



INVESTIGATION OF LOAD EFFECTS AND TEMPERATURES ON RATE OF WEAR USING BRASS AND CARBON STEEL MATERIALS.

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ABSTRACT

The study was done to predict rates of wear which occurred as a result of friction process between a brass material and a carbon steel disc was rotated with speed equal to 675 r.p.m. The wear rates were calculated for a dwell time equal to 30 minutes for each case of applied loads of 250g, 750g and 1250g. This research investigated the effects of loads applications on the variation in temperatures which were taken place due to rubbing action at contact area that may play role in specifying the wear rates. These results have indicated the style of wear rates expressed by volume and by weight that may be a guide for the designers when using those materials at similar friction conditions

الخلاصة:

تمت الدراسة للتنبؤ بمعدلات البلى نتيجة احتكاك مادة البراص و قرص الفولاذ الكار بوني الذي يدور بسرعة 675 دورة/دقيقة. تم حساب معدلات البلى لفترة 30 دقيقة لكل حالة بعد تسليط اثقال مختلفة (250غم، 750 غم، 1250غم). في هذا البحث تم التحقيق في تأثيرات الاحمال على التغير في درجات الحرارة الحاصل نتيجة الاحتكاك والذي قد يكون لها دور في تحديد معدلات البلى. وقد اشارت النتائج إلى انماط لمعدلات البلى وقد تم التعبير عنها بدلالة الحجم وكذلك بدلالة الوزن. ان هذه المؤشرات تشكل دليلا يساعد المصممين عند اختيار هذه المواد في ظروف احتكاك مشابهة.

KEY WARDS: frictional wear, rates of wear.

AIMS OF RESEARCH:

1. Calculation rates of wear for three different loads.
2. Investigating the variation in temperatures due to applied loads and their effects on the rates of wear

1-1 DESCRIPTION OF THE WEAR MACHINE:

Wear testing machine consists of carbon steel disc rotated over an even level part of metal structure connected by brackets to flange with suitable ball bearing and shaft diameter of 2.5cm. The other side of the shaft was connected to a pulley of diameter equal to 19cm. This pulley was connected to a small motor pulley of diameter equal to 9 cm through rubber belt. A motor of speed equal to 1425 rpm was used which has been reduced to 675 r.p.m through that combination of belts and pulleys (see Fig1). On other hand, two metal supporting bars fixed vertically at the ends of the even surface holding movable support which is suspended as a bridge on the upper parts of the two bars through screws. At nearly midpoint of the suspended bar, a small hollow ring was welded vertically to allow a small aluminum solid shaft - holding the brass sample - to be fitted through the hollow with enough tolerance to move up and down freely prior to load application.

1-2 INTRODUCTION

Friction between two materials rubbing each other is an area of work interesting a lot of researchers because the applications of such process are found in cars brake system and great number of machines.. For example, the noise and vibration in brake systems of cars has done by researchers like V.P. SERGIENKO, S.N. BUKHAROV and A.V.KUPREEV [9].

The target in this research was to study the case where a rotating metal disc rubbing a brass rod using different applications of loads and recording the values of temperatures at contact area for each case of load which applied for dwell time equal to 30 minutes. This case may be seen in different ways in mechanic processes. These two factors, load and friction temperature have great role in determining the rate of wear which may be used as good prediction guide to choose right materials for similar processing.

The research dealt with dry friction. *Dry friction* resists relative lateral motion of two solid surfaces in contact. Dry friction is also subdivided into *static friction* between non-moving surfaces, and *kinetic friction* (sometimes called *sliding friction* or *dynamic friction*) between moving surfaces, and may be defined as losing a part of the material from its surface [1]. Frictional wear is, also, occurred by friction forces leading to loss in weight and volume by the action of another solid according to certain conditions such as loads, roughness of surface, hardness of counter body, dry sliding, and temperatures [2&3]. Wear can also be defined as a process in which interaction of the surfaces or bounding faces of a solid with its working environment results in dimensional loss of the solid, with or without loss of material. In the results of standard wear tests, the loss of material during wear is also expressed in terms of volume because volume loss gives a truer picture than weight loss [3&5]. Abrasive wear occurs when a hard rough surface slides across a softer surface. ASTM (American Society for Testing and Materials) define it as the loss of material due to hard particles or hard protuberances that are forced against and move along a solid surface. Abrasive wear is commonly classified according to the type of contact and the contact environment. The type of contact determines the mode of abrasive wear. Abrasive wear can be measured as loss of mass by the Taber Abrasion Test according to ISO 9352 or ASTM D 1044. The wear rate by volume is expressed by the following relation [6&7].

$$V = K L S / 3 H \quad \dots\dots\dots (1) \quad \text{Archards equation.}$$

V = wear rate by volume.

k = wear factor.

L = load.S= distance slid

The rate of wear by weight is expressed by the following relation:

$$W.R = (W1 - W2) / Nt \quad \dots\dots\dots (2) \quad \text{L . Maissel formula}$$

$$= \Delta W / Nt$$

W.R= wear rate

N = disc speed (rev/ min)

R= radius of the rotated disc

t = testing time

1-3 EXPERIMENTAL PROCEDURES

Preparation of samples and technical requirements:

Two materials with different hardness were taken to be rubbed, carbon steel of hardness equal to 68HRC and CZ131brass, its hardness equal to 80HRB.

Nine samples were used, three for each different load. Each brass sample had taper end, A thermocouple gauge was used to record the variations in temperature at the contact area of friction. Digital balance to weigh loads and samples was supplied as well.

The following steps were to be taken into consideration for each experiment.

1. Values of applied loads on the samples for each case.
2. Radius of disc and its speed.
3. Period of time for each experiment.
4. Weights of each brass sample before and after each experiment (loss of weight).
5. Variations in temperature reading at contact area during the full time of the experiment.
6. The specimens were isolated by asbestos cover to prevent heat transfer out to the holder.
7. Distance slid : the distance was moved by brass sample at fractioned part of the metal disc.

THE PROCESS:

Each specimen - with cross section of diameter equal to (9mm)- had a taper end. It was fixed to a cylindrical holder which was moving freely through metal ring in a vertical direction, rubbing the rotated metal disc as a result of loads applied on the holder to push the specimen down to cause a friction action between the brass and the carbon steel disc which was rotated according to the transmitted motion through arrangement of a motor of 675rpm and pulleys. Three cases of load were applied. In each case a calculation of wear by weight and volume every half an hour was done, the variations in temperatures at friction area during the process were recorded as well using thermocouple device.

1-4 CALCULATIONS AND DISCUSSION:

The calculations applied on:

1. Temperature values were recorded at the friction area during each experiment (Table. 3).
2. Hardness of brass = 80 HRB (**100 kg/ mm²**).
3. Hardness of carbon steel = 68HRC (**150 kg/ mm²**).
4. Parameters of (table. 1), (table. 2).

1st: To calculate wear rate by weigh (kg/mm²)

$$\mathbf{W.R = (W1 - W2) / Nt} \quad \text{.....(1)}$$

W1= weight of brass sample before friction action.

W2= weight of brass sample after friction action.

$\Delta W = (W1 - W2) =$ Loss in weight.

S = Sample.

$S_A =$ Average value of loss in weight.

N = speed of disc = 675 r.p.m

R = radius of disc = 62.5mm.

t = dwell time = 30min.

2nd: To calculate wear rate by volume.

$$V = K L S / 3 H$$

.....(2)

V= Rate of wear by volume (mm³).

K = Wear factor = 1.5×10^{-3} .

L = load = 250g, 750g and 1250g

S = distant slid = 2.5mm

H = hardness of brass (100kg /mm²)

DISCUSSION:

According to the shape of taper section of the brass, the friction was started at the tip of the brass taper leading to:-

1st stage : first 15min

fast loss of weight was raising the temperature at the contact zone rapidly during to a certain maximum value, (Table.2) . This behavior was repeated with all loads (**250g, 750g, 1250g**). The loss of weight were raised - in lower rates - due to elevated loads (Fig.3).

2nd stage: after 15min. up to 30min.

The conditions were changed indicating the following results:-

1. Temperatures were started to become nearly constant, because of the increase in contact section of brass - which was subjected to friction action - leading to heat transfer to the brass rod reducing the rate of temperature raising according to loads application (Fig.4).
2. loads of **250g** and **750g** had no serious effect to cause metallurgical change into the zone of friction according to maximum temperatures they approached, while load of **1250g** had a maximum friction temperature of (145 °C to 150 °C) increasing the ductility of brass which led to deformation work reducing the rate of loss in weight comparing with previous loads.(Table.4) .

Rate of wear by weight in all cases was too small to express rate of wear comparing with rate of wear expressed by volume which were higher by (10^2) confirming that **Archards** equation is better to express the rate of wear.

CONCLUSIONS:

This research indicates following facts:

1. Rate of wear by volume is truer representative than that by weight.
2. As long as there is an increase in load application more than **1250g** on friction brass material, rate of wear will increase gradually slower due to a temperature raising at friction area which makes metallurgical work on the surface of brass increasing the ductility.
3. Load and temperature play role in specifying the rate of weight loss in material to be rubbed with harder metal.

Table (1): Loss of Weight According to Application of Different Loads and the Average Values for Each Case.

Load (Kg)	Weight of brass (g)	Sample1	Sample2	Sample3	ΔW S_A
0.250	W1	9.395	9.498	9.31	
	W2	9.30	9.40	9.15	
	ΔW	0.095	0.098	0.16	0.10
0.750	W1	9.54	9.61	9.78	
	W2	9.25	9.30	9.45	
	ΔW	0.29	0.31	0.33	0.31
1.250	W1	10.48	9.90	9.64	
	W2	10.10	9.50	9.25	
	ΔW	0.38	0.40	0.39	0.39

Table (2): Loss of Weight & Rate of Wear According to Loads Applied for Each Case.

Load (Kg)	$\Delta W(g)$ S_A	R.W= $\Delta W/Nt$ (kg/rev)	Rate of wear by volume Archards equation $V (mm^3) = K L S / 3 H$
0.250	0.10	5×10^{-8}	3.9×10^{-6}
0.750	0.31	15×10^{-8}	11.7×10^{-6}
1.250	0.39	28×10^{-8}	19.5×10^{-6}

Table (3): Temperatures Recorded at Friction Zone on the Taper Part of Specimens for Different Loads.(room temperature = 30⁰ C).

Dwell time(min.)	T °C at load 250 g				T °C at load 750 g				T °C at load 1250 g			
	T ₁	T ₂	T ₃	T _A	T ₁	T ₂	T ₃	T _A	T ₁	T ₂	T ₃	T _A
0	30	30	30	30	30	30	30	30	30	30	30	30
1	33	34	32	33	38	40	37	38	40	40	40	40
2	35	35	36	35	43	43	41	42	46	44	45	45
3	45	44	46	45	49	51	50	49	61	59	59	60
4	56	55	57	56	65	63	65	63	84	85	86	85
5	68	68	68	68	79	79	79	79	103	102	103	103
10	80	78	81	80	94	95	96	95	125	125	125	125
15	87	86	88	87	99	98	99	99	148	150	151	150
20	87	87	87	87	101	101	101	101	150	150	150	150
25	78	77	79	78	101	100	99	100	145	145	145	145
30	78	78	78	78	95	96	95	95	145	145	145	145

Table (4): Rate of Loss of Weight According to Elevated Loads.

Load	Loss in weight (g)	Friction temp.
250g	0.10 g = W1	87⁰ C
3x 250	0.31g = 3.1x W1	98⁰ C
5x 250	0.39g = 3.9x W1	150⁰ C

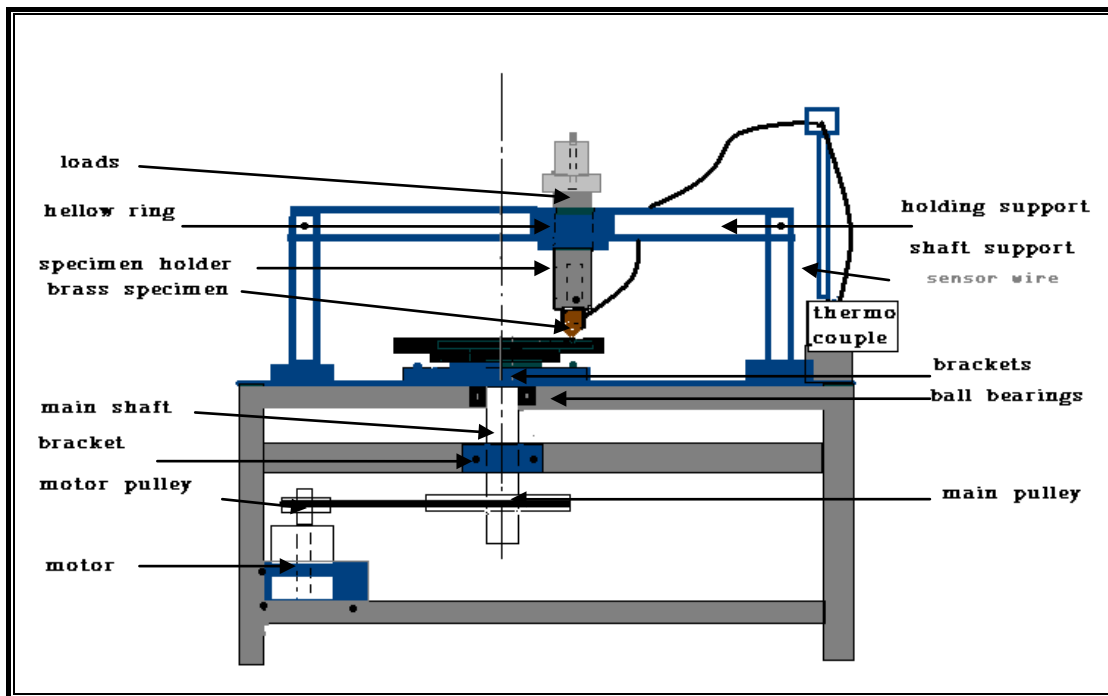


Fig. 1: Sketch Describes the Wear Testing Machine Details



Fig. 2: Wear Testing machine

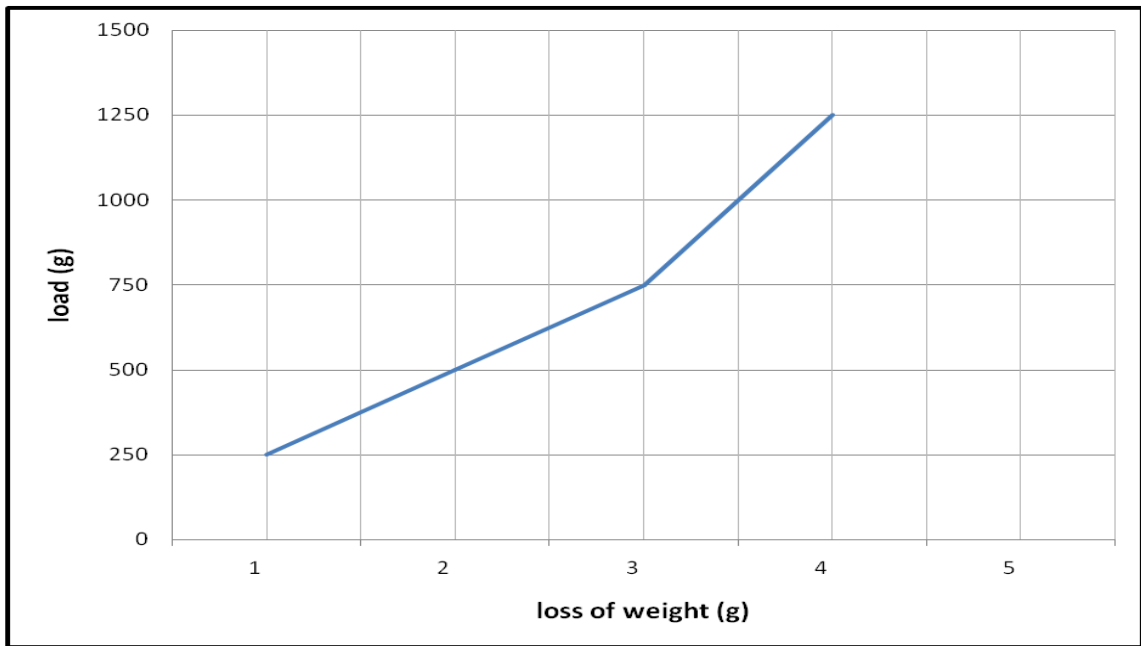


Fig. 3: A gradual Increase in Loss of Wear According to Load Increase.

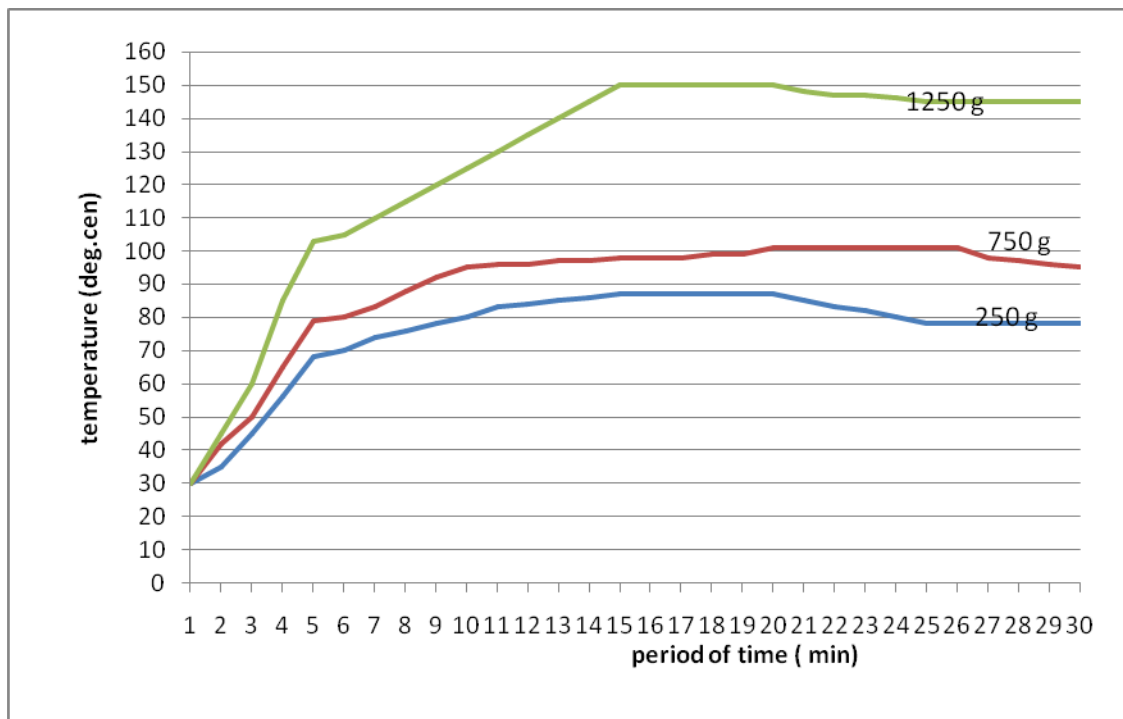


Fig. (4): Temperatures at Friction Area for Different Loads During (30min).

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