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Investigations of contact stresses and wear parameters for pin on disc using different pin materials

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Investigations of contact stresses and wear parameters for pin on disc using different pin materials

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Abstract. Wear component is an important factor influencing products service life which is based on material property and their behavior under given conditions. Therefore it is important to predict wear rate of components. In this paper we have discussed the wear parameters of pin on disc by varying pin materials. Numerical analysis was conducted on basis of load for different material components. When two bodies are in contact, contact pressure induces stresses in components.. Due to coefficient of friction, heat is generated between components. Hertz theory has been considered to determine the wear characteristic by using different pin materials on a steel disc. It was observed that aluminium alloy pin on steel disc generated low coefficient of friction, temperature rise and wear rate.

1. Introduction

Tribology is one of the most basic concepts in engineering, which studies about contact surfaces in relative motion. It is essential in today's world because large amounts of energy are lost due to wear and friction in mechanical parts. There is an attention on research to reduce the amount of energy that is wasted. Significant energy is lost more due to friction in contact surfaces. The effects of wear have to be minimized by including new technologies in Tribology to make a greener and more sustainable world. Many researchers have proposed that wear depends on many properties according to their application. The significant values for wear and friction depend on structure of the system and operating variables

2. Literature Review

M. Bezzazi et al. [1] studied on friction paramters by considering the parameters due to contact with constant relative sliding velocity. On comparing the results obtained with SAE J661, it was observed friction coefficient was decreased with rise in temperature and sliding velocity. Zhao et al. [2] studied on friction and wear behavior's of Copper based friction pairs in clutches at diverse operating conditions on UMT-3. They have observed a rise in temperature and friction coefficient increased initially from 0.28 to 0.35 and then decreased to 0.3 due to rise in temperature. Wear factor increased sharply to $K=112.2x10^{-8}$ gm/Nm. Berglund et al. [3] studied the frictional performance of Sintered bronze friction material to determine the friction characteristics in clutch system. Pin-on-disk test was carried out by Kamlichi et al. [4], to achieve the frictional performance of clutch facings in context of

Taguchi. Results showed that friction was controlled by interaction of sliding speed and temperature. Abdullah et al. [5] used Infrared camera experimental investigation, numerical approach was used to analyse the wear parameters and compared with the experimental study. Virendra et al. [6] calculated the wear of diverse types of clutch materials. Wear rate was used as comparative value for wear resistance. Results showed that torque transmission capacity of sintered iron friction material is high and can sustain higher temperature. Degrieck et al. [7] investigated the tribological behaviour of SAE-II disk tests for characteristics of wear. Fernandes et al. [8] observed that when wear debris was added to tribo-system friction coefficient decreased. Clutch tribological performances were improved. Marklund et al. [9] investigated on the friction of a small sample wet clutch in a pin-on-disc test and the temperature is measured during the tests and is compared with the measurements form a test rig for whole friction discs.

H.So et al. [10] investigated the wear characteristics various speeds. Due to increase temperature of the contact surfaces decreased the flow stresses to certain extent which resulted in 12 plastic zone in sub surfaces of rubbing bodies. Kennedy et al. [11] studied on the effect of sliding speed which lead to the wear on the disc. The effect of temperature near the contact was studied in depth which further led to wear due to tracks. Bressan et al. [12] studied that due to pin different hardness, wear resistance varied subsequently. Bortoleto et al. [13] carried out the investigation with varying pin loads at a sliding speed. Theoretical and experimentation was to find the variation of stresses and generation of tracks on the disc. Davim et al. [14] investigated tribologicalbehaviorof dry sliding using ANOVA, the results were compared and the influence of sliding distance factor and temperature was studied. Hegadekatte et al. [15] worked on implementing a simulation on tribometer to study the wear parameters. Davim et al. [16] studied on the couple field problem considering structural and thermal parameter using Regression analysis. Nigam et al. [17] applied numerical techniques for analyzing parameters of pin on disc. The numerical results obtained were compared with the actual experimentation. Abdul et al. [18] Simulated on the frictional force applied on pin wear tester. Irwan et al.[19] investigated on Pin on-disc to calculate the volume lost and the wear of materials.

3. Hertzian theory for Contact pressure

For contact stress analysis, Hertz theory is considered where the contact surfaces are subjected to compressive forces. Due to relative motion between the contact surfaces, heat is generated due to friction. The indent produced by the pin induces resifual streses in the disc upto certain depth.

Figure 1 represents the indent formed due to a sphere of radius R making an elastic half-space of depth d, which creates a contact area of radius as shown below:

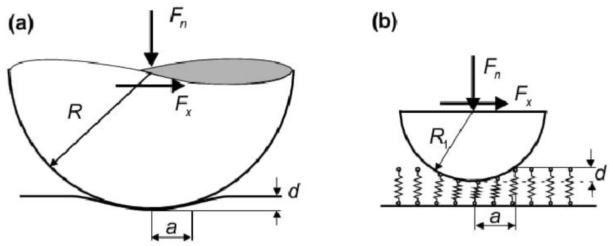

Figure 1. Contact Stress

Contact area of radius is given by: $a = \left(\frac{3 * Fn * R}{4E}\right)^{\frac{1}{3}}$

Where $\frac{1}{E} = \frac{1-(v1^2)}{E1} + \frac{1-(v2^2)}{E2}$

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Where,

E_1, E_2 are elastic module

v_1, $v_2$are Poisson's ratios associated with each body

Stiffness:$k = (2 * E^2 * R * Fn)^{1/3}$

Stress:$\sigma = \frac{0.4*k}{R}$

Maximum contact pressure at centre of circular contact area is:$P = \frac{3*Fn}{2*\Pi*a^2}$

Depth of indentation is given by: $\Delta = \frac{a^2}{R}$

The friction coefficient is: $\mu = \frac{\tau}{H}$

Where,

τ = Shear strength= $\sigma/3$

H= hardness of softer material

4. Results and Discussions

Wear parameters are calculated for different combinations of pin and disc materials. Wear volume, wear rate, specific wear rate are analyzed. Also due to coefficient of friction, heat is generated between surfaces which generate wear volume. Contact pressure induces stresses in the components due to which wear is generated in components. Hence, coefficient of friction and contact pressure are calculated and analysed for different materials.

Wear Volume:

Wear volume is calculated for five different pin materials (Steel, Carbon steel, Aluminium, Brass, Alumina) and steel disc. The wear volumes pin on steel disc for different sliding distance and loads are determined. With increasing load, the wear volume was increasing linearly for all sliding distances. Wear rate is very high for brass pin on steel disc under same loading conditions

Wear Rate:

In order to understand variation in wear behavior with load for different materials, wear rate is calculated for five different pin materials (Steel, Carbon steel, Aluminium, Brass and Alumina) and steel disc.

The results are listed below:

Wear rate of steel pin on steel disc is low for applied loading conditions. Also wear rate of aluminium pin on steel disc is also relatively low for same loading conditions. Wear rate is very high for brass pin on steel disc under same loading conditions.

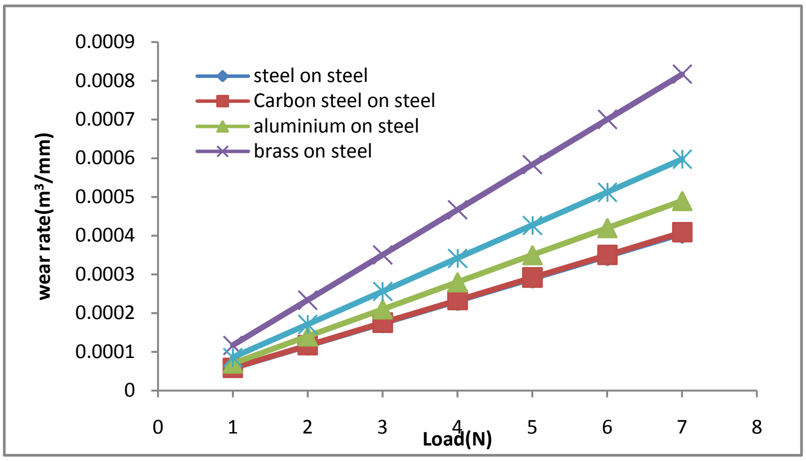

Figure 2. Wear rate Versus Load for different combinations of materials for pin on disc

Specific wear rate:

Specific wear rate is further accurate description of wear parameters of any materials, particularly for metals, alloys and composites. It is used as a precision indication of wear properties of sliding bodies under action of loads, speeds, sliding distance or time. In order to understand variation in wear behavior for different materials, wear rate is calculated for five different pin materials (Steel, Carbon steel, Aluminium, Brass and Alumina) and steel disc.

The results are listed below:

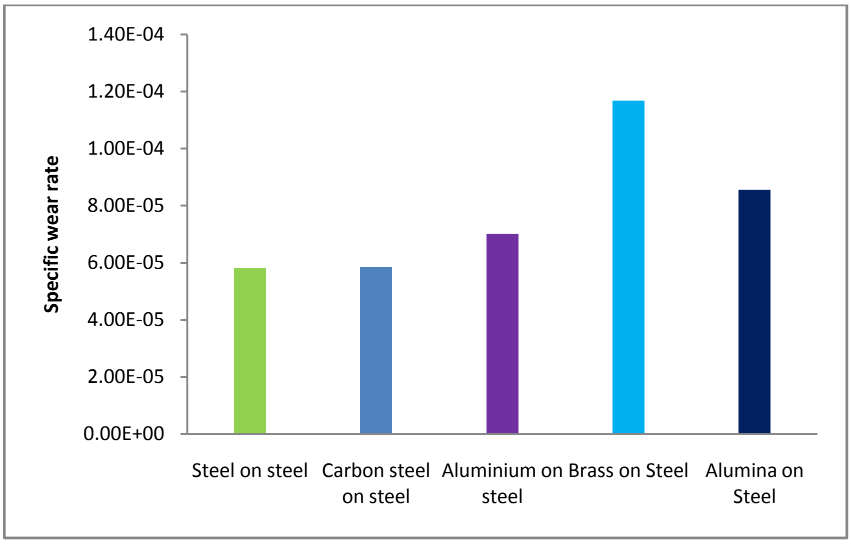

Figure 3. Variation of Specific wear rate with Load at different combinations of materials for pin on disc

The above graph indicates specific wear rate is maximum for brass pin on steel disc and is minimum and approximately same for steel and carbon steel pins on the steel disc.

Contact pressure:

Contact pressure induces stresses on components. The effect of contact pressure is calculated for different pin materials (Steel, Carbon steel, Aluminium, Brass and Alumina) and steel disc.

The results are listed below:

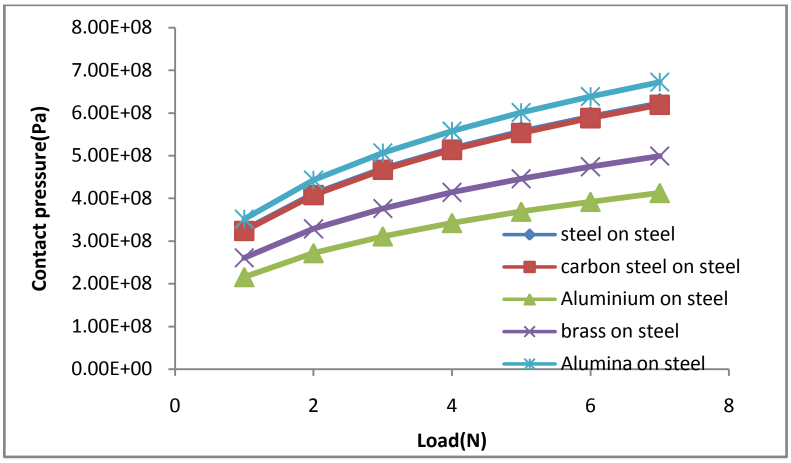

Figure 4. Contact Pressure Versus Load for different combinations of materials for Pin on disc.

The above graph represents contact pressures of different combinations of materials for varying loads. With increasing load, the contact pressure is increasing linearly in all materials. Contact pressure is low for aluminium alloy pin on steel disc and contact pressure is high for alumina in on steel disc.

Stress and Coefficient of Friction:

Coefficient of friction induces heat due to rubbing of surface which are in contact and relative motion. In order to understand the stresses induced and coefficient of friction for materials, they are calculated and tabulated as follows:

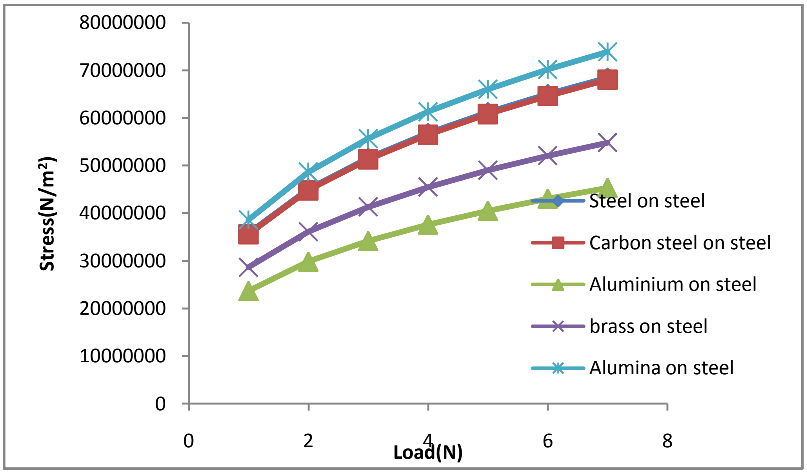

Figure 5. Stress Versus Load for different combinations of materials for Pin on disc

The above graph represents Stresses of different combinations of materials for varying loads. Contact stresses increasing with load for all materials. Contact stress is low for aluminium alloy pin on steel disc is high for alumina in on steel disc.

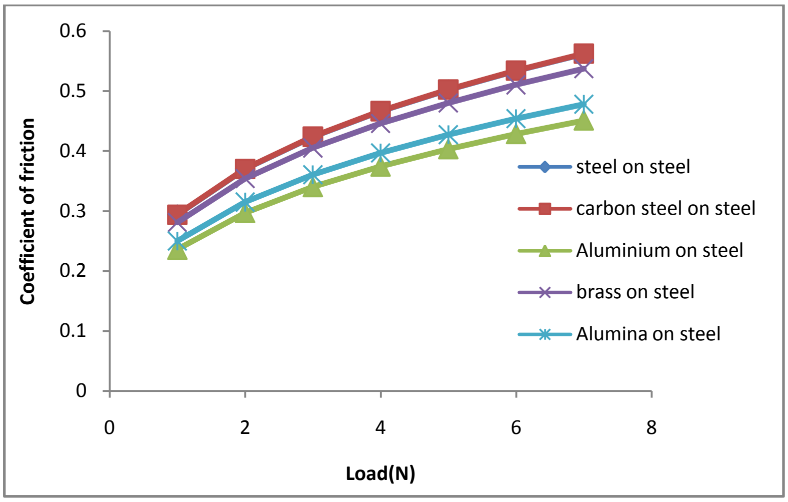

Figure 6. Coefficient of friction Versus Load for different combinations of materials for Pin on disc

The above graph represents coefficient of friction of different combinations of materials for varying loads. With increasing load, the coefficient of friction is increasing linearly in all materials. Coefficient of friction is low for aluminium alloy pin on steel disc is high for alumina in on steel disc.

5. Conclusions

The present study summarizes that

- Wear rate is found to be very low in case of steel and aluminium alloy materials compared to other materials, which is around.
- Coefficient of friction is observed low, which is 0.23 in aluminium alloy pin on steel disc where as it is high in case of steel pin on steel disc was 0.35.
- Low contact pressure of 0.26GPa is observed in aluminium alloy pin on steel disc compared to other materials.
- Induced stress is low in aluminium alloy i.e. 2.3GPa is observed in case of aluminium alloy on steel disc when compared to other materials.
- Temperature generated is low for Aluminium alloy which is 303-degree kelvin.
- Low stresses are induce in aluminium alloy pin on steel disc and high stresses are induced in steel pin on steel disc

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