Design and Manufacturing of Wear Testing Machine

Dhwani Patel[1], Janmejay Munjani[1], Jay Astik[1], Kalpesh Patel[1], Hiral H. Parikh[2]

[1]*Final Year Mechanical Engineering Student. School of Science and Engineering, Navrachana University, Vadodara – 391410, (Guj.), INDIA*

[2]*Assistant Professor, School of Science and Engineering, Navrachana University, Vadodara – 391410, (Guj.), INDIA*

Corresponding authors Emails: 12103324@nuv.ac.in, hiralp@nuv.ac.in

Abstract: **Nowadays, there is demand to evaluate tribological performance of new engineering materials using different techniques. Various laboratory tribo-machines have been designed and fabricated such as Pin-on-Disc (POD) and Pin-on-Ring (POR) to evaluate dry and wet wear and friction performance of the material. A concept of integrating more than onetribo-technique (i.e. POD and POR), working simultaneously under same test condition against same material is introduced in a current designed machine. Adhesive dry wear modes can be conducted on the machine for line and area contact.**

Keywords- Wear, Wear Testing Machine (WTM), Pin-on-Ring (POR), Pin-on-Disc (POD), Adhesive wear, Tribology
Abbreviations: WTM (Wear Testing Machine), POD (Pin-on-ring), POR (Pin-on-ring)

I. INTRODUCTION

Wear removal (or displacement) of material from one body happens when subjected to contact and relative motion with another body. Wear is a **System Property**, NOT a Materials Property.Wear of a system differs from situation to situation. So it is important to perform mechanical test which simulate the condition material will experience in actual use. To incorporate different conditions, tribo-machine has corresponding wear test methods as shown in figure 1.

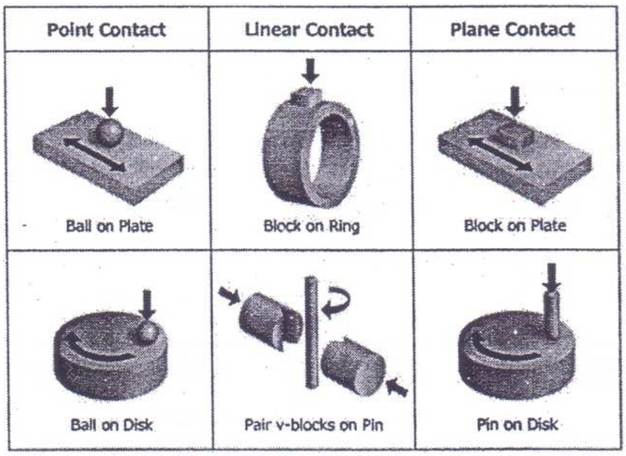

Figure 1: Different arrangement in Tribo-Machines [1]

In tribological loadings, there are three principle orientations of the composites with respect to the sliding direction for both forms.

These orientations are:

1. Parallel (P-O): mats of fibres are perpendicular to the counter face and parallel to the sliding direction.
2. Anti-Parallel (AP-O): mats of fibres are perpendicular to the counter face and perpendicular to the sliding direction too.
3. Normal (N-O): mats of fibers are parallel to the counter face and sliding direction.

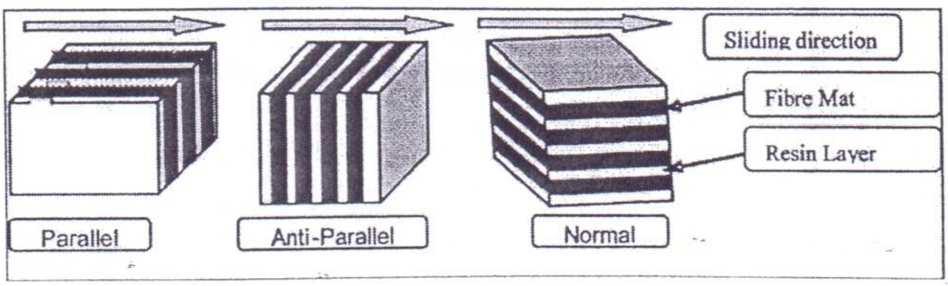

Figure 2: Types of orientation [2]

II. LITERATURE REVIEW

Many researchers have worked on the POD and POR test ring to identify the wear properties of material. Table 1 shows the studies carried out by different researchers.

Table 1: Literature Review

No.	Author	Fiber	Resin	Parameter	Machine	Dry/Wet
1	Umeshdwivedi(2007) et al[3]	Bamboo	Unsaturated polyester	SD, Filler Conc.	POD	Dry
2	NARISH SINGH et.al (2011)[4]	Kenaf	Unsaturated polyster	SD, O	POD	Wet
3	B. Yousif (2012)[5]	Glass	Unsaturated	SV,L,SD	POD, POR	Dry, Wet
4	Antaryami Mishra (2012)[6]	Rubber dust	Epoxy resin	L,SD,S,SV %Of rubber dust	POD	Dry
5	A.Prabhu et al (2012) [7]	Banana	Unsaturated polyester	SV,L,SD	POD	Dry
6	S.MADHUSUDAN et.al (2012)[8]	Treated & untreated	Epoxy resin	L,S, fiber content	POD	Dry
7	Sudhakumar et.al (2012)[9]	Rice-husk	Epoxy resin	SD,fiber content	POD	Dry
8	M.Sudheer et al (2013)[10]	Glass	Epoxy	Sv,L,fibre content	Sliding wear,POD	Dry
9	Duxin li et al (2013)[11]	**PA6 with graphite**		Content Ratio	POD	Wet
10	Biplov Kumar et.al(2013) [12]	**SS202 against SS304**		Ti,L,SV	POD	Dry

- POD- Pin on Disk, POR- Pin On Ring
- SD- Sliding Distance, L-Load, SV- Sliding Velocity, Ti-Time, S-Speed, O-Orientation

III. DESIGN STEPS FOR WEAR TESTING MACHINE

A. Calculation of Power Requirement of motor

Maximum load=100N=N

Diameter of disc= 165mm=2r

Max. RPM=1000

μ_{avg}=0.5 (Considering worst case scenario)

Torque, T= f*r*2
= μN*D…… (1)

Hence,

Total power= 1.28 HP

Hence, 1.5 HP motor is used.

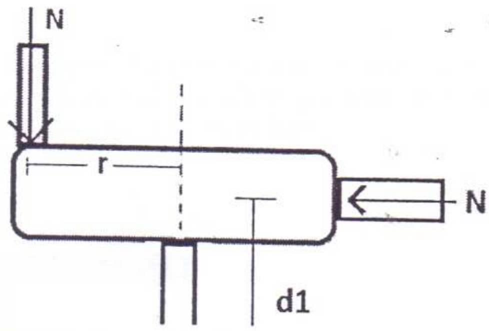

Figure 3: Free body diagram of load acting on disc and motor shaft

B. Levers

Torque= Force*Length
For both POD and POR, the load applied on one end should completely transfer at another end. Hence length of the lever on both side of hinge must be equal.
Force, F_{max}=100N
Yield stress, σ=400MPa

Factor of safety=1.5

$$\frac{\sigma}{1.5} = \frac{F}{A} \quad \text{...... (2)}$$

Figure 4: Side view of our Pin-on-disc Arm

Minimum Area Required 0.375mm^2, which is quite low even at critical sections.

IV. PRINCIPLE WORKING OF POD & POR

A. Pin On Disc

Pin on disc is one of the famous method for wear testing machine. In POD arrangement, Lever is designed to transfer a load from one end to another. At one end known Weight is applied which is transferred to other end where Pin holder is mounted which as a result will apply same amount of force on pin. As the plate moves in rotational motion the frictional force will act between pin and a disc. As it shows in figure 5. The Wear rate is calculated from volume loss of pin during specific run. This simple method facilitate determination and study of dry wear of almost every solid state material combination.

Arrangement for accurate positioning,To ensure Horizontal disc, gauge sensor is put on disc surface. Then byAllen keys screwing or unscrewing of a disc from its supporting disc is done. To put pin perfectly perpendicular to a disc, spacer is used. Guideway is provided to get desired diameter track on disc. The machine base is leveled in horizontal position by screwing or unscrewing adjustable rubber pads at each corner of table.

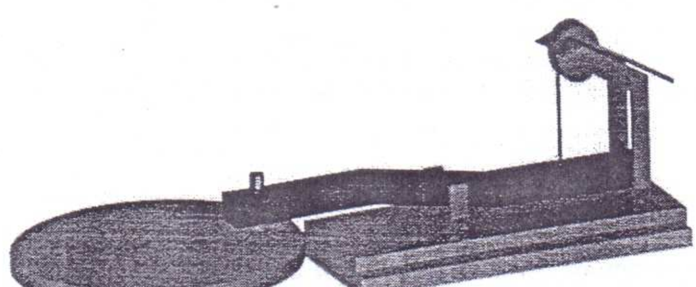

Figure 5: Mechanism of our machine for Pin-on-Disc (POD)

B.Pin On Ring

As the name suggest the sample will be in contact of peripheral area of the disc, having line contact. So wear measured here will be of line wear. The mechanism here is L shaped arm which will transfer the weight load, as shown in figure 6. The wear would be calculated in the same manner of volume loss.

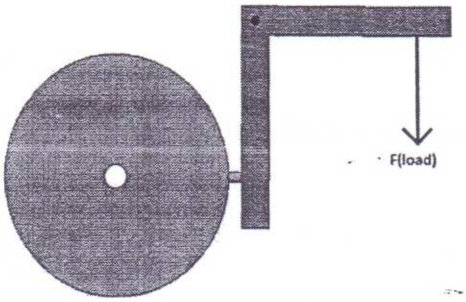

Figure 6: Mechanism of our machine for Pin-on-Ring (POR)

V. MANUFACTURING AND ASSEMBLY OF WTM

Assemble of WTM is shown in figure 7.
Manufacturing of this machine is done in house. And the material used are EN8 and MS. And it used Manufacturing processes like Milling, Turning, Grinding and Welding etc.
The processes like surfacing of the supporting disc was done outside to match the roughness of the Wear Disc. Wear Disc with 0.8Ra surfacing of EN31 material is sourced from Market.

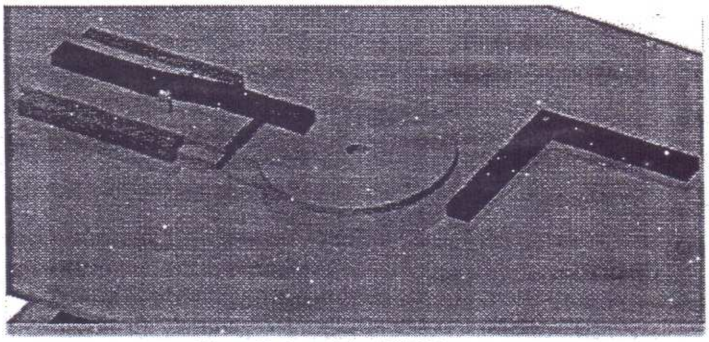

Figure 7: Assembly of WTM

VI. TESTING PROCEDURES ON WTM

A. Test Parameters

Load: Values of the force in Newton's at the wearing contact.
Speed: RPM of disc
Distance: The accumulated sliding distance in meters.
Atmosphere: The atmosphere (laboratory air, relative humidity, argon, lubricant, etc.) surrounding the wearing contact.

B.Procedure and Measurement:

Before experiment, pin's weight and dimension are measured. Pin then will be fixed in pin-holder keeping desired track diameter on disc. And with experimental parameter value (i.e. speed and weight) experiment will be carried on. Time of experiment is noted. Pin's dimensions and weight is then measured. Volumetric and weight loss is then calculated.

C.Calculation and Reporting:

1. The wear measurements should be reported as the volume loss in cubic millimeters for the pin and disk, separately.

2. Use the following equations for calculating volume losses when the pin has initially a **spherical end shape of radius** *R*and the disk is initially flat, under the conditions that only one of the two members wears significantly:

$$\text{pin (spherical end) volume loss, mm}^3 = \frac{\pi(wear\ track\ dia.,mm)^4}{64(Sphere\ Rad,mm)} \quad \text{...... (3)}$$

3. Assuming that there is **no significant disk wear**. This is an approximate geometric relation that is correct to 1 %.

$$\text{disk volume loss, mm}^3 = \frac{\pi(wear\ track\ rad,mm)(track\ width,mm)^3}{6(sphere\ Rad,mm)} \quad \text{...... (4)}$$

4. There is another way for calculating volume loss, we would be using this one in our apparatus. Here we have to get the density of test sample and mass before and after of Experiment. That difference would give us **Mass loss** in grams

   And to find **volume loss**, mm^3

$$= \frac{mass\ loss,g}{density} * 1000 \quad \text{...... (5)}$$

VII. SUMMARY

The main aim after making this machine is to conduct POD and POR at the same time under same or variables. Design and manufacturing of Wear Testing Machine is under B.Tech. Final year dissertation and all materials are locally sourced and manufactured in house to make it cost effective.

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