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INFLUENCE OF VARYING LOAD ON WEAR RATE AND FRICTIONAL RESISTANCE OF EN-8 STEEL SLIDING AGAINST EN-31 STEEL

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ABSTRACT

The aim of this work is to study the influence of varying load on EN8alloy steel when it is sliding against EN31 alloy steel. The wear test was carried out by using Pin on Disc apparatus. The counter face discs were machined from the EN31 steel composition and the test was carried at low loads and high loads. Variations of friction coefficient and the wear rate at different normal loads and high load were investigated. The result shows that the wear rate increases when the load increases. An interesting result showed that the Co-efficient of Friction decreases at normal loading conditions and when the load increases from 125N, the Co-efficient of Friction increases till 175N.The Scanning Electron Microscopy (SEM) image of the worn out specimen reveals that the formation of groove lines on the sliding surface due to adhesion strength of the material is very less when it subjected to higher loads.

Keywords: wear resistance, frictional resistance, pin-on-disc, adhesion, co-efficient of friction.

1. INTRODUCTION

Earlier studies [1-15] revealed that the variation of friction depends on interfacial conditions such as normal load, geometry, relative surface motion, sliding velocity, surface roughness of the rubbing surfaces, surface cleanliness, type of material, system rigidity, temperature, stick-slip, relative humidity, lubrication and vibration. The normal load plays an important role for the variation of friction and wear loss.

In many metal pairs, the friction coefficient is low at low loads and a transition occurs to a higher value as the normal load is increased. At low loads, the oxide film effectively separates two metal surfaces and there is little or no true metallic contact, hence the friction coefficient is low. At higher load conditions, the film breaks down, resulting in intimate metallic contact, which is responsible for higher friction [11]. Friction may increase or decrease as a result of increased sliding velocity for different materials combinations. An increase in the temperature generally results in metal softening in the case of low melting point metals. An increase in temperature may result in solid-state phase transformation which may either improve or degrade mechanical properties [12]. Now days, many materials either sliding or rolling are used in different applications. The increase in demand for light weight and energy efficient materials with high strength, stiffness, and wear resistance lead to the experiment of many materials. EN8steel is one type of medium strength steel that is suitable where good all-round performance is required. EN8 is widely used for applications which require better properties than mild steel but does not justify the costs of an alloy steel. EN8 can be flame or induction hardened to produce a good surface hardness with moderate wears resistance.EN8 is widely used for many general engineering applications. Typical applications include shafts, studs, bolts, connecting rods, screws, piston rod etc., where Wear and Friction are responsible for many problems. This leads to experiment the effect of wear rate and frictional resistance of EN8steel sliding against EN31steel at various loading conditions.

a) Experimental setup

The wear resistance of materials is usually obtained by performing wear tests in a laboratory equipment named tribometer. A standard laboratory test that simulates the severe conditions of mechanical components is the pin-on-disc testing equipment, the test is carried out at selected constant parameters as the total sliding distance, the normal load on the pin, the sliding velocity and controlled conditions of temperature and relative humidity.

This test is used to find out the wear and friction .A pin on disc tribometer consists of a stationary "pin" under an applied load in contact with a rotating disc. The pin can have any shape to simulate a Specific contact, but spherical tips are often used to simplify the contact geometry. Friction is determined by the ratio of the frictional force to the loading force on the pin. In a pin–on–disk wear test a standard test specimen is held pressed against a rotary flat disk, then brought perpendicular to the disk. They may be positioned vertical or horizontal but the test results may differ. The specimen may have a Spherical end or flat end. Normally the load is applied through a lever arm. The wear results are generally reported as volume loss or weight loss. Wear results are usually obtained by conducting a test for a selected sliding distance and for selected values of load and speed. The test specimen is cylindrical or spherical and the diameter ranges from 2mm to 10mm.

Pins: In the fabrication of pins, round bars of EN-8 steel were utilized. The pins were machined by the conventional methods, i.e., turning and grinding to obtain the desired pin shape with a rounded tip with radius approximately 10mm and length of 20mm as seen in Figure-1.

Figure-1. Pin-on disc apparatus.

Discs: The Disc is made up of EN-31 alloy material
The pin on disc test has proved useful in providing a simple wear and friction test for low friction coatings.

Figure-2. Machined pins before wear test.

2. RESULTS AND DISCUSSIONS

The test was conducted at a constant speed of 450rpm at 20 minutes time for each specimen. The following readings were recorded.

The load has a significant influence on the wear loss of the material. The wear loss increases when the load increases. Wear loss increases gradually till the load reaches 150N. At load 175N, wear loss is suddenly increased and once it reaches 200N, much worn out takes place. It is clearly shown in the graph. This indicates wear of EN-8steel against EN-31 attains a new phase of transformation at high load (200N). This leads to increase in temperature and the material becomes ductile.

Here also the load plays a crucial role on the co-efficient of friction. When the load slowly increases gradually, the coefficient of friction gets decreases accordingly. The graph shows that the load is indirectly proportional to the co-efficient of friction till the load reaches 40N.

Table-1. Values at constant speed 450RPM.

Load in N	Weight Loss (gm)	Volume(mm3)	Wear Rate (mm3/N-m)
20	0.0239	29.8750	0.000417
30	0.076	95.0000	0.000884
40	0.1128	141.0000	0.000984
100	0.3033	379.1250	0.001059
125	0.422	527.5000	0.001178
150	0.6658	832.2500	0.001549
175	1.1515	1439.3750	0.002297
200	4.3836	5479.5000	0.007650

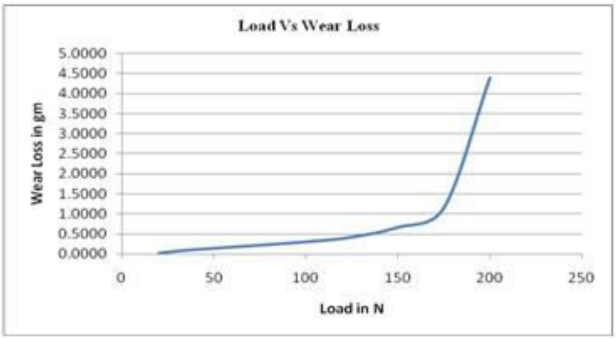

Figure-3. Effect of load on wear loss.

When the load increases from 100N to 125N, still the condition is same. The co-efficient of friction decreases gradually. Once it reaches 125N, dramatic increase in COF takes place till it reaches 175N. Then after, it decreases very gradually. This clearly indicates that at high load conditions, the change of phase takes place and the material becomes more ductile.

It is observed from the figure that as the load increases the wear also increase for all conditions because whenever applied load increases the friction at the contact surface of the material and rotating disc increases. This leads to increase in temperature and the material becomes ductile.

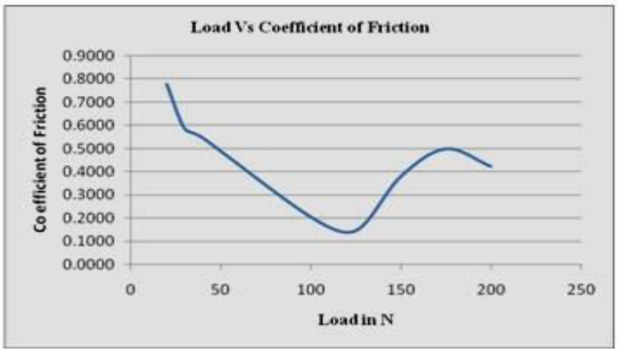

Figure-4. Effect of load on co-efficient of friction.

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So wear particles get adhered to the surface and leads to less wear rate. The wear rate is increased gradually up to 50N. The wear particles get adhered to the surface and layer called smeared layer is formed. Further there is sudden increase in wear rate due to normalization at higher loads. The increase in temperature increases the ductility.

a) Wear rate result analysis

Calculation

Volume (mm^3) = Mass (kg) / Density (kg/mm^3)
= 0.0239 x 1000 / (0.8) = 29.875mm^3
Sliding distance = π x Dia of Disc (D) x speed (N)
= π x 0.120 x 475x 20 = 3581.4 m
Wear Rate = $\frac{\text{Volume loss}}{\text{Load x sliding distance}}$
= 29.875 / (20) x (3581.4)
= 0.000417 mm^3/ N-m

For the various Loading conditions, the wear losses and the wear rates have been calculated and tabulated as below.

The following table lists the various wear rate values and loss in weight at various loads. The wear rate increases gradually up to 175N and a sudden increase afterwards.

The variations of Wear rate with a track radius 50mm at 450rpm is shown in the table. The reduction of shear strength of the material and increased true area of contact between contacting surfaces may have some role on the higher wear rate at higher sliding velocity or speed conditions [15].

Load in N	Weight Loss (gm)	Volume(mm3)	Wear Rate (mm3/N-m)
20	0.0239	29.8750	0.000417
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200	4.3836	5479.5000	0.007650

b) Scanning electron microscopy

It is clear that the scanned image surface of the worn out specimen at the load of 150N is consisting of more groove linings which indicates adhesion strength of the material is very less when it subjected to higher loads. Thus, it might be reasonable to conclude that at higher sliding speeds, an increased plastic deformation of the matrix leads to a transition from cutting to ploughing or wedge formation during abrasion. Material is displaced on either side of the abrasion groove without being removed. While in wedge forming, tiny wedge shaped fragments are worn only during the initial contact with an abrasive particle

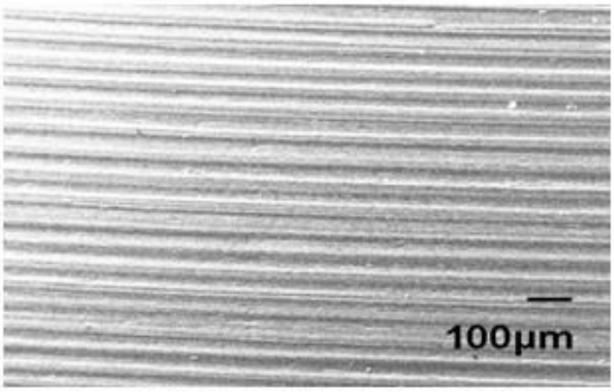

Figure-5. SEM image of worn out specimen.

3. CONCLUSIONS

Some vital conclusions can be drawn in accordance with the wear tests conducted with a pin-on-disc configuration.The increase in bulk temperatures of the rubbing bodies decreases the flow stresses of the rubbing materials to a certain extent, which results in an increase in the plastic zone size in the sub surfaces of the rubbing bodies. Consequently, the friction coefficient as well as wear rate increases with increasing sliding speed when the normal load is over certain levels.

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