

## Study of the Influence of Surface Roughness, Sample Heat and Sample Shape on Wear Rate Measurements

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### ABSTRACT

Metal samples such as Copper and Aluminum and alloy as Brass were prepared and machined as discs (plane sample) and as a half rings (curvature sample). The samples were polished by using metallographic paper with different grades. The micro roughness and the initial weight were measured for all samples before wear tests, and then the samples were subjected to wear testing system under lubricated condition, fixed normal load of 15N, sliding time 30 min and sliding speed of 750 rpm. During the running of wear testing system the temperature of the samples were measured. The wear rate was calculated by employing the weighing method. It is clear from the results that micro roughness values increasing leads to increase in weight loss , wear rate and the temperature of samples .The effect of sample shape on weight loss , wear rate and sample heat is also obvious when noticing that the different measurements of weight loss, wear rate and sample heat of curvature samples are higher than that of plane samples .

**Key words:** micro roughness, Copper, Aluminum, Brass, Wear.

### دراسة تأثير خشونة السطح، درجة حرارة النموذج وشكل النموذج على قياسات معدل البلى.

#### الخلاصة

تم في هذا العمل تحضير وتشغيل نماذج من المعادن كالنحاس والألمنيوم ونموذج من السبائك كالبراص وتشغيلها كأقراص (نماذج مستوية) وأنصاف حلقات (نماذج منحنية) . تم تنعيم جميع النماذج باستخدام ورق تنعيم بمختلف الدرجات وتم قياس الخشونة المايكروية للسطح لجميع النماذج وكذلك قياس أوزانها الابتدائية وبعدها تم اجراء فحص البلى تحت شرط التزييت وتحت حمل عمودي ثابت مقداره 15 نيوتن ووقت انزلاق 30 دقيقة وسرعة انزلاق 750 دورة/دقيقة . خلال تشغيل منظومة فحص البلى قيس درجة حرارة النماذج وتم حساب معدل البلى باستخدام الطريقة الوزنية . ومن النتائج التي حصلنا عليها يمكن ملاحظة ان الزيادة في قيم الخشونة المايكروية تؤدي الى زيادة في الوزن المفقود ومعدل البلى ودرجة حرارة النماذج. كذلك فان تأثير شكل النموذج على الوزن المفقود ، معدل البلى ودرجة حرارة النماذج يبدو واضحا حيث أظهرت قياسات الوزن المفقود، معدل البلى ودرجة حرارة للنماذج المنحنية انها اعلى من تلك التي قيست للنماذج المستوية .

## INTRODUCTION

Sliding friction is primarily a surface phenomenon consequently it depends very markedly on surface condition, such as roughness, degree of work hardening, type of oxide film and surface cleanliness[1]. In general, they are supported by the surface irregularities which are present even on the most carefully prepared surfaces, such roughness are usually characterized by means of a profilometer in which a fine stylus runs over the surface and moves up and down with the surface counter [1,2]. The study of the tribological properties of the linear – cylindrical in an internal combustion has attracted much attention in the last few years. linear – cylindrical wear is known to play major role in an internal combustion engine durability, performance, emission, fuel economy and lube oil consumption [3]. The problem is a typical tribology problem where the interaction mechanisms between two surfaces in relative motion have to be identified [4]. T.Hiskado, K.Miyazaki and et al[5] studied the factors that will cause differences in wear and surface deterioration across the roll surface. Limiting the factors such as roughness change on wear and have been reported about the effect of material flow stress, lubricant and surface roughness values on wear for pins having the greater wear amount is small as compared with that of the high surface roughness. Chin Wei Chang and Chun Pao Kuo [6] used new technique namely laser assisted machining (LAM) to improve the surface roughness values, where shows that LAM produces a better surface quality than conventional machining, and the surface roughness degraded considerably and the LAM processes, the cutting force is obviously significantly reduced and the case of cutting increased accordingly, resulting in evident improvement in surface roughness. S.Thamnaii, B.Bin omer and et al [7] studied the surface roughness investigation and hardness by burnishing on titanium alloy and proved that a lower surface roughness value and increased surface hardness leads to the wear rate. To overcome on wear problem some researchers as S.K.Jo, W.J.Lee[8] carry out studies to generate new materials for industry. M.Seeman, G.Ganesan and etal[9] were published about the effect of surface roughness in machining of particulate aluminum metal matrix composite and were founded that the surface roughness are greatly influenced by the various parameters. The tribological properties of aluminum alloy slid against steel were investigated from the stand point of surface chemistry and when added glycerol mono – olate to hydrocarbon oil, the wear and friction are reduced [10].

P.M.Ming, D.Zhu and etal [11] investigated the wear resistance of copper and concluded that the smallest relative electrode – wear ratio of the deposited copper material and enhance the wear resistance about 10%. P.L.Menezes and K.V.Satish[12] published research about the role of surface texture, roughness and hardness on friction during unidirectional sliding and proved that the friction predominantly depends on surface texture of the harder counter surface.

## THEORETICAL PART

### Wear definition

Wear is the progressive loss of material due to interacting surface in relative motion. It is quantitatively measured as the specific wear rate defined as volume loss per sliding distance and load, and the wear is the removal of material from one or both of two solid surfaces in a solid – state contact, it will occur when solid surface is in a sliding, rolling or impact motion relative to another. Wear occurs through surface interactions and asperities and component may need replacement after relatively small amount of material has been removed or if the surface is unduly roughened [13, 14].

## Wear Theories

The theories of wear as follows:

### 1-Classical Theory

According to Rabinowicz adhesive wear occurs when surface slide Against each other and the pressure between the contacting asperities is sufficiently high enough to cause local plastic deformation. Hardness of a material determines the real area of contact between asperities of contacting materials [15].

### 2-Adhesive wear theory

The adhesive wear theory stated by Archard which was defined wear volume as function of sliding speed , normal load and material hardness[16] .

$$W= KdP/ 3H$$

Where W: wear volume, K: wear coefficient, d: sliding distance, P: applied normal load, H: bulk hardness

### 3-Delamination wear theory

Suh[17] proposed that at low sliding speed wear debris formation could be described by a delamination wear theory . Wear processes such as adhesive wear, fretting and fatigue were all related to this same mechanism. Such stated that wear occurred by the following sequential steps:

- Cyclic plastic deformation of surface layers by normal load.
- Crack or voids nucleation in the deformed layers.
- Crack growth nearly parallel to the surface.
- Formation of thin long wear debris particles and their removal by extension of cracks to the surface.

### Lubrication

The purpose of lubrication is to separate the surfaces moving relative to each other with a film of a material which can be sheared with a low resistance without causing any damage to the surfaces . The term Lubrication is applied to two different situations [13,18] . Fluid lubrication which occurs when a thick film of some liquid or gas completely separate two solids . The other type is called (solid film) lubrication in which a soft solid film of substantial thickness interposed between the sliding surfaces . Most lubricants are introduced into sliding system with the aim of reducing the amount of interaction between the contacting surfaces . Thus a lubricant may be used to reduce the amount of wear , or the degree of surface adhesion . Some times the prime task of the lubricant is to reduce the interfacial temperature , which produce some harmful change . For example local melting in one of the contacting surfaces materials [19-20] .

### Wear rate calculation

Weighing method is the simplest way of measured wear. The specimen is weighed before and after running, and the weight loss calculated to get the wear rate according to the following equation [21,22].

$$W.R.= w /\pi DMT \text{ (g/cm)}$$

where W.R: Weight wear rate (g/cm)

w : weight loss (gm) , D : Hard disc diameter (cm) .

M: sliding speed (r.p.m.) . T : sliding time (min.) .

The resolution of this method depends upon the used balance . In this work , we will depend on this method for determine the weight loss and wear rate measurements .

## EXPERIMENTAL PART

### Sample preparation

Sample of metals such as Copper and Aluminum and Brass alloy previously produced as rod shapes (product by Fluka company) were prepared by machining into two shapes namely flat disc (plane sample) of 2.5cm as a diameter and 0.3cm as a thickness , the other sample shape is a half ring (curvature sample) of 2.5cm as a diameter and 0.3cm as a thickness . All sample were cleaned by solution namely Titan carb and shoke cleaner product of Turkey and then polished with metallographic paper with different grade.

### The initial measurements

The initial measurements involved the surface micro roughness, initial weight and the heat of sample. Surface micro roughness was conducted by using micro roughness tester type TR-2200, and initial weights were measured for all sample before and after wear testing by using sensitive electronic balance type (KERN) of accuracy of  $10^{-4}$  g ,and the heat of sample was measured by using thermocouple contact with sample .

### Wear test procedure

All samples were subjected to wear testing system under lubricated condition. Each sample was placed in the holder of sample under fixed parameter such as load of 15N, sliding speed of 750 rpm and sliding time of 30min. The container of wear system was filled with lubricant type Al-Dura of specification SAE: 40HD, Flash point:236 , Viscosity at 100 °C: 15centistock Pour point at -9 °C . The weight of sample was measured before and after running and the sample heat was measured during the wear testing.

## RESULTS AND DISCUSSION

Figures (1) and (2) represent the wear rate of Brass, Copper and Aluminum as a function of surface roughness for plane and curvature samples and Figures (3) and (4) represent the weight loss of Brass, Copper and Aluminum as a function of surface roughness for plane and curvature samples. from these figures can be shown obviously that the wear rate and weight loss increased when the surface roughness values increased In the beginning of the sliding , the removal of some materials from the specimens was due to wear , arises when junctions weld together become broken by relative motion . In the same time one can be shown that the wear rate and weight loss for curvature sample is higher than the wear rate and weight loss of plane sample this behavior may due to the several reasons such as the increasing of the contact area between the two mating surface and then the friction between them increased too and also to the heat which arise in contact area between the mating surface as shown in Tables (1) and (2) and to the arise particles between the mating surfaces can damage surface and lead to fatigue and wear these results agrees with Ref.[17]

Figures (5- 7) illustrates the microscopic photographs for Aluminum, Copper and Brass respectively. These figures show the damage occurred during sliding process after 30 minutes. The reveal of fine cracks and adhesive wear actions were clearly observed in these figures and confirmed with wear theories which was mentioned in theoretical part.

## CONCLUSIONS

It is clear from the present results that the conditions of increasing surface roughness will increase the weight loss and hence the wear rate for all samples. In addition, the surface

roughness is proportional with the sample heat. The shape of sample has an affected on the weight loss, wear rate and the sample heat.

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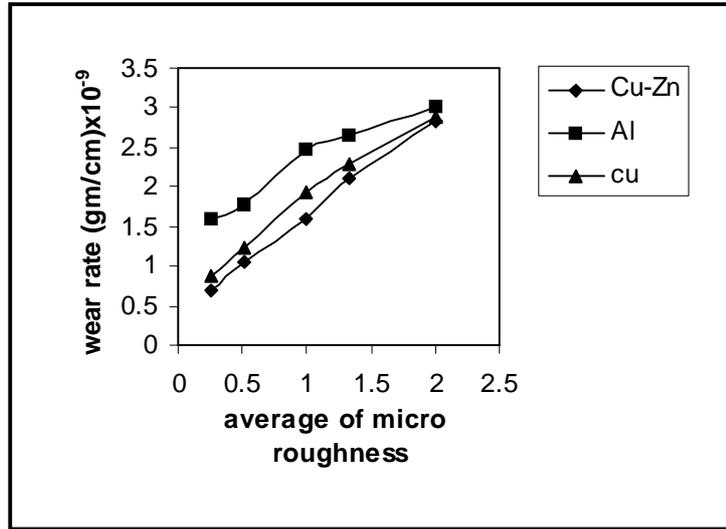
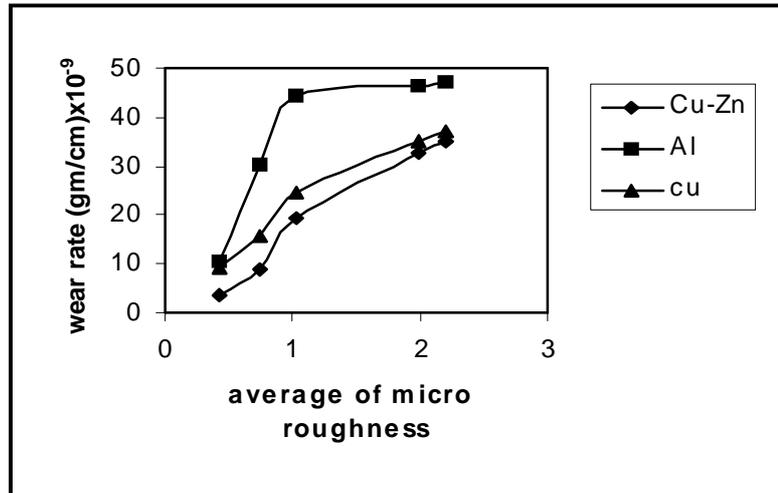
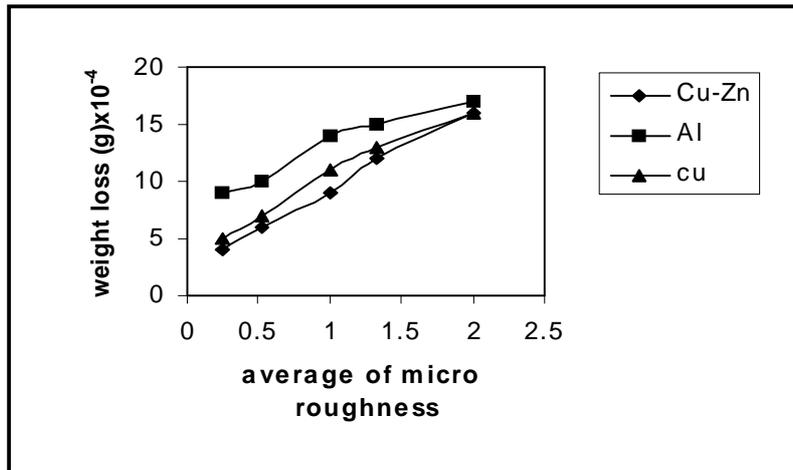


Figure (1) Wear rate of plane samples as a function of micro roughness .



Figure(2)Wear rate of curvature samples as a function of micro roughness .



Figure(3) weight loss of plane samples as a function of micro roughness .

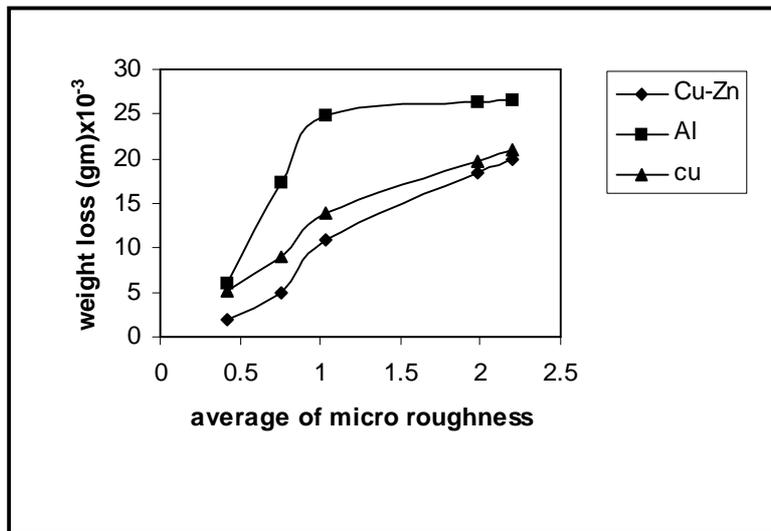


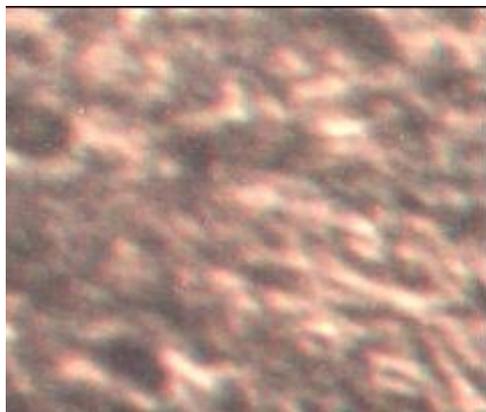
Figure (4)weight loss of curvature samples as a function of micro roughness .

Table (1) Temperature plane samples versus with micro roughness.

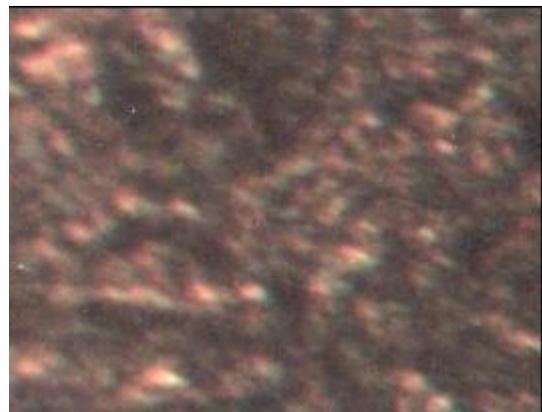
micro roughness	Temp. of Cu-Zn (°C)	Temp. of Cu (°C)	Temp. of Al (°C)
0.240	17	18	20
0.550	24	26	27
1.000	26	28	30
1.330	27	30	32
2.000	28	31	33

Table (2) Temperature curvature samples versus  
with micro roughness.

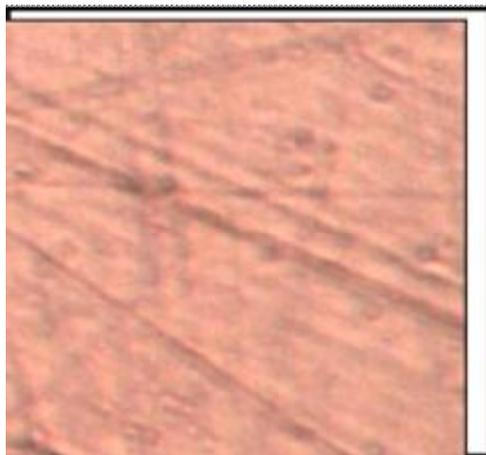
micro roughness	Temp. of Cu-n (°C)	Temp. of Cu (°C)	Temp. of Al (°C)
0.425	19	20	22
0.752	27	28	30
1.031	30	31	24
1.982	32	34	36
2.200	33	35	36



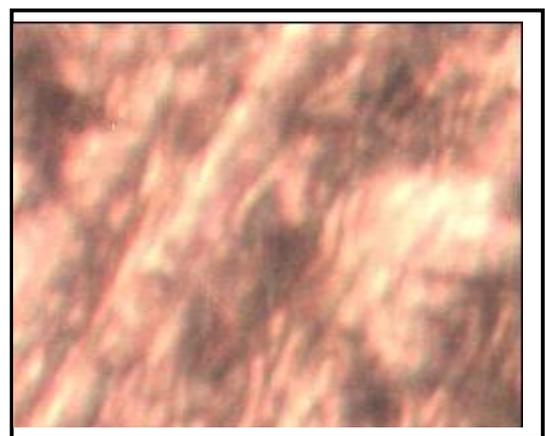
Figure(5a) Aluminum before wear testing.



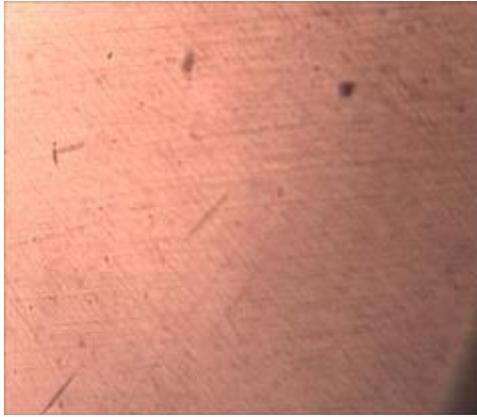
Figure(5b) Aluminum after wear testing .



Figure(6a) copper before wear testing.



Figure(6b) copper after wear testing.



**Figure(7a) Brass before wear testing.**



**Figure(7b) Brass before wear  
Testing.**