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Investigation of Erosion Effect on Surface of Basalt Fibre Reinforced Polymer Composites

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ABSTRACT

In the present study the erosion behavior of basalt fibre reinforced composite was studied. Slurry pot erosion test were conducted on the composite samples with 30%, 40% 50% and 60% reinforcement. Slurry concentration, speed and contact angle were considered as the parameters. The sand particles from the range of 212, 425 and 600μm were suspended in the water. The results revels that the slurry erosion was found to be increased with slurry concentration and the turning speed. The impact angle with 900 has the major influence on the erosion. The highest mass loss due to erosion is found in the sample with 30% reinforcement and the minimal mass loss due to erosion is found in the sample with 60% reinforcement.

Keywords : Slurry Erosion, Composite Material, Basalt fibre, Green material.

IV.INTRODUCTION

A composite material combines two or more components to provide a special set of qualities. The components are mixed together on a macroscopic scale yet are not soluble in one another. Reinforcing phase and matrix phase are two aspects. Composites are materials made of a matrix, a weaker substance, and reinforcement, a strong load-bearing material. The reinforcement offers its matrix phase extra strength and stiffness by occupying it. In an excellent performance composite, fibres take up the greatest space and bear the majority of the applied load. The fibres were enveloped by matrix, which shields them from chemical and ecological impact. The load is transferred to the fibres via the matrix material, which also holds the fibres together. It gives the structure form and stiffness. The fibres are separated by the matrix so that they may each operate independently, this delay or prevents a fracture from spreading. Such composites are chosen for particular owing to its high strength to weight ratio since the matrix shields the reinforcing fibres against chemical assault and structural stress [1]. Due to its elevated attenuation effects and lack of corrosion issues, fibre reinforced polymers have the capability to minimize noise, rattles, and ride severity when used in place of steel, since it has a positive effect on a portion of production costs [2]. Modernistic fibre is crucial for infrastructure projects and serves as a cornerstone for the growth of the focus on high and innovative industries [3]. Modernistic fibre composite material components with free from environmental contamination have been in high demand in recent years.

Basalt rock, a naturally occurring substance included within volcanic rocks made through frozen lava, is the source of basalt fibre, a special product. Since classical era, pulverized rock has been employed in engineering because of the rock's tremendous hardness. This mineral has exceptional tensile, thermal, and durability qualities. Basalt is a metamorphic rock that implies it started off in a melt condition, and is hard, thick natural mineral that is widespread around the world. Basalt had also long been seen in the foundry methods to create mosaics and blocks for use in construction. Moulded basalt tubular plates to steel tubing also have extremely good erosion resistance in industrial settings, the basalt fibre is obtained by heating raw mineral from 1500 °C to 1700 °C and squeezing it through platinum or rhodium pot bushings both fragmented and continuous versions of these fibres are produced.

In case of temperature consistency, sound and thermal attenuation, vibrational tolerance, and longevity, basalt fibre is quite comparable with glass fibre. Additionally, basalt fibre is well-suited to conditions with saltwater and chemical assault. For such characteristics, it provide an excellent replacement for glass fibre like a reinforcing phase, and when paired. The fibre is lower in cost has ability to put back glass fiber variety of industries, including maritime, aviation, and the automobile sectors. These fibres are a great economical option to other elevated resistance to temperature so they can withstand temperatures as low as -200 °C and as high as 700 °C to 800 °C, Temperature barriers, composite reinforcement, and acoustic barriers are common applications[4]. Basalt fibers are resistance to alkaline environment as it can withstand pH up to 13 - 14 and relatively less stability in strong acids. Moisture regains and moisture content of basalt fibers is less than 1% [5]. The slurry erosion is the phenomenon which causes the severe damage to the materials. Typically the slurry includes abrasive particles suspended in in the liquid medium. Slurry erosion increasing now a days due to increase in the number of slurry handling process such as, transport lines for slurries, aeronautical, mining and process industries and thermal and hydroelectric power plants. Slurry erosion behaviour of composite material is widely studied but still there is need to expand the knowledge of wear phenomenon of composite due to its complexity [6]. Use of better erosion resistant material can mitigate the deleterious effect of erosion in such applications. However, the accurate prediction of erosion behaviour of material is very difficult as numerous parameters govern the erosion phenomenon. All these parameters can be broadly classified as impinging variables, particle variables and material variables. The relative importance of these parameters in the systems undergoing erosive wear varies depending on the different flow configurations and their physical characteristics [7].

The table below displays the different characteristics of basalt fibre

TABLE I

Properties of basalt fibre

Density (g/cm^3)	Tensile strength (GPa)	Elastic modulus (GPa)	Elongation at break
2.7	4.85	89	3.15%

V. METHODS AND MATERIAL

When fabricating composite specimens, specific material selection requirements are fundamental. It relies on factors including the material's weight benefits, oxidation resistance, affordability, adaptability, and strength. Bi directional basalt fibres with 200 gsm (woven fabric) were purchased from Nickunj Eximp Pvt Ltd, Mumbai, India. The properties of basalt fibre were shown in Table 1. Polyester resin with density 1.2 g/cc was purchased from MechStore, Bengaluru, India. The current effort involves the synthesis of four distinct basalt fibre reinforced with epoxy resin composite compositions. The specimens were made using the hand layup method. Table 2 displays the various components of the composite specimen.

TABLE III

Different composition of specimens

Sample	S1 (70:30)	S2 (60:40)	S3 (50:50)	S4 (40:60)
Reinforcement	Basalt fibre			
Matrix	Epoxy resin with hardener			

The constant cross section (300 x 300 x 5mm) is selected. The templates (mould die) were made from wood. According to the desired profile, the basalt woven fabrics were cut to the desired size, so that they can be deposited on the template layer by layer during fabrication. This is followed by the uniform application of epoxy resin over basalt fiber. Another layer is layered and epoxy resin is applied and a roller is using for removing all the trapped air. Specimens are prepared with variation of constituent layers according to the calculated weight fraction. After the layers are laid up a teflon layer to which mould releasing agent is applied and kept on a steel plate. Further compaction pressure is applied and allowed for curing at atmospheric temperature for 24 hours then it is taken out.

Figure 1: Fabricated composite with varying composition

A. Slurry erosion test

The erosion test specimen size of 25mm x 25mm x 4mm is fixed with the help of adhesive to stainless steel bolt. The test setup includes a DC motor belt drive and slurry unit. The motor is coupled with a vertical splindle, which has chuck fixed at the end. The samples are placed in a check in the orientation with the impact angle of the abrasion particles.

The motor is connected with the dimmerstat for regulating the speed. To prepare slurry, silica sand of size 212, 425 and 600μm having concentration of 25, 50 and 75 gms/ltr were mixed with water. The samples have been rotated at a velocity of 250, 500 and 750rpm. The samples are measured as a function of weight loss using weighing machine with an accuracy of 0.1mg. The schematic representation of the slurry erosion test setup is shown below.

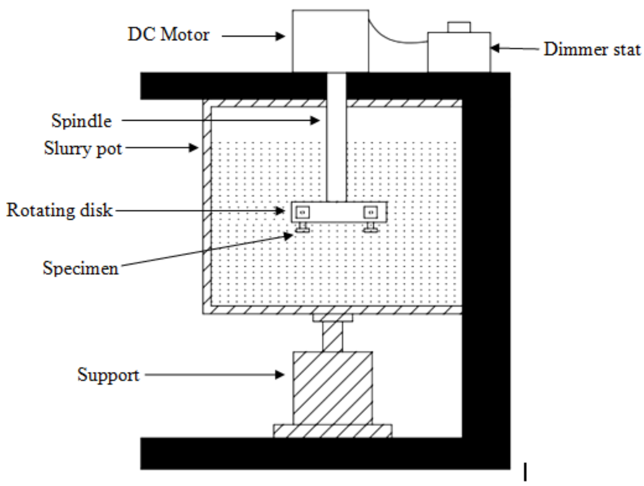

Figure 2 : Schematic representation of slurry pot erosion test setup

Generally laboratory test method is popularly adopted to evaluate erosion resistance of material in which practical conditions are simulated to generate meaningful and reproducible data. Slurry erosion test is a simple and inexpensive test which can provide a rapid ranking of the erosion resistance for different materials. The present slurry pot erosion tester facilitates to handle flat samples. It also allows using slurry with variety in its volume, and concentration and particle size of sand. The much needed uniform distribution of solid particles along the vertical section of the slurry is controlled by the speed of the stirrer [8]. In the present investigation, the effect of stirrer speed on the distribution of sand particles inside the slurry pot is studied for variety of slurry.

VI. RESULTS AND DISCUSSION

The table 3 gives the result of mass loss in composite material due to erosion at an impact angle of 90^0 and table 4 gives the result of mass loss in composite material at an impact angle of 180^0.

TABLE IIIII

Slurry erosion test results of composite specimens at an impact angle of 90^0

Trail No	Speed (rpm)	Particle Size (µm)	Slurry concentration (gms/ltr)	S1	S2	S3	S4
1	250	212	25	0.098	0.095	0.081	0.013
2	250	425	50	0.109	0.106	0.097	0.047
3	250	600	75	0.117	0.114	0.103	0.079
4	500	212	50	0.098	0.096	0.093	0.062
5	500	425	75	0.123	0.119	0.112	0.083
6	500	600	25	0.094	0.089	0.086	0.068
7	750	212	75	0.128	0.121	0.117	0.044
8	750	425	25	0.098	0.096	0.091	0.057
9	750	600	50	0.103	0.099	0.094	0.081

TABLE IVV

Slurry erosion test results of composite specimens at an impact angle of 180^0

Trail No	Speed (rpm)	Particle Size (µm)	Slurry concentration (gms/ltr)	S1	S2	S3	S4
1	250	212	25	0.054	0.023	0.016	0.009
2	250	425	50	0.081	0.073	0.056	0.031
3	250	600	75	0.093	0.089	0.078	0.044
4	500	212	50	0.089	0.082	0.069	0.041
5	500	425	75	0.096	0.086	0.074	0.057
6	500	600	25	0.064	0.051	0.043	0.039
7	750	212	75	0.083	0.079	0.059	0.022
8	750	425	25	0.088	0.084	0.078	0.036
9	750	600	50	0.094	0.071	0.063	0.051

The increase in slurry concentration increases the density of the mixture and hence requires greater energy for the suspension of additional particles. If the energy supplied is not enough then particles tries to settle down [9]. Hence the relative concentration in the lower region of the slurry tank increases and that in the upper region decreases with the increase in slurry concentration. This trend is common for slurries of different particle size.

The patterns of erosive loss for different stirrer speed are as shown in figure 3 and figure 4.

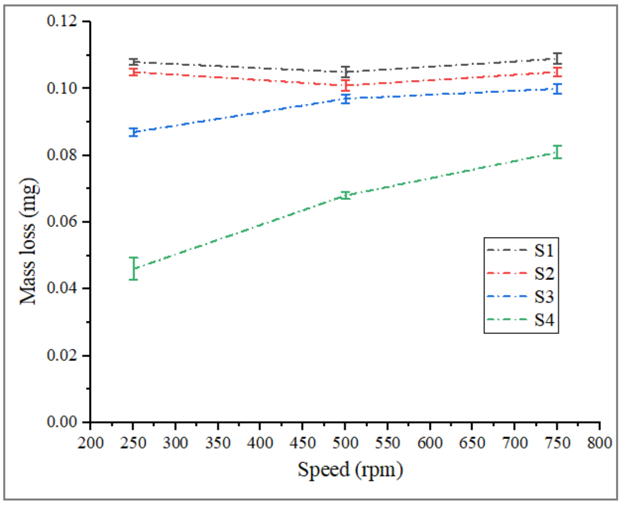

Figure 3: Effect of speed on slurry erosive wear for an impact angle 90^0

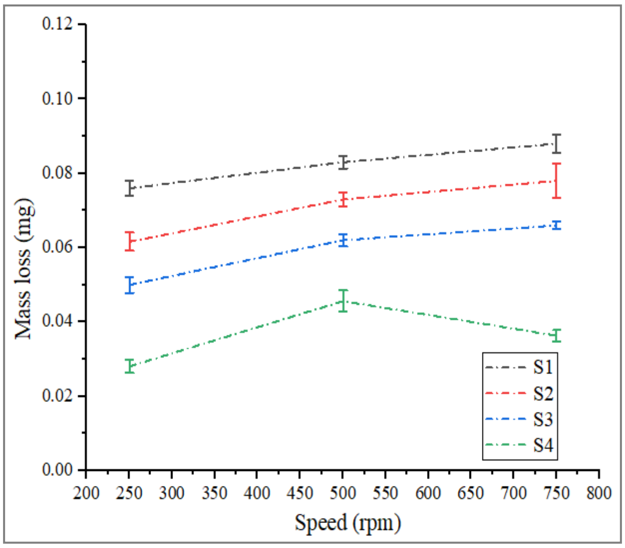

Figure 4: Effect of speed on slurry erosive wear for an impact angle 180⁰

The effect of factors on slurry erosion of basalt fibre reinforced composite is studied using the graphs. Initially at the low value of speed, the erosion of the composite was relatively low. As the speed increases the erosion increased drastically increased in a sample with an impact angle of 90^0. As increase in turning speed and the slurry concentration increases the erosion of the composite, meanwhile, maximum erosion wear took at an impact angle of 90^0 compared to 180^0.

VII. CONCLUSION

The following conclusions are drawn from the present study.

- Increase in turning speed and slurry concentration results in increase in erosion of the composite.
- The peak erosion of the composite is found at an impact angle of 90^0.
- The basalt fibre composite with 60% reinforcement yields better results compare to other three compositions.
- The rise in stirrer speed to 750rpm improves the uniformity of abrasion particles, which influences the erosion in the composite material.

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