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STUDY BEHAVIOR THE COEFFICIENT OF FRICTION AND WEAR RATE OF THE BRASS ALLOY CuZn30 ON COUNTERFACE MATERIAL CONVERSELY

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Abstract: *This research is devoted to study of the afore mentioned phenomena (i.e. wear & friction) including the important roles that certain factors play in, such as sliding speed, normal load, sliding time, type of material and hardness of disc. Three load were used (10, 15, and 20 N), which represent elastic, elastoplastic, plastic sort of loads, at different values of sliding speed (95, 250, and 350 rpm). However, increasing of normal load causes increase in the coefficient of friction and wear rate for brass CuZn30, whereas the effect of sliding speed results in a decrease in the wear rate and coefficient of friction. Wear rate and coefficient of friction increase with increasing sliding time until they reach steady-state value. Coefficient of friction was found to be related to the hardness of disc. However, wear rate increases with increasing disc hardness to some extent, and than decreases again.*

Keywords: *brass CuZn30, sliding speed, sliding time, coefficient of friction, wear rate.*

1. INTRODUCTION

Friction is the resistance to movement of one body over other body. The word comes from the Latin verb *fricare*, which means to rub. The bodies in question may be a gas and a solid (aerodynamic friction), or a liquid and a solid (liquid friction); or the friction may be due to internal energy dissipation processes within one body (internal friction). In this article, the discussion will be limited to the effects of solid friction. Friction plays an important role in a significant number of our daily activities and in most industrial processes. It helps in starting a body into motion, changing its direction, and subsequently stopping it. Without friction, we could not readily move around, grip objects, light a match, or perform a multitude of other common daily tasks. Without friction, most threaded joints would not hold, rolling mills could not operate, and friction welding would obviously not exist. Without friction, we would hear neither the song of the violin nor the squeal of the brake [1]. Friction is commonly represented by the friction coefficient, which symbols μ or f generally are used. The friction coefficient is the ratio between the friction force, *F*, and the load, *N* , Equation (1):

$$\mu = \frac{F}{N}. \tag{1}$$

The friction coefficient typically ranges from 0.03 for a very well lubricated bearing, to 0.5 to 0.7 for dry sliding. A value of 0.2 to 0.3 allows for comfortable walking; however, walking on ice is very difficult.

Wear is the progressive damage, involving material loss, which occurs on the surface of a component as result of its motion relative to the adjacent working parts [2].

Perhaps the biggest challenge in solving wear problems is that of anticipating the type(s) of wear to which components will be subjected. Material can be removed from a solid surface in only three ways: by melting, by chemical dissolution, or by the physical separation of atoms from the surface. The last method can be accomplished either by the one-time application of a high strain or by cyclic straining at lower magnitudes. Mechanical and chemical processes may operate separately or together, such as abrasion in a corrosive medium.

Abrasive wear occurs when a hard surface or hard particles plough a series of grooves in a softer surface. The wear particles generated by adhesive or corrosive mechanisms are often hard and will act as abrasive particles, wearing the contact surfaces as they move through the contact [2]. The most common wear model is named Archard's Wear Law, although Holm [3] formulated the same model much earlier than Archard. However, Archard and Holm interpreted the model differently [4]. The model has the following general form, Eq. 2:

$$V = K \cdot \frac{F_N}{H} \cdot s \,, \tag{2}$$

where V is the wear volume, K is the dimensionless wear coefficient, F_N is the normal load, H is the hardness of the softer contact surface and s is the sliding distance.

Equation (2) is often reformulated by dividing both sides by the apparent contact area A and by replacing K/H with k:

$$\frac{V}{A} = k \cdot \frac{F_N}{A} \cdot s \,, \quad \frac{F_N}{A} = p \,, \quad \frac{V}{A} = h \,,$$
$$\xrightarrow{\text{yields}} \; h = k \cdot p \cdot s \,, \tag{3}$$

where h is the wear depth in m, k is the dimensional wear coefficient in m^2/N, p is the contact pressure in Pa and s is the sliding distance in m, as before.

This wear model is widely used. The wear and friction problems are extremely important because of the negative effect on the accuracy of the sliding parts, in addition to the large material losses caused by wear. Observed (Archard), the wear rate decreases with time in the lubricated state, while it increases in the dry state [6]. There are two cases of wear. The severe wear and mild wear, it is observed that the severe wear is formed when the load hanging is high, while mild wear occurs when the normal load is hanging relatively small [7]. Severe wear is characterized by the rough surface and the size of debris wear ranges between 10 to 100 µm. Mild wear is characterized by the smooth surface and the size of debris is less than in the case of severe wear; it ranges from 1 to 0.01 µm, and the debris of the wear is a peel oxidant [8]. Archard has observed that the transition from mild wear to severe wear obtain an increase of load. Severe wear causes the large damage to material and quick replacement of the tops of Micro roughness which is opposite of what is happening in the mild wear [9].

The alloys of copper with zinc and brass are the first alloys accompanying the development of mankind. Nowadays, they are widely applied in technology, and next to light metals they belong to the most commonly used alloys in the group of non-ferrous metals. Brass is gives the results in high-resolution and is widely used in industry [5]. Thanks to its specific properties, brasses are applied in various domains of industry, among others in civil engineering, armaments industry, aircraft industry, machine building, the production of motor cars, electrical industry, ship-building, precision mechanics, and chemical industry and many others, even in the production of musical instruments [10]. It was observed that the wear mild in the case of alloy brass CuZn30 turns severe wear after a period of time and then a few turns to mild wear, while the alloy brass CuZn40 with the content of 2 % lead gives severe wear when the normal load is little [9]. A cold worked brass CuZn30 should be annealed at a temperature of 400 – 600 °C followed by cooling in air or quenching in water. The greater the degree of cold working the lower is the temperature necessary for full annealing. Grain growth occurs and the strength of the brass is lowered considerably when annealing at temperatures above 600 °C [7]. High quality brass CuZn30 is generally made from very clean scrap and the purest copper and zinc. Most specifications demand the iron content to be less than 0.1 % and bismuth less than 0.005 % since both these elements affect the ductility of the brass. Although the brasses CuZn30 may be cold worked to a very pronounced degree without detriment, they do not work at all well when hot. If material is forged at high temperature, it tends to crack and disintegrate. The material is often called HOT SHORT [7].

2. EXPERIMENTAL DETAILS

The use of a wear is in the case of touching between the two solid bodies under the influence of vertical load (pin-on-disc), designed according to the specifications (ASTM), and shown in Figure 1. The experiments were conducted on the brass alloy CuZn30, the chemical composition of alloy brass CuZn30 is presented in Table 1. The usage of the discs, with 200 mm diameter each, of high carbon steel with varying hardness is shown in Table 2. The examination the sample (pin) was performed after every 10 minutes of running and calculation of how much weight was lost. The experiment per a sample was stopped after an hour. Samples were prepared in a rod-shaped diameter of 10 mm and a length of 92 mm to suit the specifications of the device (pin-on-disc). Roughness was measured with the Talysurf-Hobson device. After each experiment examination process was performed of the surface, without making any change to it, by using the naked eye and scanning electron microscope (SEM) type JEOL-JSM-T20.

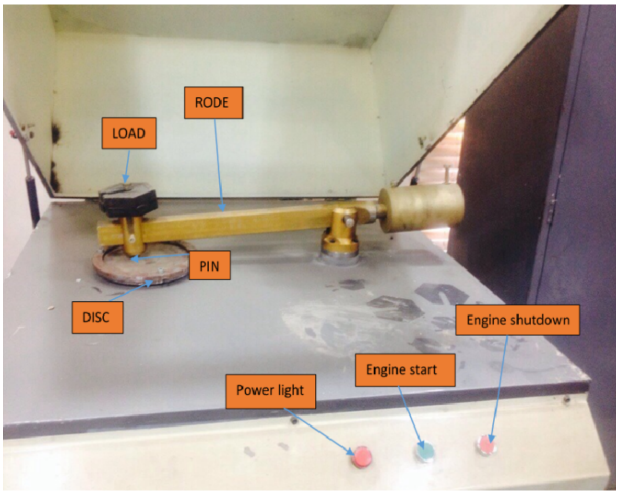

Figure 1. Pin-on-disc device

2.1 Wear rate measurement

The wear rate was measured by the method of weight, where the sample is weighed before and after the running by the delicate digital balance (0.0001 mg), type Mettler HK 160. Weight lost is calculated wear rate:

$$\frac{\mathrm{d}V}{\mathrm{d}L} = \frac{W}{\pi \cdot \rho \cdot D \cdot N \cdot T}, \tag{4}$$

where $\mathrm{d}V/\mathrm{d}L$ is volume the rate of wear, W is weight lost [g], L is sliding distance [cm], ρ is density of brass [g/cm^3], D is diameter which rotate by the sample [cm], N is sliding speed [rpm], T is sliding time [min].

2.2 Coefficient of friction measurement

Friction force was measured by using the Strain Gauge type (Koyma-Japan), where the two measures are linked into the form of half bridge each measuring coefficient (2.09 ± 1 %), bridge linked to a digital amplifier type 5702, where strain is transferred to the chart recorder type (Beld win messtechnich HBM Hotinaer), linked to a digital amplifier and a calibration curve determines the force acting on the sample (in the same direction of the force of friction).

3. EXPERIMENTAL PROGRAM

Wear experiments were carried out for three different normal loads of (10, 15 and 20 N) and three different velocities (95, 250 and 350 rpm) at atmospheric condition. Each test was conducted for at least three repeated times at the same test conditions to ensure the repeatability. The ring surface was abraded before each test with a P1500 grade emery paper; also, the pin was initially rubbed against the P1500 grade emery paper pasted on the ring to establish a conformal contact of the composite pin with the counterpart (cup). The program is divided into groups practical for brass alloy CuZn30. To measure the wear rate it takes of 10 minutes per read (10, 20, 30, 40, 50 and 60 minutes) as shown in Table 3, and time to measure coefficient of friction is 2 minute per read (0.5, 2, 4, 6, 8 and 10 minutes), as shown in Table 4.

Table 1. Chemical content of brass CuZn30

Components	Cu	Zn	Sn	Pb	Fe	Ni	AL	Total	Impurities
Brass CuZn30	70.1	29.6	-	-	-	0.001	0.039	99.7	0.3

Table 2. Hardness and surface roughness of steel and brass CuZn30

Component	Brass CuZn30	Disc 1	Disc 2	Disc 3	Disc 4	Disc 5
Hardness, HV	113.8	300	340	395	500	600
Surface roughness [µm]	0.25	0.35				

Table 3. The program is divided into groups practical for brass alloy CuZn30

Material	Sliding speed [rpm]	Normal load [N]	Surface roughness [µm]		Hardness, HV	
			Disc	Pin	Disc	Pin
Brass CuZn30	95	10	0.35	0.25	300	136.486
		15				
		20				
	250	10				
		15				
		20				
	350	10				
		15				
		20				

Table 4. Experimental program to study the effect of disc hardness

Brass alloy CuZn30					
No. experience	Hardness, HV	Normal load [N]	Sliding speed [rpm]	Surface roughness [µm]	
				Disc	Pin
Disc 1-01	300	15	350	0.35	0.25
Disc 2-02	350				
Disc 3-03	395				
Disc 4-04	500				
Disc 5-05	250				

4. RESULTS AND DISCUSSION

4.1 Behaviour of the coefficient of friction and wear rate of the brass CuZn30 on counterface material

It has become axiomatic in the field of tribology that virtual contact area is larger than the real contact area, taking the Figure 2 into consideration it became clear that effect track width of sample on the disk increases with sliding time. Reach value is greater than the diameter sample, and this indicates that the thermoplastic flow to the sample has been obtained, after a period of time, due to the height of the region obtained by the thermoplastic flow of disk and that the level of curvature slide. The impact of sample has been photographed on the disk after two minutes with different magnification by device type (photo microscope – M400), where the transition metal of the sample to disk initially has intermittent as in Figures 3 and 4 because of the nature of the surface, where the real contact area at the start of the process is small but increases as a result of the high temperature and softer metal and obtain the flow of thermoplastic, and which are then coverage track fully material brass CuZn30. This leads to the stability of the value of the coefficient of friction after a period of time, as in Figure 5.

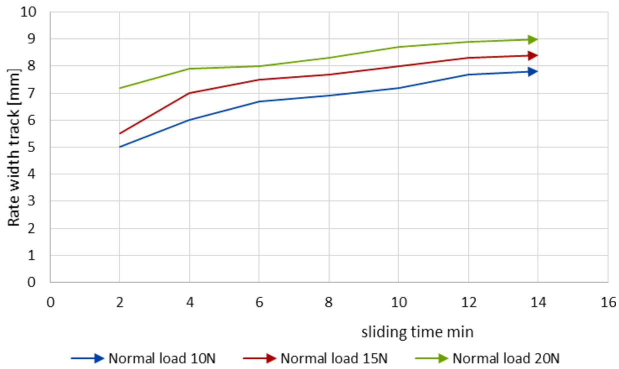

Figure 2. Relationship between sliding time & normal load; brass CuZn30, sliding speed 350 rpm

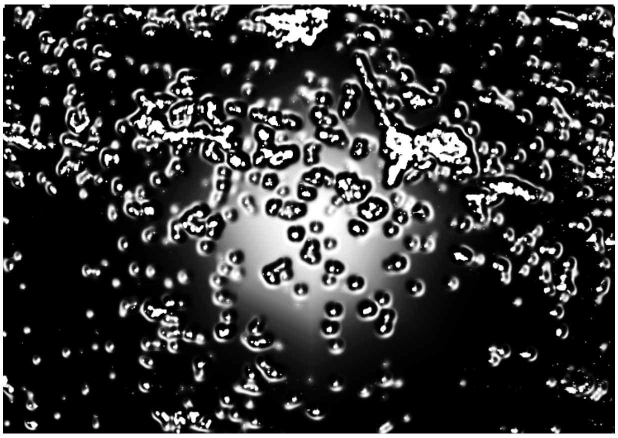

Figure 3. Track of pin material (brass CuZn30) on disc; magnification power 28 ×

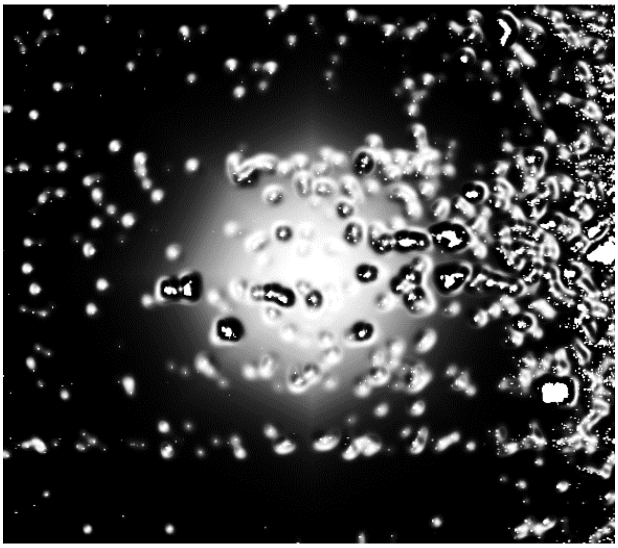

Figure 4. Track of pin material (brass CuZn30) on disc; magnification power 7 ×

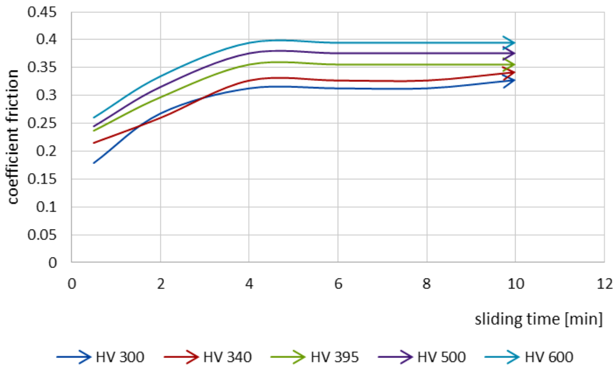

Figure 5. The practical results of dry sliding when vertical load was 15 N and sliding speed 350 rpm for brass CuZn30

4.2 The coefficient of friction and rate wear of counterface material (disc) on brass alloy CuZn30 (pin)

The Figure 6 shows the wear rate of the brass CuZn30. The highest wear rate was for HV 300, and the wear rate is less than the HV 600, and for the state of stability when the HV 395. However, a HV 395 is the transformation point of the increase in the rate of wear to decrease the greater the hardness of the disk. From this it is clear that whenever the hardness of the disk was near hardness sample receives an increase in the rate of wear. The largest difference between them is less wear rate. This is few in the wear rate, but it leads to an increase in the coefficient of friction due to increased real contact area, and whenever the high hardness disk as it occurs the flow of thermoplastic metal soft more probable, leading to an increase in the coefficient of friction with increasing hardness metal surfaces on each, causing occurrence work

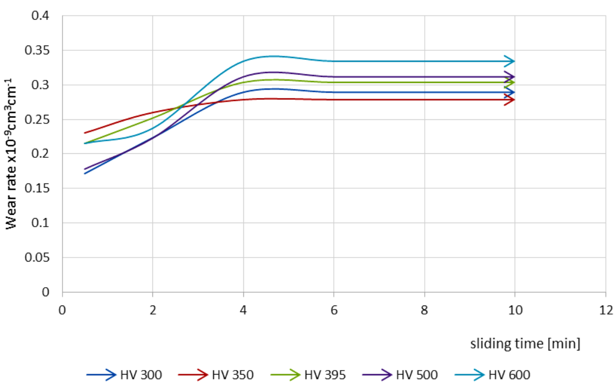

Figure 6. The practical results of dry sliding when vertical load was 15 N and sliding speed 350 rpm for brass CuZn30

hardening of the surface and subsurface distortion. In Figure 7 observe that the hardness of the metal was less as we move away from the surface layer towards the strength of the metal basic. The value of hardness is higher at the region between the surface wear and subsurface. This indicates a work hardening of this layer more than others, and can be seen in this layer (Figs. 8 and 9).

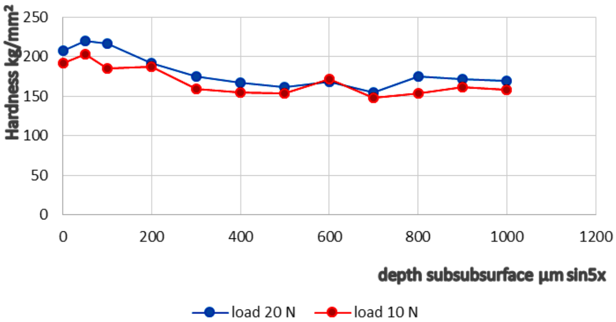

Figure 7. The relationship between hardness and depth of the subsurface (brass CuZn30; sliding speed 350 rpm)

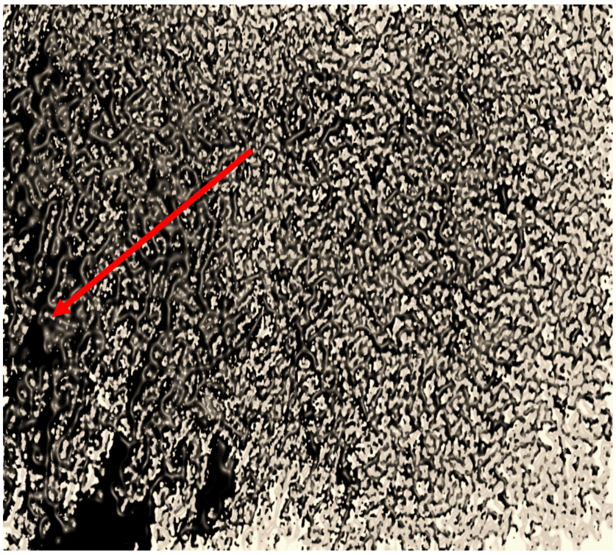

Figure 8. Ultrastructure of the layer below the surface, when the load was 20 N, sliding speed 350 rpm, hardness of disk 300 for brass CuZn30; magnification power 700 ×

5. CONCLUSIONS

The coefficient of friction depends on the nature of the installation of alloy metal, and depends on the amount and type of distortion that occurs.

At least the coefficient of friction increase elements follows operate as a lubricant. The value of the coefficient of friction depends on the hardness of the disk user, where increasing upwards in both materials (disc and pin).

The drop the value of the coefficient of friction does not mean a decrease in the rate of wear.

The wear rate increases with increasing hardness of the disk and to a certain value, followed by a decrease the increase of the hardness to this extent. In the case of the sliding surfaces prefer to use components intermetallic soft to ease the transition from one surface to the other, and thus decreases the friction between the plant surfaces.

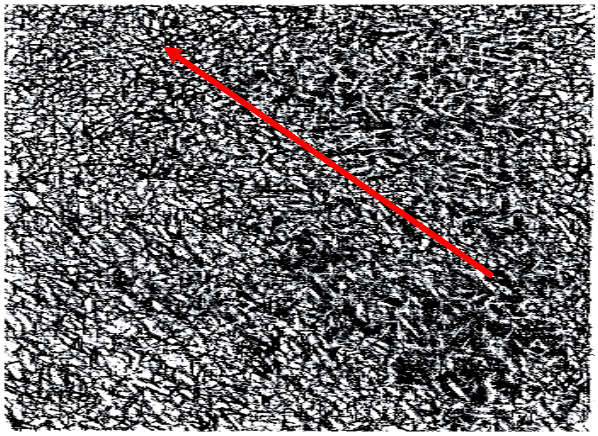

Figure 9. Ultrastructure of the layer below the surface, when the load was 10 N, sliding speed 350 rpm, hardness of disk 300 for brass CuZn30; magnification power 350 ×

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