Erosion Wear Characteristics on Aroma Skin and Biochar Filled Polyester Composites

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Abstract:This work focused on erosion behaviour of pure polyester, aroma skin (5wt%) and biochar (7.5wt%) reinforced polyester composites. The hand-layup method is used to develop the composite plate. To investigate the erosion wear rate of the developed composite plates, the sized specimen is subjected to erosion studies. As per ASTM G76 the erosion test was done with the help of air jet erosion tester. To study the parameters of different reinforcement, impingement angle and impact velocity of the fabricated specimen. The erosion behaviour of particulate reinforced polyester composites is evaluated at two different reinforcement (aroma skin and biochar) and three different wt% (0wt%, 5wt% and 7.5wt%) at varying impingement angles (30^o, 45^o, 60^o and 75^o) for regular time intervals. The standoff distance, impact velocity and erodent discharge rate were kept constant. Alumina oxide is used as erodent material with the size of 50µm. From the result, it is observed that increase in impingement angle increase the erosion rates. Another observation is made that addition of reinforcement in matrix material also shows increase in wear rate of composite. In comparison of both aroma skin and biochar reinforced polymer composites, biochar enhances the erosion resistance of composite in all impingement angles.

Keywords* : *Aroma skin, Biochar, Polyester resin, Hand-layup, Erosion wear.

I. INTRODUCTION

In recent trend towards erosion wear performance of polymer composites by eroding the particle with various angles of impingement and impact velocities strike the material and damage the top surface which leads to material loss and changes in functional behaviour [1], [2]. Fibres and inorganic fillers are added in poly phenylene sulphide (PPS) which enhances the tribological properties [3], [4]. The erosive wear behaviour of fibre and particulate based polymers has not much investigated [5], [6]. Particle size, particle shape, velocity and impingement angle are some of the parameters to be consider in solid particle erosion test [7]. The friction and wear behaviour was studied in PEEK composites reinforced with fibre and particulate [8], [9]. Mahapatra et al. reported that increase in erosion rate of glass fibre reinforced composites is mostly due to impact velocity [10]. Suresh et.al studied that short fibre reinforced PEK composites with varying wt% shows ductile nature in different impact velocity and impingement angle. The erosion wear is increase with increase in wt% of fibre and maximum at 30^o impingement angle [11]. Sınmazcelik and Taskıran reported that the random orientation of short fibre and mineral powder based PPS composite with changes in impingement angle and impact velocity shows semi ductile nature. The rate of erosion is maximum at 60^o impingement angle [12]. Srivastava studied that the erosion rate is minimum in 2g wheat flour filled GFRP [13]. The erosion performance of sheep wool reinforced polyester composites has not yet reported in the literature.In this present work, aroma skin and bichar reinforced polyester composites were selected as test specimen. The erosion performance of these composites were studied with constant standoff distance, impact velocity and erodent discharge rate and at varying wt% of reinforcement and impingement angles.

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II. EXPERIMENTAL DETAILS

A. Materials

In this work aroma skin and biochar was chosen as reinforcement material and polyester resin as matrix material. The polyester resin and additional ingredients (MEKP & CN) as catalyst and accelerator were brought from VB Pvt. Ltd., Chennai, Tamil Nadu, India. The Collected aroma skin and biochar contains dust particles and moisture content, it was removed by conventional method and dried at room temperature. Dried aroma skin and biochar is processed in ball mill to reduces the size. The processed aroma skin and biochar is sieved and the collected particles are in powder form in the range of 90-150µm for fabrication of composite.

B. Fabrication of Composite

To develop the composites, polyester resin as matrix, aroma skin and biochar are used as reinforcement material. By using hand-layup method the composite plates are developed. Initially, the glass mould is cleaned and applying wax over surface of the mould for easy removal of fabricated composite. 2%MEKP and 2%CN as catalyst and accelerator is stirred properly in the polyester resin followed by reinforcing material (aroma skin) and poured on the mould cavity. Finally the mould is closed and compressed conventionally. Composites of two different wt% (5wt% and 7.5wt%) as aroma skin and biochar reinforced polyester composite are prepared by using the same procedure. For proper curing, the castings are put under a constant load for 24 hours at room temperature. The fabricated composite is cut into suitable dimensions for erosion test as per ASTM standards.

The process flow for this work is shown in Fig. 1 and the developed composite is shown in Fig. 2. The detailed wt% of reinforcement for the erosion test is shown in Table I and the testing parameters to conduct erosion studies is shown in Table II.

Fig. 1. Fabrication process

Fig. 2. Fabricated composite

Table- I: Detailed composition of the specimen

Composite	Composition
CP1	Pure Polyester
CP2	Polyester+5wt% aroma skin
CP3	Polyester+7.5wt% biochar

Table- II: Erosion Test Parameters

Fixed parameters		Variable parameters	
Erodent material	Alumina oxide	Time (mins)	2,4,6…60
Particle size of erodent (µm)	50	Reinforcement (wt%)	PP, 5wt% AS and 7.5%BC
Velocity of impact (m/s)	100		
Erodent discharge rate (g/min)	3.3		
Testing Temperature	RT	Angle of impingement (α, °)	30, 45, 60 and 75
Standoff distance (mm)	10		
Diameter of nozzle (mm)	3		

III. RESULT AND DISCUSSION

From the researchers investigations impact velocity, impingement angle, erodent size, shape, hardness and discharge rate, standoff distance and time have an important effect on erosion wear rate. This effect shows that a variation depends upon the testing of materials as ductile, brittle or semi-ductile. For brittle and ductile materials the erosion rate is maximum at an impingement angle of 15-20^{o} and 90^{o} and for semi ductile materials it was found that the erosion rate is maximum at angle of 45-60^{o}. The delamination of fibres on surface of the materials is stop easily when increasing the erodent flow. The fact is increasing the striking speed of particle on the surface of material is the most important factors which leads to increase in wear rates, changing the angle of impingement should possess less wear rate as compare to speed variation. Besides striking speed, impingement angle and varying the size of erodent plays a vital role in increasing the rate of erosion. But, the effects of changes in direction of fibre leads to less wear rate when compared to other factors.

The most important parameters which influence erosive wear are impingement angle, impact velocity, erodent size, shape and discharge rate, standoff distance and time. The sequence of damage in fibre reinforced polymers due to erosive action. At the initial stage, material removal takes place in resin rich zones, further action which leads to breakage of fibres and laterally the fibre and matrix bond was damaged due to erosion.

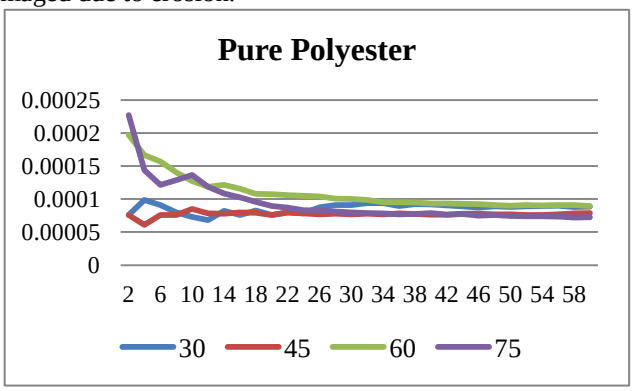

Fig. 3. Pure polyester

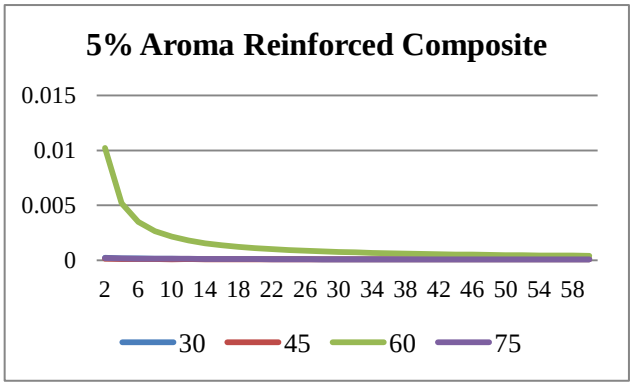

Fig. 4. 5% Aroma Reinforced Composite

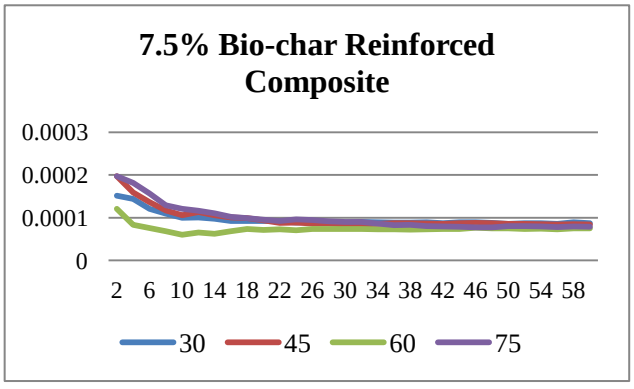

Fig. 5. 7.5% Bio-char Reinforced Composite

From the above figures it clearly shown that the maximum erosion rate is occurs at an impingement angle of 75^{o}for pure polyester resin.

While we adding the reinforcement of aroma coffee skin with 5wt% the erosion rate is maximum at 60°and we adding the reinforcement of biochar with 7.5wt% the maximum erosion rate is takes place at an impingement angle of 45 and 75°.

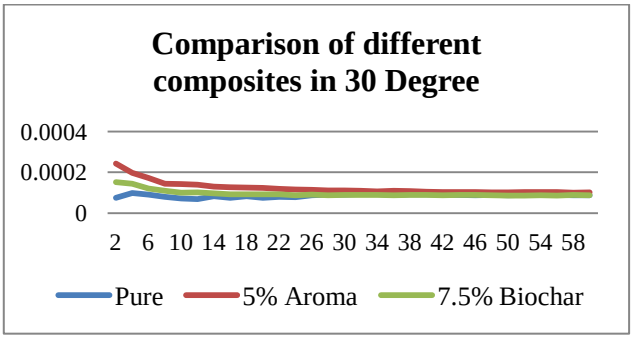

Fig. 6. Comparison of different composites in 30 Degree

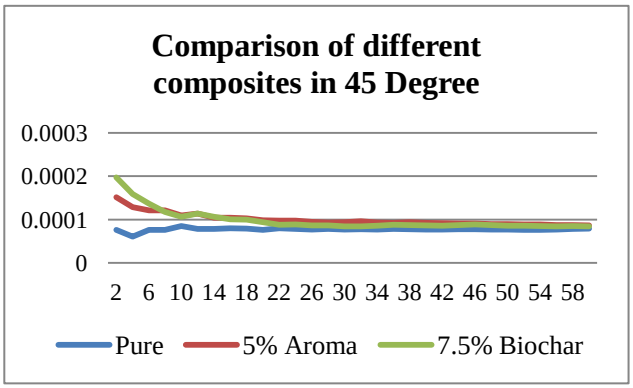

Fig. 7. Comparison of different composites in 45 Degree

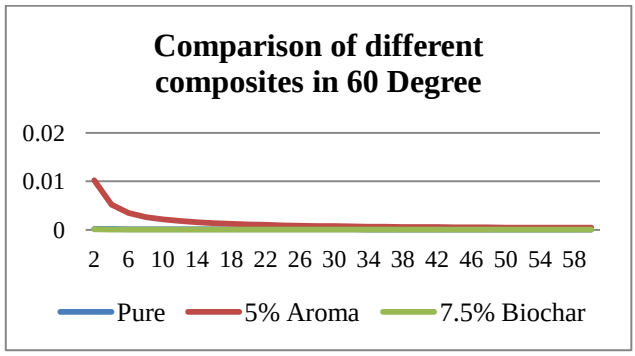

Fig. 8. Comparison of different composites in 60 Degree

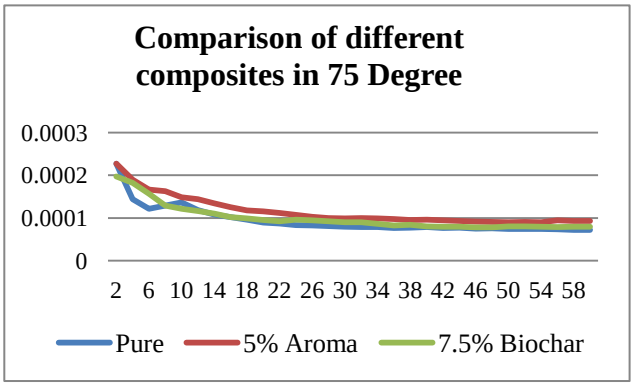

Fig. 9. Comparison of different composites in 75 Degree

A comparison graph is plotted for four different angles (30, 45, 60 and 75) with varying wt% of the composites (Pure, 5wt% Aroma and 7.5wt% Biochar). From the comparative graphs it is understand that the erosion rate of 5wt% aroma is maximum at an impingement angle of 30°. At the angle of impingement is 45° the maximum erosion rate is occurs in 7.5wt% of biochar. The erosion rate for 5wt% of aroma is maximum at an angle of 60° and the maximum erosion rate is takes place at an angle of 75° for pure polyester resin and 5wt% of aroma.

IV. CONCLUSION

The following conclusions are made for the erosion performance of sheep wool reinforced polyester composites.

1) Fabrication of particulate reinforced polyester composites consisting of aroma and biochar as reinforcement in polyester resin is possible in simple hand lay-up technique.
2) Increases the wt% of particle reinforcement significantly alter the erosion performance of the composites.
3) Increases the angle of impingement increase in wear rate of the composite.
4) The erosion wear performance of polyester composites improves with the incorporation of particulate fillers. Among the three different weight percentage (Pure, 5wt.% aroma and 7.5wt.% biochar) 7.5wt.% biochar gives the better erosive wear resistance in all impingement angles when compare to other composites.
5) Erosion wear behaviour of these composites improves with addition of biochar reinforcement. It may be recommended for the application of light weight vehicles because of its nature as biodegradable and eco-friendly.

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Mr. J. Manivannan completed his B.E. Mechanical Engineering in K.S.Rangasamy College of Technology, Tiruchengode. He has completed his M.Tech (CAD/CAM) in Kalasalingam University, Krishnankoil. He is serving as Assistant Professor in same institute and doing his research as part time mode. His area of research as performance studies on polymer matrix composites. He has published 4 Journal papers (Impact Factor and Scopus Indexed) and more than 15 International Conference papers.

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