent decades, the polymer composites are finding its space in tribological applications which is being perceived as an alternative to metallic and alloy family [7]. The inclusion of synthetic filler

in polymer composite has been practiced for decades which is now due to many concerns like environmental, societal and economic problems, Industries are now looking for an environmentally friendly product [8]. Natural filler-based polymer composites are in greater demand for tribological applications due to its various advantages like friendly to nature, easy in inclusion during fabrication, good affordability and easy availability. In addition, filler-based polymer composites are less dense thus resulted in light weight. For the point of view of its tribological application natural filler polymer composites are good in abrasion resistance, higher damping capability and can undergo self-lubrication during service [9]. It has good deformability properties that is another advantage sum up in the earlier discussed.

The utilization of natural fillers in polymer composite have been much studies in recent times aiming for the possible tribological sustainable materials [10]. Several kinds of natural fillers are reinforced in polymer viz: rice husk, wheat husk, coconut shell filler, almond shell filler, walnut shell filler and this list is never ending [11]. Among all walnut shell filler has greater advantage over others in wear applications due to its hard surface characteristics. In addition, its low moisture content helps in strong bond formation [12]. A fair amount of literature has been reported in last few years describing the effect of walnut filler on the wear characteristics of polymer composites. Green composite fabricated with poly vinyl ester was analyzed for sliding wear behaviour and reported that inclusion of walnut filler greatly helps in reducing contact friction between the mating surfaces at varying load and velocity [13]. At higher walnut filler loading (40 wt. %) in polypropylene lead to significant drop in the wear and 5 % improvement hardness [14]. The surface modification of epoxy for enhanced wear characteristics can be achieved by walnut filler [15]. Walnut shell filler-based composites have shown good properties for brake friction pad composites with the purpose of eliminating the synthetic filler and reported that addition of walnut has produce fruitful results in polymer for enhanced wear resistance [16]. The effect of walnut filler in glass fiber reinforced polymer composite also showed good interaction within the hybrid composite and resulted in improved surface wear characteristics. Therefore, the present study sticks to the analysis of hardness and specific wear of walnut shell filler reinforced glass fiber polyester composite. Glass fiber in chopped form with polyester resin and walnut shell filler with mesh size ranging from 250-300 microns fabricated by conventional open had lay-up method and characterized for Vickers hardness and specific wear rate.

Material

Walnut is a natural fruit fiber with a huge availability in the State of India. The walnut shells were cut into small pieces by using hammer. These small pieces were then grounded into powder form using an iron mortar and domestic grinder machine. The collected powder was then sieve shaker to microns of size averaging 250-300 microns by using the sieve shaker. Glass fiber from Laxmi polymer was brought in the form of mat in bidirectional form. It was cut into a short fiber of size 5 to 8 mm for the purpose of reinforcement in matrix. The polyester resin with suitable accelerator was purchased

from AmTech Ester Pvt. Ltd. Delhi. The matrix, fibers and fillers for the fabrication of hybrid composites are shown in figure 1.

(a) (b) (c)

Figure 1. Showing (a) Chopped glass fiber, (b) grounded walnut filler and (c) polyester resin

Composite fabrication

A very effective and conventional technique called hand lay-up method was skilfully used to fabricate the composite on a wooden box of size 150 x 150 x 4 mm. Post fabrication, the easy felicitation of composites panel was achieved by using mylar sheets above wooden box. A spray was applied at inner side of mylar sheets to avoid sticking of mylar sheets with panels.

Mixed walnut filler and polyester resin was poured over the glass fiber placed over the lower wooden box. Then, the composition was covered by mylar sheet and then by upper half. On top of all, a gradual load of 25 kg was placed and let it cured for 20 hours, The composite was removed and cut in the desired shape for the testing. The process was repeated at variable loading of walnut filler.

Table 1. designation and loading ratio of reinforcement of matrix

Sr. No.	Designation	Weightage of reinforcement and matrix
1	C0	90 wt. % polyester, 10 wt. % glass fiber and 0 wt. % Walnut filler
2	C1	80 wt. % polyester, 10 wt. % glass fiber and 10 wt. % Walnut filler
3	C2	75 wt. % polyester, 10 wt. % glass fiber and 15 wt. % Walnut filler
4	C3	70 wt. % polyester, 10 wt. % glass fiber and 20 wt. % Walnut filler

Characterization of composites

The samples characterized for Vickers hardness was cut in the dimension of 10 mm × 10 mm × 4 mm sharpened, polished with accuracy. The test was conducted in digital Vickers

hardness machine as per ASTM E 92 standard. The indenter used was having apical angle of 136^0 of diamond material.

A three-body abrasive wear tests were performed on dry sand rubber/wheel abrasion tester as per ASTM G 65 test standards. The conditions maintained was time = 10 minutes, at two different loading conditions that is, 51 N and 75N. a précised electronic balance machine was used to measure the specific wear as per following equation given below.

$$W_S = \frac{\Delta V}{F_N \times S_S} \qquad \frac{mm^3}{Nm} \qquad \text{Eq. (1)}$$

Where W_s = Specific wear rate (mm^3/Nm), ΔV = Volume loss (mm^3), S_s = Sliding distance (m) and F_N = Normal load (N).

Results and discussion

Influence of walnut filler on Vickers hardness of composite

The figure 2 clearly explain the influence of walnut filler on the Vickers hardness of glass fiber polyester composites. With no loading of walnut filler, the composite itself was observed to behave like a hard material due to the inclusion of glass fiber. However, loading of walnut filler has positive effect on the hardness of the composite. The optimised loading of walnut filler was found to be 15 % at which the values of hardness was highest i.e., 18.87 HV among all loading. The hardness reduced at 20 wt. % of walnut loading and declined to 15.88 HV. It is recommended to reinforced walnut filler in composite material because it performs well against the indentation due to high tenacity of walnut filler. The bonding between the cellulosic filler and polymeric chain of polyester was enhanced and shown effective resistance against the indentation of composite.

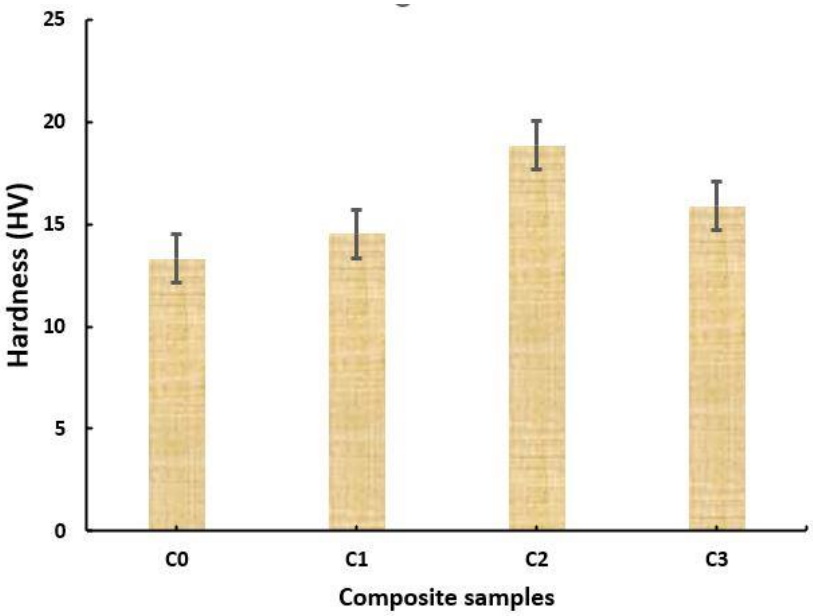

Figure 2. Vickers hardness of composites

Influence of walnut filler on specific wear rate of composite

As depicted in figure 3, the effect of walnut filler on the specific wear of composite was found to be reduced significantly. At 0 wt. % of walnut filler loading, the specific wear rate was highest at both normal load (75 N and 51 N).

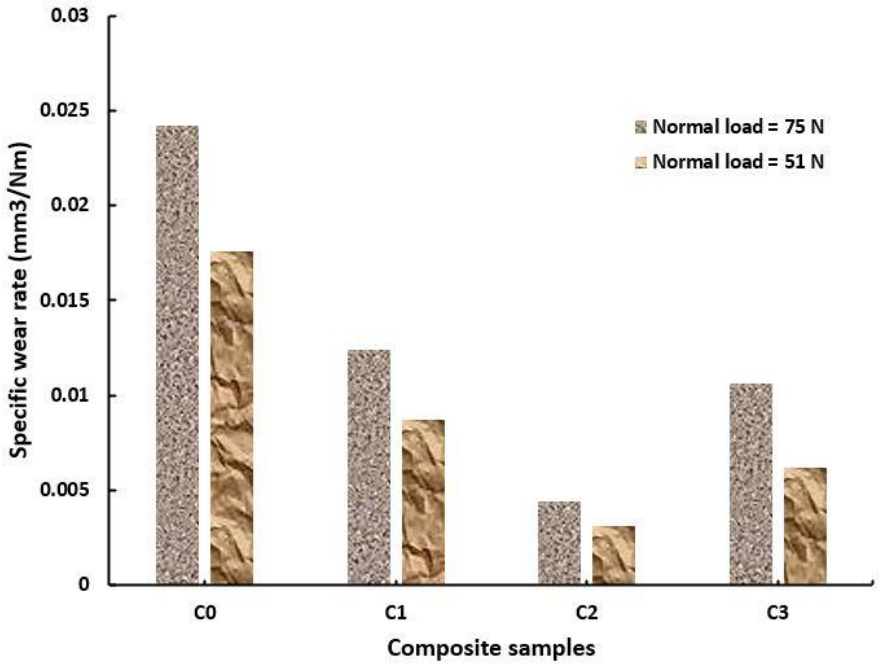

Figure 3. Specific wear rate of composites

Upon loading 10 wt. % walnut filler the specific wear reduced of noteworthy value, and with 15 wt. % addition of walnut filler, the specific wear observed the lowest among all composite. It was observed that, the walnut filler loading at 20 wt. % promote the specific wear as compared to C2. It may be due to the large agglomeration of walnut filler at the outer surface of composite leading higher wear of composites. The normal load also showed significant effect on the specific wear since, at every walnut filler loading, the specific wear was higher for the case of 75 N normal load as compared to case of 51 N normal load.

Conclusion

A hybrid composite comprising fixed chopped glass fiber with variable walnut filler loading in polyester resin was successfully developed by hand lay up method and tested for Vickers hardness and specific wear rate. The inclusion of walnut filler promotes hardness to composite and also helped in reducing the specific wear of composite. It was also perceived that the normal load effects largely on the specific wear since at higher normal load, the specific wear was increased. The optimum filler loading at which highest hardness and lowest wear rate obtained was at 15 wt. % of walnut loading.

Reference

1. Gangil, B., Ranakoti, L., Verma, S., Singh, T., & Kumar, S. (2020). Natural and synthetic fibers for hybrid composites. Hybrid Fiber Composites: Materials, Manufacturing, Process Engineering, 1-15.
2. Khare, J. M., Dahiya, S., Gangil, B., & Ranakoti, L. (2021). Influence of different resins on Physico-Mechanical properties of hybrid fiber reinforced polymer composites used in human prosthetics. Materials Today: Proceedings, 38, 345-349.
3. Singh, T., Pattnaik, P., Aherwar, A., Ranakoti, L., Dogossy, G., & Lendvai, L. (2022). Optimal Design of Wood/Rice Husk-Waste-Filled PLA Biocomposites Using Integrated CRITIC–MABAC-Based Decision-Making Algorithm. Polymers, 14(13), 2603.
4. Lalit, R., Mayank, P., & Ankur, K. (2018). Natural fibers and biopolymers characterization: a future potential composite material. Strojnícky časopis-Journal of Mechanical Engineering, 68(1), 33-50.
5. Ranakoti, L., Gangil, B., Mishra, S. K., Singh, T., Sharma, S., Ilyas, R. A., & El-Khatib, S. (2022). Critical Review on Polylactic Acid: Properties, Structure, Processing, Biocomposites, and Nanocomposites. Materials, 15(12), 4312.
6. Ranakoti, L., Rakesh, P. K., & Gangil, B. (2021). Revue des Composites et des Matériaux Avancés-Journal of Composite and Advanced Materials. Journal homepage: http://iieta. org/journals/rcma, 31(2), 81-92.
7. Rakesh, P. K., & Ranakoti, L. (2019). Friction and Wear Analysis of Reinforced Polymer Composites. Reinforced Polymer Composites: Processing, Characterization and Post Life Cycle Assessment, 105-118.
8. Mishra, S. K., Dahiya, S., Gangil, B., Ranakoti, L., & Agrawal, N. (2021). Mechanical properties of fibre/filler based poly (Lactic Acid)(Pla) composites: A brief review. Acta Innovations, 41, 5-18.
9. Ranakoti, L., Gupta, M. K., & Rakesh, P. K. (2019). Analysis of mechanical and tribological behavior of wood flour filled glass fiber reinforced epoxy composite. Materials Research Express, 6(8), 085327.
10. Paul, R., Gouda, K., & Bhowmik, S. (2021). Effect of Different constraint on tribological behaviour of natural fibre/filler reinforced polymeric composites: A review. Silicon, 13(8), 2785-2807.
11. Omrani, E., Menezes, P. L., & Rohatgi, P. K. (2016). State of the art on tribological behavior of polymer matrix composites reinforced with natural fibers in the green materials world. Engineering Science and Technology, an International Journal, 19(2), 717-736.
12. Dobrzyńska-Mizera, M., Knitter, M., & Barczewski, M. (2019). Walnut shells as a filler for polymeric materials. Drewno: prace naukowe, doniesienia, komunikaty, 62(203), 153-168.
13. Pashaei, S., & Hosseinzadeh, S. (2017). Sliding wear behaviour of walnut shell powder filled vinyl Ester/WSP green composites. Quarterly Journal of Iranian Chemical Communication, 5(2, pp. 121-236, Serial No. 15), 138-146.
14. Moustafa, N. M., Mohammed, K. A., Al-Ameen, E. S., Ogaili, A. A. F., & Al-Sabbagh, M. N. M. (2020). Mechanical and tribological properties of walnut/polypropylene natural

composites. Journal of Mechanical Engineering Development Research, 43(4), 372-380.
15. Shejkar, S. K., Agrawal, B., Agrawal, A., & Gupta, G. (2022). Physical, mechanical, and sliding wear behavior of epoxy composites filled with surface modified walnut shell particulate. Polymer Composites. https://doi.org/10.1002/pc.26847
16. Qi, S., Fu, Z., Yun, R., Jiang, S., Zheng, X., Lu, Y., ... & Prikasky, M. (2014). Effects of walnut shells on friction and wear performance of eco-friendly brake friction composites. Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, 228(5), 511-520.