

An Experimental Investigation of Ploughing Wear of 10015 Grade Mild Steel and 6000 Grade Aluminum

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Abstract

Ploughing wear is the micro-level abrasive wear and in this type of wear material shifted to the sides of the wear surface. In this research work, 10015 grade mild steel and 6000 grade aluminum sample were experimentally investigated for ploughing and cutting wear. This experimental investigation for ploughing wear of (mildsteel and aluminum) under the effect of scratching/cutting at different forces which responsible for roughness and damage of surface and this rough motion of parts of machine decrease the efficiency and working life of machine such as parts of IC engine and compressors. A setup has been made on shaper machine on the place of clapper box and ploughing wear rate was estimated experimentally at various different operating parameters. The spring force was calculated with the help of stiffness and displacement of the spring and the cutting force was calculated by ultimate stress with the help of spring force. Ploughing wear was calculated by the cutting and spring force. The experimental results showed that ploughing wear directly proportional to the force and loss of material of specimen. The ploughing wear and coefficient of friction found minimum in mild steel sample in comparison of aluminum sample within the observed range of sliding velocity and force.

Keywords: *Ploughing wear, 10015 Grade Mild Steel, 6000 Grade Aluminum*

INTRODUCTION

There is a continuing interest in extending the reliability and material capabilities in mechanical systems both at sliding and rolling motion. Tribological applications are excellent example of situation where improvement in the material and the operation which has to be performed on it for increasing the efficiency and reliability of a component, Even reducing the cost of maintenances.[1] The scratch test is been held on material is an AISI304 in which we use the tool of spheroconical indicator at different speeds 1, 3, 27mm per minute at the different load 1N to 15 N ,different load it is found that the material surface topography has been changed and residual stress induced, when the tool is more penetrated then there will be change in strain rate at the higher speed plastic deformation rate is higher deformation rate higher, which caused friction coefficient to be of higher magnitude during this work, to find out the rate of abrasive wear.[2,3] Surface texture influence by friction and transfer layer formation during sliding in these investigation, various kind of surface texture with varying roughness were produced on steel plate pin made up of Mg-8 Al alloy, in

these sliding tester to understand the surface texture of the harder surface and load on coefficient of friction and transfer layer transformation under both dry and lubricant condition, normal load from 1-120N, sliding velocity of 2mm sec scanning electrons micrograph of the different surface away from the wear tracks using a optical profilometer the coefficient of friction depend on surface texture and independent of surface roughness the ploughing component of friction was highest for the surface that promotes plane strain condition. [4]It depends upon the tools sharpness, edges for the surface at different load and different speed of tool the effect of surface of specimen and calculate wear. [5,6]

During the operation either sliding or rolling where take place in this work, calculated the force which is required for the ploughing wear during the sliding motion. Firstly, design and fabricated the experimental setup and all component of set up were made up of mild steel because it was less costly and having good machining characteristics. A spring were used for calculate the force and copper linear to the shaft for smooth motion where high speed steel tool is used for

cutting the specimen during the sliding motion. Cutting force, total force, ploughing wear and coefficient of friction were calculated from the setup.

DEVELOPMENT OF EXPERIMENTAL SETUP

In this research work, the experimental setup was designed and manufacture. The parts and assembly of setup were draw in Auto CAD-2D as per dimension and 3-D model prepared by using Pro-E 5.0 and assembly drawing exported in Ansys 14.5 simulation

software for structural analysis. Boundary condition were applied in Ansys and result of simulation shown the spring force, cutting force, ploughing friction force, ultimate stress and tool wear. For manufacturing of setup by different machining operation like facing, chamfering, drilling, milling, boring grinding and welding were done. All prepared parts were assembled as per assembly drawing and prepare a experimental setup for an experimental investigation of ploughing wear.

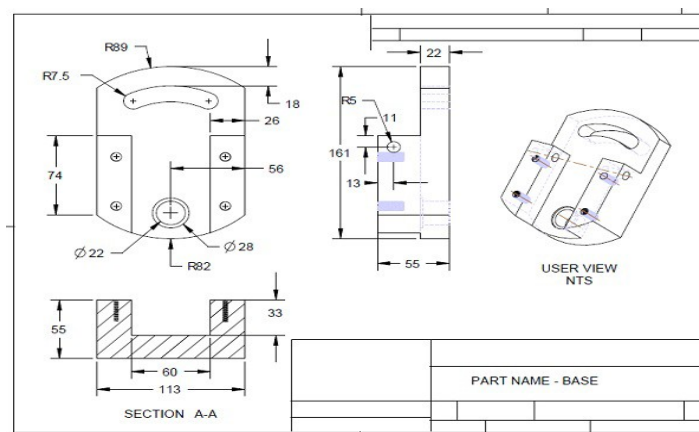


Figure 1: 2D - CAD Drawing



Figure 2: Pro-E 3D-Model of

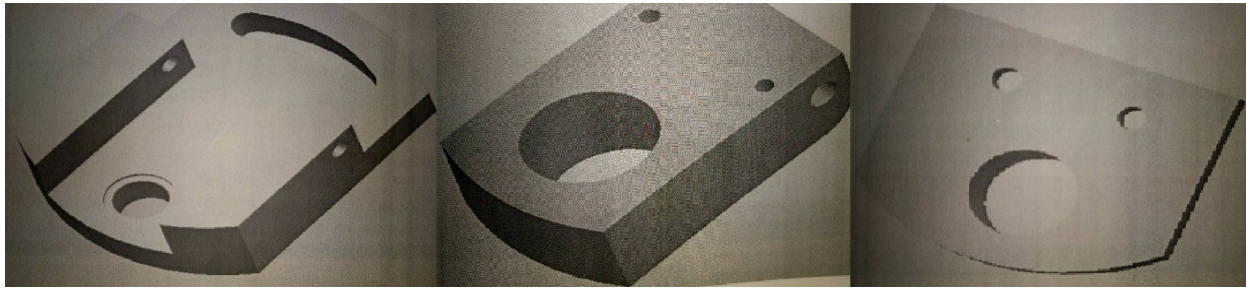


Figure 3(a): Apron clamping bolt

(b) Clapper box

(c) Outer plate



Figure 4(a): Clapper box with rods and collar (b) Clapper box (c) Clapper box with spring attached



Figure 5(a): Clapper box with scale

Figure 5 (b): Shaper machine

EXPERIMENTAL PROCEDURE

This experimental were carried out on shaper machine, a clapper box block is replaced by the new components; in which

changes were made in dimension with other additional parts were attached. The clapper box was made up of mild steel in top position of clapper was given 10° to 14° pin

attached to machine and become one assembly in clapper box two holes were provided in which mild steel rod with spring is attached. The shaft was fixed to clapper box block by provided collar and key and shaft was remain fixed on upper plate at back side copper linear provided for smooth motion of shaft and spring is attached to shaft on the outer plate. A small square shape tool post was welded and fixed tool with nuts. The tool was single point cutting tool of HSS whose angle was 60° . Now adjust the tool with the specimen now ON machine take ideal stroke then set the position of tool and specimen so it can easily scratch the specimen during these process spring was compressed. The spring and scale assembly were used for measure the total force required for starching the specimen. The cutting force was known with

the help of ultimate strength of material by using of UTM machine with the help of these two value ploughing friction force is calculated. **See figure 6(a,b).**

RESULTS

In this work, sample of mild steel grade and aluminum grade were experimentally investigated on the fabricated setup for ploughing wear rate.

Following are the dimensions of sample, calculations and experimental results of Mild Steel sample given below:

Gauge length of mild steel sample = 288mm

Outer diameter of mild steel sample = 25mm

A single point cutting tool whose angle = 60°



Figure 6 (a): Sample of mild steel Figure 6(b): Sample of aluminum

Firstly calculated the spring force by the formula

$$F = K * X$$

Where,

F= force

K=stiffness of spring

X= displacementn of spring

In spring loaded tool set-up were used three springs; out of them two springs have the same stiffness. The arrangement of three springs in the set-up is shown in the figure given below.

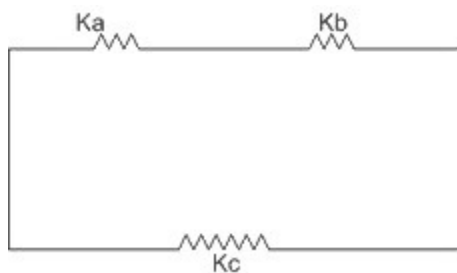


Figure: arrangement of springs in setup

Now,

For calculating the value of stiffness of spring we using the formula as below:

$$K = \frac{W}{X}$$

Where,

K- Stiffness of spring

W-Load in Newton

X- Deflection of spring in mm

Stiffness of first spring

$$K_a = \frac{9.81}{6.9} = 1.422 \text{ N/mm}$$

Stiffness of second spring

$$K_b = \frac{9.81}{6.9} = 1.422 \text{ N/mm}$$

Stiffness of third spring

$$K_c = \frac{9.81}{9.2} = 1.066 \text{ N/mm}$$

Thus the average value of three spring is

$$\frac{1}{K_{avg}} = \frac{1}{K_a} + \frac{1}{K_b} + \frac{1}{K_c}$$

$$\frac{1}{K_{avg}} = \frac{1}{1.422} + \frac{1}{1.422} + \frac{1}{1.066}$$

$$\frac{1}{K_{avg}} = 2.344$$

Keq = 0.427 and deflection(x=12.6mm)

Thus, F=0.427*12.6

$$F = 5.380 \text{ N}$$

Now, calculating the cutting force

Cutting force = ultimate strength*area

For calculating the ultimate stress,

Ultimate strength = load/area

$$\text{Ultimate strength} = \frac{180}{22.7 * 25 * 25} = 0.367 \text{ N/mm}^2$$

Cutting force = ultimate strength*area

Cutting force = $0.367 \times 0.4 = 0.147\text{N}$

Now, finally calculating ploughing friction force for material

Ploughing friction force = Total force - Cutting force

Ploughing friction force = $5.380 - 0.147 = 5.233\text{N}$

Thus, the resultant value of ploughing friction force equal to 5.233N

For Aluminum:

Gauge length of aluminum = 288mm

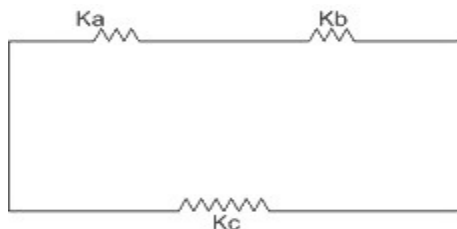
Outer diameter of aluminum = 25mm

First we will calculate the spring force by using the formula

$$F = K \times X$$

Where, F-force, X-displacement of spring

If spring loaded tool post set-up, we used three springs, out of them two spring has the same stiffness, The arrangement of three springs in the set-up is shown in the figure given below:



Now,

For calculating the value of stiffness of spring we using the formula as below:

$$\text{Stiffness (k)} = \frac{\text{load (W)}}{\text{deflection (X)}}$$

K-stiffness of spring

W-load in Newton

X-deflection of spring in mm

Stiffness of first spring

$$K^a = \frac{9.81}{6.9} = 1.422\text{N/mm}$$

Stiffness of second spring

$$K_b = \frac{9.81}{6.9} = 1.422\text{N/mm}$$

Stiffness of third spring

$$K_c = 1.066\text{N/mm}$$

Thus the average value of three springs is

$$\frac{1}{k_{eq}} = \frac{1}{k_a} + \frac{1}{k_b} + \frac{1}{k_c}$$

$$\frac{1}{k_{eq}} = \frac{1}{1.422} + \frac{1}{1.422} + \frac{1}{1.066}$$

$$\frac{1}{k_{eq}} = 0.7032 + 0.7032 + 0.938$$

$$\frac{1}{k_{eq}} = 2.344$$

$$K_{eq} = 0.427$$

And deflection($x=12.6\text{mm}$)

Thus,

$$\frac{\text{Total force}}{\text{Spring force (F)}} = K \times X$$

$$F = 0.427 \times 12.6$$

$$F = 5.380 \text{ N}$$

Now, calculating the cutting force

Cutting force = ultimate strength * area

For calculating the ultimate stress

Cutting force = Ultimate strength * area

$$= 0.102 \times 0.6 = 0.061 \text{ N}$$

Now, finally calculating ploughing friction force for material

Ploughing friction force = total force - cutting force

$$= 5.380 - 0.061 = 5.319 \text{ N}$$

Thus, the resultant value of ploughing friction force equals to 5.319 N.

The differences between the above two result is 0.086 N.

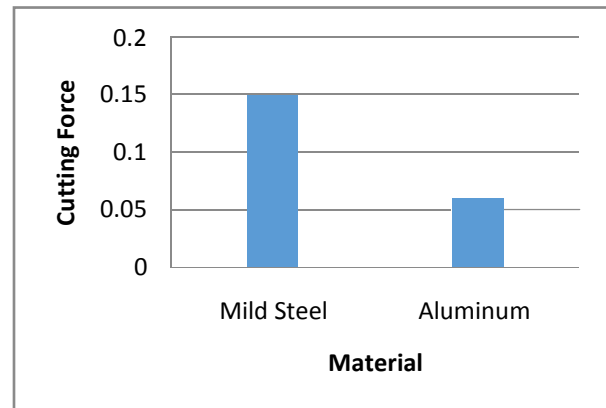


Figure: Cutting force vs Material

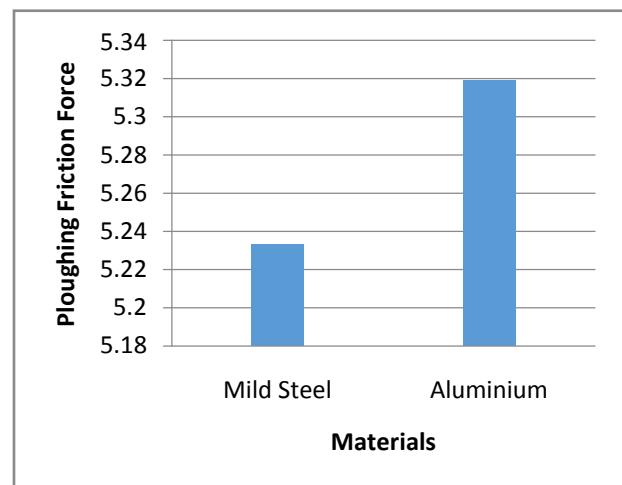


Figure: Ploughing friction force vs Material

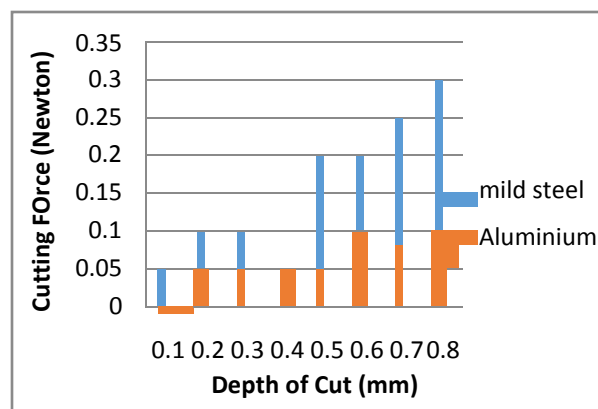


Figure: Cutting force vs Depth of cut

CONCLUSION

It was observed from the experimental results that ploughing wear rate of mild steel sample were minimum in comparison of aluminum sample. The ploughing wear was affected by the cutting force, as cutting force increases wear rate of both sample were decreases. The results shows, wear rate of aluminum sample increases due to lower cutting force but wear rate of mild steel

sample decreases with due to higher cutting force. The cutting force depends on ultimate stress of material, as ultimate stress increases the ploughing wear decreases. The mildsteel sample has ultimate stress N/mm^2 and aluminum sample has ultimate stress $0.102N/mm^2$. The experimental results found that mild steel sample has lower value of ploughing wear in comparison of aluminum sample. This research study concluded that mild steel has characteristics of minimum wearout by ploughing mechanism at higher value of cutting forces in comparison of aluminum. If in place of aluminum components of machine, ic engine etc. use of mild steel component , it minimize the chances of failure of machine component by ploughing wear and enhance service life of components as well as machine, ic engine etc.

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