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Study of wear pattern behavior of aluminum and mild steel discs using pin on disc tribometer

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ABSTRACT

The unlubricated sliding of metal parts is important in many mechanical devices covering a wide range of sliding velocities. However, the effect of sliding velocity of the tribological behaviour of unlubricated metal parts has not been widely studied. Similarly, the relationship between microstructures developed at high sliding velocities and tribological behaviour have not been studied in depth. A tribometer is an instrument that measures tribological quantities, such as coefficient of friction, friction force, and wear volume, between two surfaces in contact. Different types of tribometer are four balls, Pin on disc, Block on ring, Bouncing ball and twin disc. The main focus of our research study is pin on disc tribometer, which is an advanced tribometer with precise measuring of friction and wear properties of combination of metals and lubricants under selected conditions of load, speed and temperature. The main element of this tribometer are a pin sliding on the flat face of the disc in a vertical plane with provisions for controlling load, speed and oil temperature and for measuring friction. This is the simplest form of tribometer used to measure wear and friction between two metals. This research relates to the various aspects (coefficient of friction, wear patter, lubrication testing, result graphs) obtained by pin on disc tribometer.

Keywords: *Tribology,Pin on Disc (POD), Wear Pattern,Lubrication, Specific wear rate.*

INTRODUCTION

The word Tribology has been derived from the Greek word *tribos* which means rubbing and logy which means study. Tribology deals in friction, wear and lubrication between the two interacting surfaces in relative motion and of relative subjects and practices. Tribology is the art of applying operational analysis to problems of great economic significance, namely, reliability, maintenance, and wear of technical equipment, ranging from spacecraft to household appliances[1]. Study of rubbing requires study of various disciplines including physics, chemistry, mathematics solid mechanics, fluid mechanics, thermodynamics, heat transfer, material science, lubrication, machine design and performance[2][3]. A tribometer is an instrument that measures tribological quantities, such as coefficient of friction, friction force, and wear volume, between two surfaces in contact [6].

MATERIALS AND METHODS

Test Setup

This apparatus, figure 1, is model of Pin on Disc Tribometer working at very low rpm, at constant sliding velocity and fixed radius of wear circle. This apparatus can be used in lab to perform wear testing of given metal and study the effect of lubrication of different lubricants on that particular metal under different loading conditions. The specific wear rate is calculated, the specific wear rate helps in determining wear resistance provided by the metal under running conditions.

Figure 1: Test setup "Pin on Disc Tribometer"

The setup consists of a frame, ring arrangement, pin rod (cast iron) and metal discs (Aluminium and mild steel) supported on a board. The disc is rotated by a DC motor of 24.6W, with 3 rpm; the weights (Max 500g) is applied on the disc by placing the weights on the pan, to generate a wear pattern on the surface of the disc. The balancing of the rod holding the pin is done by the copper string and a metal wire having high tensile strength. The depth of penetration is measured using a range meter setup consisting of micro controller 89c52, IC 0804 and a LCD display. For lubrication HP racer 2 stroke engine oil is used.

Test Procedure

Steps to be followed in order to conduct the experiment are:-

- Place the test metal disc on DC motor.
- Place the pin over the disc.
- Run the motor at full speed and ON the range meter.
- Place the weights in the pan and observe the wear pattern on disc made by pin. Simultaneously, note the reading from range meter.
- Measure the radius of wear circle made by pin on the disc.
- Take the highest value of depth of penetration and plot the graph between depth of penetration and applied load (Dry testing).
- Calculate the specific wear rate

Specific Wear Rate, K:

$$K = \frac{\text{(Volume of Wear)}}{\text{(Applied Load) x (Sliding Distance)}}$$

Where

Volume of Wear = (π x (Radius of pin point)^2 x Depth of penetration).

Sliding Distance = (2 x π x Radius of wear circle).

S.I. Unit of Specific Wear Rate, K is (mm)^3/(N-m).

- Plot the graph between specific wear rate and applied load (Dry testing).
- Apply lubricant on the disc.
- Repeat the step 4 to step 8 for wet testing.

Data acquisition includes maximum depth of penetration and specific wear rate for both aluminium and mild steel are as follows:

For Aluminium Disc (Dry Testing):

Table 1: Range meter table of Aluminium for Dry Testing

S. No.	Applied Load	Range Meter Value	Max. Depth of Penetration.
1.	100g	0, 12, 20, 25, 30, 28, 20, 0	0.030
2.	200g	20, 38, 78, 82, 68, 70, 48, 0	0.082
3.	300g	66, 28, 64, 70, 92, 48, 86, 60	0.092
4.	400g	54, 88, 42, 62, 90, 92, 56, 48	0.092

Radius of Wear = 3.5 cm.
Now, calculating the specific wear rate for each value of applied load(table 2).

Table 2: Specific Wear Rate of Aluminium for Dry Testing

S. No.	Applied Load	Specific Wear Rate, K (x 0.001)
1.	100g	0.107
2.	200g	0.146
3.	300g	0.109
4.	400g	0.085

For Wet Testing:
Lubricant : HP Racer 2 Low Smoke Engine Oil.

Table 3: Range meter table of Aluminium for Wet Testing

S. No.	Applied Load	Range Meter Value	Max. Depth of Penetration.
1.	100g	0, 8, 16, 25, 28, 24, 18, 10	0.028
2.	200g	8, 16, 30, 38, 45, 64, 56, 32	0.064
3.	300g	22, 26, 30, 54, 67, 84, 80, 52	0.084
4.	400g	30, 49, 67, 89, 86, 60, 51, 32	0.089

Radius of Wear = 3.5 cm.
Now, calculating the specific wear rate for each value of applied load(table 4).

Table 4: Specific Wear Rate of Aluminium for Wet Testing

S. No.	Applied Load	Specific Wear Rate, K (x 0.001)
1.	100g	0.1
2.	200g	0.114
3.	300g	0.1
4.	400g	0.079

Similarly, for **Mild Steel (Dry Testing):**

Table 5: Range meter table of Mild Steel for Dry Testing

S. No.	Applied Load	Range Meter Value	Max. Depth of Penetration.
1.	100g	0, 10, 15, 18, 25, 20, 16, 12	0.025
2.	200g	8, 12, 28, 48, 46, 40, 14, 38	0.048
3.	300g	14, 18, 44, 48, 55, 50, 49, 43	0.055
4.	400g	42, 50, 65, 78, 70, 65, 55, 53	0.078

Radius of Wear = 3.5 cm.
Now, calculating the specific wear rate for each value of applied load (table 6):

Table 6: Specific Wear Rate of Mild Steel for Dry Testing

S. No.	Applied Load	Specific Wear Rate, K (x 0.001)
1.	100g	0.89
2.	200g	0.86
3.	300g	0.65
4.	400g	0.69

For Wet Testing:
Lubricant: HP Racer 2 Low Smoke Engine Oil.

Table 7: Range meter table of Mild Steel for Wet Testing

S. No.	Applied Load	Range Meter Value	Max. Depth of Penetration.
1.	100g	0, 8, 10, 18, 20, 16, 15, 12	0.020
2.	200g	12, 28, 32, 38, 40, 36, 28, 30	0.040
3.	300g	30, 36, 42, 45, 48, 40, 38, 35	0.048
4.	400g	39, 50, 58, 65, 70, 62, 54, 50	0.070

Radius of Wear = 3.5 cm.
Now, calculating the specific wear rate for each value of applied load (table 8):

Table 8: Specific Wear Rate of Mild Steel for Wet Testing

S. No.	Applied Load	Specific Wear Rate, K (x 0.001)
1.	100g	0.71
2.	200g	0.71
3.	300g	0.57
4.	400g	0.63

Test results
For Aluminium metal disc, graphs are as follows:

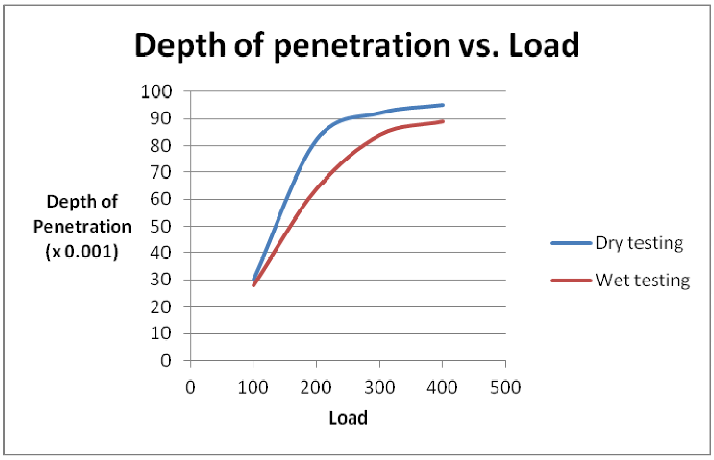

Figure 2: Graph between Depth of Penetration vs. Load for Aluminium.

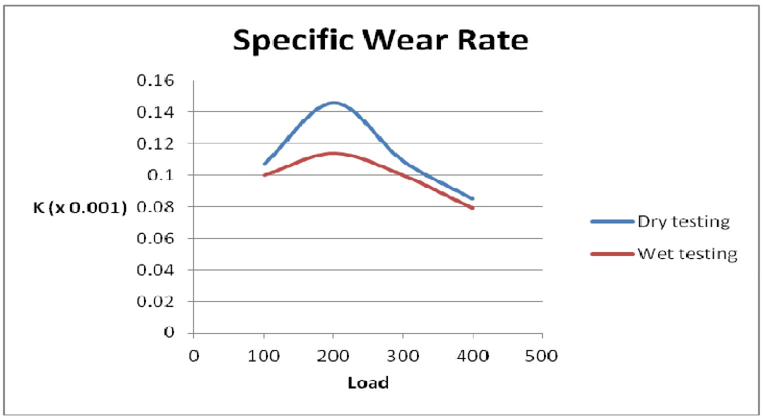

Figure 3: Graph of Specific Wear Rate for Aluminium.

For Mild Steel, graphs are as follows:

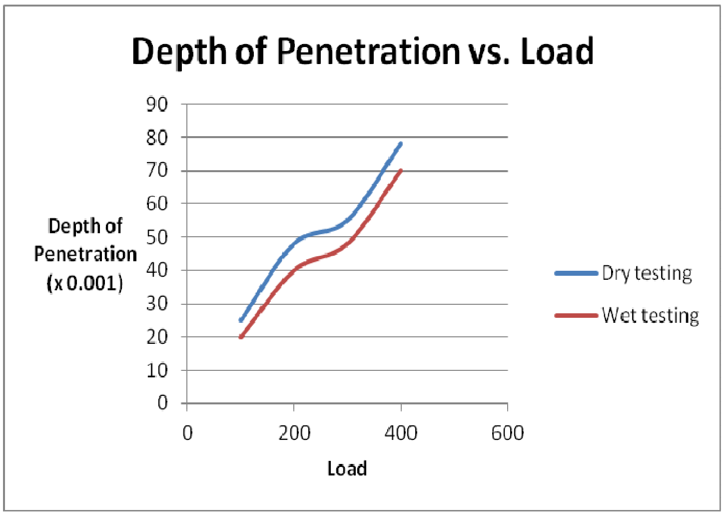

Figure 4: Graph between Depth of Penetration vs. Load for Mild Steel.

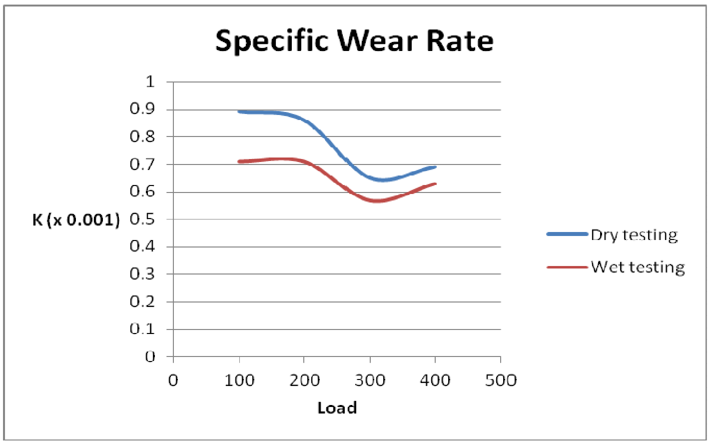

Figure 5: Graph of Specific Wear Rate for Mild Steel.

Analysis
Graph 1 shows the behavior that the depth of penetration increases with increase in applied load in both cases (dry testing as well as wet testing) for aluminum and mild steel discs. This means they are almost directly proportional to each other.

Using this concept, we can predict what type of lubrication must be used to prevent metal from damage, as increase in thickness of lubrication reduces the depth of penetration.

Graph 2 shows the behavior that specific wear rate decreases with increase in applied load . Lesser the specific wear rate, more the metal have the ability to resist wear under loading conditions for both the disc.

Note: These results are valid for fixed thickness of metal sheet and sliding velocity, as result may vary if anyone or both conditions are varied.

Metal Disc after conducting, both the Dry and Wet testing on them.

Figure 5: Mild Steel Disc

Figure 6: Aluminium Disc

CONCLUSION

Main conclusions of this research are as follows:

- There is a variation in depth of penetration of each metal (Aluminum and mild steel) with respect to varied applied load.
- Specific wear rate helps in determining wear resistance provided by the metal under running conditions.
- Dry testing and wet testing conducted by us on the metal disc help to find the effect of lubricant (HP racer 2 stroke engine oil) on the wear pattern. Lubricant forms a thin layer of film between two metals and reduces the rate of wear between the two metals. This can help in development of new materials, comparing two lubricants on same metal as well as showing the result and analysis of additives in the lubricant which can react with metal during running condition.
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