International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 6, June-2018

DEVELOPMENT AND TESTING OF TWO-BODY ABRASION TESTER FOR COMPOSITE MATERIALS & SOFT METAL ALLOYS

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Abstract— ***This paper describes the fabrication of a two-body abrasion tester for composite materials and soft metal alloys. Composite materials are tested for different applied loads of 10, 15, 20 and 25N. It is noticed that the specific wear rate has increased with increase of applied load. Similar tests are conducted with supplied equipment and observed that an error of 3.05% is obtained in specific wear rate with respect to the fabricated setup. Therefore, the developed setup has the ability to conduct experiments as per standards.***

Keywords— Abrasion tester, composite materials, soft metal alloys

I. INTRODUCTION

Now-a-days, fiber reinforced polymer composites are being used as friction bearing materials in industries and automotive sectors such as brake liner, electrical contact brushes etc. Friction bearing property of composite materials is weaker than conventional monolithic materials [1-3]. However, they have significant tensile and bending strength. The wear resistance of the polymer matrix can be improved by incorporating small hard particulates as filler along with continuous fibers. Fibers will improve the mechanical strength, and filler material will enhance the wear resistance of the matrix. Fillers are added to increase the stiffness of the composite, and to reduce the cost of the component [4,]. Rout and Satapathy [5,6] have used waste granite powder and rice husk as filler material in glass-epoxy composites to study the wear performance. They found 45 % improvement in wear resistance of granite filled composites than the unfilled samples. Mahapatra and Chaturvedi [7] have investigated the effect of graphite filler on glass-epoxy composites. They found significant improvement in both mechanical and tribological property of the composites than the unfilled ones. Suresha et al. [8] have investigated the mechanical and tribological properties of woven/glass hybrid composites reinforced with fly ash as filler material. They observed maximum flexural strength and modulus for 5 wt.% filled jute/glass-epoxy composites. Similarly, Rout and Satapathy [9] have studied the wear strength of rice husk filled glass-epoxy composites. They found enhancement in wear strength of the filled samples than the unfilled ones. It has been observed that most of the investigators have used sophisticated equipments to conduct the abrasion wear test. However, developing country like India, and to promote the make in India program, an attempt has been made to fabricate a two-body abrasion tester for conducting experiments. The developed tester can be used for composites and soft metal alloys. Further, the same experiments are conducted in the two-body abrasion tester supplied by Ducom Instruments Pvt. Ltd, Bangalore. Specific wear rate of both the equipments are compared.

II. EXPERIMENTAL SETUP

The Experimental set up consists of the popularly used pin on disc apparatus as shown in Figures 1 & 2. The main power source is a DC motor of 1-3 Amp, 230 V. This DC motor is connected to the pin on disc assembly using a V – Belt and pulley arrangement. The torque from the pulley connected to disc shaft is transferred to the disc using thrust bearing and two journal bearings. An abrasive (Emery Paper Grade 150) is placed on the disc upon which the specimen is held stationary against rotating steel disc and normal force is applied by placing load (10g, 20g, 30g, 40g, and 50g) on pin. The specimen is held in place (stationary) by two metal flats lengthwise and wooden blocks width-wise fixed on the slots made in the metal flats. The pin holder is slotted to adjust the radius at which the specimen is placed on the disc, giving us another way to vary the sliding velocity and sliding distance. The sliding velocity is also varied by varying input voltage through the variance, which is connected to motor.

III. COMPONENTS AND DESIGN DETAILS

The following is a description of all the components of the apparatus and a look into the design of the

Apparatus using these components

1. Base

Wooden base was chosen on which the platform for both the motor and the disc are welded on ***L*** bars which are bolted on to the base. It helped in decreasing the vibrations. It is of dimensions 850 × 465× 20 mm^3. A common platform for both motor and disc is used to have less vibration.

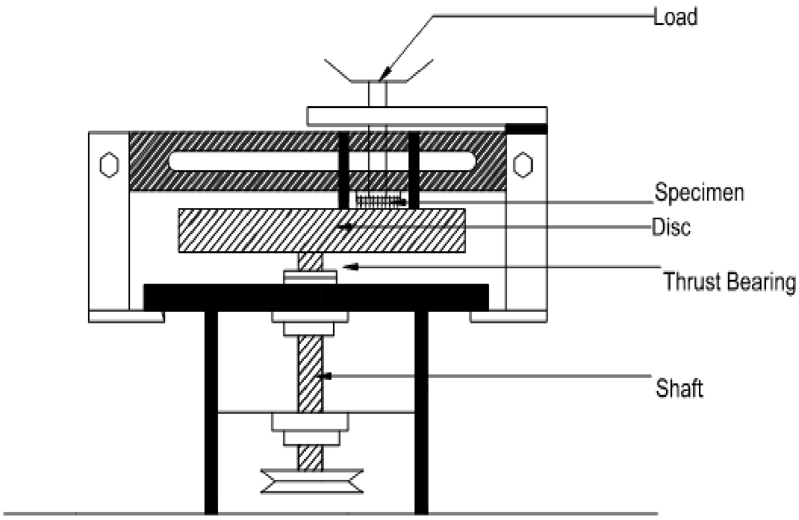

Fig.1 Schematic diagram of the two-body abrasion tester

Fig.2 Actual photograph of the two-body abrasion setup.

2. Motor

A centrifugal pump motor has been used with specifications of 125 W, 230 V, 1-3 Amp. A more powerful motor should be used as it would give better results under higher loads. This motor is fixed vertically and pulley is tightened on its shaft using two set screws. The platform of the motor was built using 4 L – Bars (length 100 mm) were welded to a flat thin plate (dimensions 205 × 195 mm^2) and for motor mounting two flat plates (height 120 mm) were welded on the flat plate (drilled at appropriate places for bolting).

3. Belt and pulley arrangement

Initially, it was thought to place the motor horizontally and use bevel gears. However, the issue of making casing for the bevel gears, difficulty in installation such as misalignment, transfer of motor vibrations directly to disc, made us turn to belt and pulley arrangement. The belt and pulley arrangement turned out to be better in these respects in comparison to bevel gears. The pulley (diameter (d_1) 50.97 mm) attached to the motor was made using an aluminium block in order to reduce the radial load on the shaft of the motor. The pulley push fitted to the disc shaft is made of cast iron and it is of larger diameter (d_2 99.01 mm) in order to get higher torque for the disc. The belt is a V-Belt (standard - B 35/932) of distance between centres equal to 350 mm. V belt was used as there is less slip in comparison to flat belts.

4. Disc arrangement

As can be seen from the schematic diagram (Fig.1), three bearings have been used for then disc shaft (diameter of 22.28 mm). The topmost bearing placed upon the platform is a thrust bearing. Thrust bearing is used here in order to take the axial load due to the vertically positioned disc (diameter of 22.4 mm and thickness 8 mm). The other two bearings are ball bearings used to take higher radial load and for easy centring of the disc. The rotating alloy steel disc (HRC 71 with surface finish 10 μm) is at a height of 275 mm with respect to the base. In order to align the two pulleys the platform is placed upon a shock absorber (white coloured placed on wooden base) of dimensions 360 × 305 × 10 mm^3. The platform is made using 4 L bars (length of 225 mm) and welding them on to a metal plate (dimension 200 × 200 × 10 mm^3). Another plate is welded at height of 150 mm with respect to the base for mounting of the second ball bearing. All of these metals are mild steel.

5. Pin locking

As can be observed in Figs. 2 and 3, that two small metal flats (dimensions 90 × 50 × 5 mm^3) are welded horizontally. On both sides of these plates two flats (dimensions 80 × 40 × 4 mm3) are welded vertically. These vertical flats are drilled above the disc and two long metal (320× 40 × 5 mm3) flats (with a gap of 40 mm between them) are attached on these holes. These long metal flats are slotted such that the position of two wooden blocks (dimension 40 × 40 × 20 mm^3) placed width wise can be adjusted using these slots. Wooden blocks were taken as they are lighter and easy to drill. The wooden blocks and longmetal flats allow for proper restriction (locking) in the movement of the composite specimen. Finally, on one side, a slotted metal plate (length 160 mm, and slot of 70 mm length), through which the pin passed and held in place, is bolted on a horizontal flat (65 × 45 × 4 mm^3), welded on the vertically welded flats. The metal plate on which pin is passed is slotted so as to adjust radius at which specimen is placed on hardened disc. Two pin holders can also be used in order to completely restrict the pin in the radial directions.

Fig. 3 Pin locking arrangement

6. Pin

The pin consists of a hollow stainless steel rod (outer diameter of 25.67 mm), an aluminium block (dimensions 38× 38 × 5 mm^3) and a load holder (dimensions 55 × 40 × 20 mm^3). The hollow rod allows for a pin with less weight. The aluminium block (so chosen because of its lesser weight) is push fitted on to the pin in order to hold the cuboid specimen under its cross sectional area, allowing for uniform wear of the specimen. On the load holder different combinations of 10g, 20g, 50g, 100g etc. are placed in order to get incrementing loads on the specimen. Initial weight of the pin is 270 grams.

IV. PRELIMINARY TEST

1. Two-body abrasive wear test

Two-body abrasive wear tests were conducted on abrasive wear tester. In this method, the test specimen (composite) is placed over hardened disc and resultant wear of the material expressed as volume loss as shown in Table 1.

2. Steps Involved

(i) Initial weight of the composite sample was measured.
(ii) The composite sample (glass-epoxy reinforced with 10 wt.% granite powder) of dimension 25×25×5 mm^3 was placed on the top of the disc at a predetermined radius and rotated at an angular speed.
(iii) A tachometer was used to find the rpm of the motor and motor speed can be changed by the variac voltage.
(iv) From the motor speed, speed of disc was calculated by using pulley diameter and belt thickness.
(v) The required amount of load was placed on the load holder.
(vi) After running the machine for a specified period, the final weight of the sample was measured.
(vii) The difference in weight divided by the initial weight of the sample gives the weight loss.

3. Test observations

TABLE 1: SAMPLE TEST FOR A COMPOSITE SPECIMEN

Variac Voltage **(V)**	Motor speed (rpm) **(N_1)**	Disc shaft speed (rpm) **(N_2)**	Radius of placing specimen **(mm) (r)**	Disc angular speed (rad/s) **(ω_2)**	Disc tangential velocity **(v_2)**	Sliding distance **(m)**	Time of test **(min)**	Load **(N)**	Initial weight **(gm)**	Final weight **(gm)**
110	534	304.8	69	32	2.2	1200	10	10	4.476	4.213
								15	4.476	4.111
								20	4.476	4.021
								25	4.476	3.965

V. RESULTS AND DISCUSSIONS

Specific wear rate

The specific wear rate of the composite samples were calculated as Eq.1

$$K_s = \frac{\Delta V}{F.d} \qquad (1)$$

Where, K_s is the specific wear rate (mm^3/N.m), ΔV is volume loss (mm^3), F is load applied (N), d is the sliding distance (m).

The volume loss ΔV is calculated as per Eq.2

$$\Delta V = \frac{\Delta m}{\rho_{ct}} \tag{2}$$

Where, ρ_{ct} is the density of the composite sample (gm/mm^3) and it is calculated as per Eq.3

$$\rho_{ct} = \frac{1}{\left(\frac{W_f}{\rho_f}\right)+\left(\frac{W_m}{\rho_m}\right)+\left(\frac{W_p}{\rho_p}\right)} \tag{3}$$

Where, W, ρ, and p represent the weight fraction, density, and filler respectively. The term f, m, and ct indicate the palm fiber, the epoxy matrix and their composite respectively.

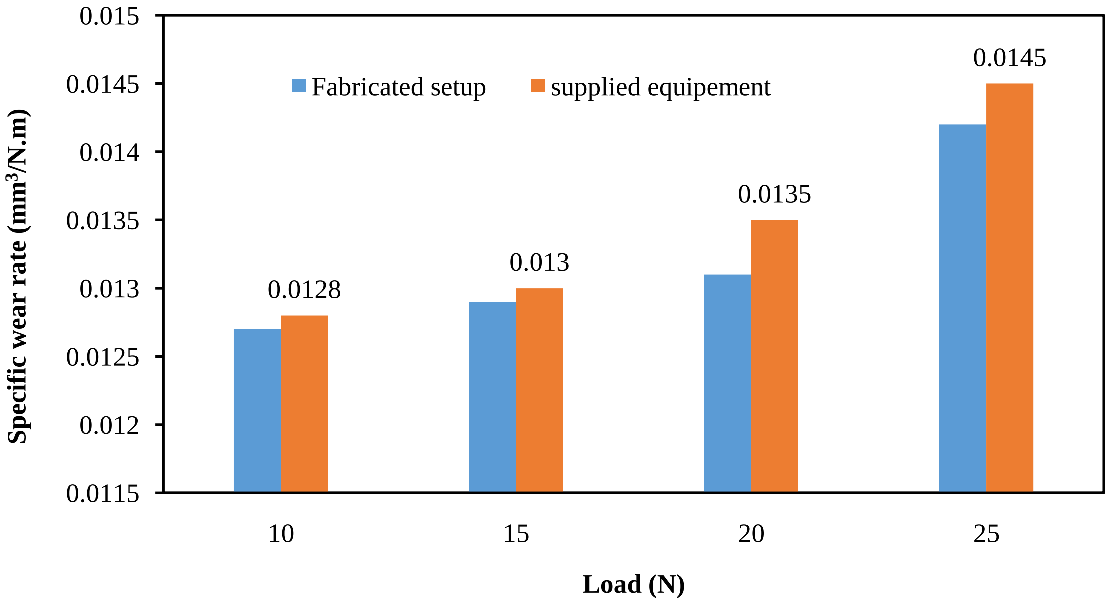

Fig.4 variation of specific wear rate with load

The specific wear rate of the composite sample is increasing with increase of load as shown in Fig.4.

The error percentage of the specific wear rate is calculated and shown in Table 2. It is observed that maximum error (%) of 3.05 is obtained from the comparison study. Hence, the developed setup can be successfully used to conduct experiments in accordance with international standards.

TABLE 2: COMPARISON OF SPECIFIC WEAR RATE BETWEEN FABRICATED AND SUPPLIED SETUP

Test load (N)	**Specific wear rate (mm^3/N.m)**		**Error (%)**
	Result obtained from fabricated setup	**Result obtained from supplied abrasion tester**	
10	0.0127	0.0128	0.78
15	0.0129	0.013	0.77
20	0.0131	0.0135	3.05
25	0.0142	0.0145	2.11

VI. CONCLUSIONS

- The two-body abrasion tester is successfully designed and fabricated with minimum cost.
- Specific wear rate of the samples are increased with increase in applied loads.
- Composite samples are successfully tested with maximum error percentage of 3.05 with the setup.
- The developed setup can be successfully used to conduct experiments in accordance with international standards.

The author is grateful to Dr. I. Panigrahi, Prof. A.K. Sahoo, and Mr. Arabinda Panda for their help and guidance during the design and fabrication of the setup in the CDC Lab of KIIT University, Bhubaneswar.

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