A comparative study of tribological behavior of Steel and brass under dry sliding condition

1st Bougoffa Mohammed Seyf Eddine, 2nd Sayah Tahar .

1st Laboratoire de Science et Génie des Matériaux, Faculté de Génie Mécanique et Procédés U.S.T.H.B, B.P. 32 El Alia, Bab Ezzouar, Alger 16111, Algérie,

2nd Laboratoire de Science et Génie des Matériaux, Faculté de Génie Mécanique et Procédés U.S.T.H.B, B.P. 32 El Alia, Bab Ezzouar, Alger 16111, Algérie,

…………………………

Seif.bougoffa@gmail.com

***Abstract*—The objective of this study is to evaluate the friction and wear behavior of hard steel and brass alloy under dry sliding condition, the tribological behavior was investigated and compared by wear tests, using CSM tribometer. These tests consisted of measuring the wear loss and the friction coefficient of samples. Experiments are conducted at normal load 5 and 10 N, sliding velocity 0.04 and 0.15 m/s. Variations of friction coefficient with the duration of friction at different normal load and sliding velocity are investigated. Results show that the two alloys had similar friction and wear performance, although their grain structures and compositions are different. friction coefficient decreases with the increase of normal load and sliding velocity. On the other hand, it is also found that wear loss increase with sliding distance and their trend curve follows a logarithmic law. Microscopic of worn surfaces for each material were carried out and compared.**

Keywords—Tribological behavior, Friction, Wear, sliding distance.

I. INTRODUCTION

The alloys studied hard steel and brass are widely used in applications where a high resistance to wear and corrosion is necessary. However, their properties such as hardness and wear resistance are not always well determined. Wear is an evolutionary phenomenon and irreversible; each state of a system permanently destroys the previous state, so that it is very difficult, even impossible, to reconstitute the past from the observation of a degradation.

The understanding of a phenomenon of wear requires that we can record, if possible continuously, the various parameters allowing to characterize the state of the studied system over time. Unfortunately, these parameters are very numerous, it is estimated, for example, that takes between 100 and 200 to define the only geometric characteristics of one of the surfaces rubbing ... and we must still characterize the other surface, the physicochemical state of the materials on a sufficient depth, the state and composition of the environment, the thermal factors and mechanical, etc

Aggression due to wear are a common problem in engineering, that the piece, the device, the system, are in contact with solids, liquids or gases. In general, the damage caused by wear can be mitigated, even avoided, by substituting more resistant materials. However, such materials are often very expensive. Considering of these imperatives we are led to consider treatment techniques and surface coating, which offers another way to combat wear and corrosion. Wear involves a large part of chemical reactions; layers surface chemically inert can sometimes be more resistant to friction than hard layers, especially in the presence aggressive environments. This technique is industrially widespread in many sectors for tribological applications, such as the automobile (bearings, cylinders, ...), aeronautics (feet blades, ...), biomaterials (prostheses, ...). plasma projection is a process flexible, both for the choice of materials and for the experimental conditions, thus allowing a wide range of applications. Although steel and brass alloy have been investigated for orthopedics application from several aspects, such as mechanical properties, corrosion resistance, and castability, A few studies have reported on its friction and wear resistance [1-4],, which is an important factor for total hip prostheses material. This research study the behavior of ferrous and non-ferrous materials in wear and friction using CSM tribometer. The results of this work can be beneficial for practical implication of machine design and other mechanical concerned mechanisms.

II. EXPERIMENTAL METHOD

A. Experimental device

The tests were carried out on a tribometer brand CSM. a cylindrical mass posed in its medium on an axis being used as support. The support of the mass transmits the normal force (1), by actuating the lever (2), with the pawn (3) fixed by bite (4) rotated by an electrical motor (5). The coefficient of friction is determined during the tests by measuring wear loss for the pion by determining the loss of volume during the test. This simple method facilitates the study of the mechanisms of friction for a large variety of material couple without agent of lubrication. Moreover, the control of the parameters of test such as speed, the contact pressure, the frequency, the duration of test as well as the environmental parameters (temperature, hygroscope, lubrication) make it possible to reproduce the real requests of use of these materials. The materials chosen in this investigation are Aluminum and brass.

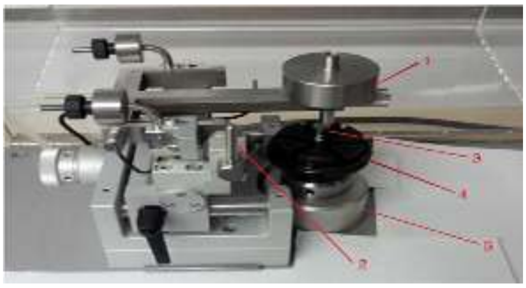

Fig. 1. View of the CSM Tribometer

B. *Experimental procedure*

The detail experimental conditions are shown in Table 1.

TABLE I. EXPERIMENTAL CONDITIONS.

N °	Parameters	Operating conditions
1	Normal load (N)	5 - 10
2	Sliding velocity (m/s)	0.04 - 0.15
3	Sliding distance (m)	432 - 882
4	Duration of the test (s)	1800
5	Average surface roughness of samples	0.5 - 0.7 µm
6	Surface condition	Dry
7	Temperature(°c)	20(±1)
8	Relative humidity	40(±1) %
9	Pin material	steel
10	Material of samples	Brass Steel

III. RESULTS

A. *Caracterization of coefficient of friction*

Figures 2 to 5 show the coefficient of friction recorded during dry sliding wear of Steel and Brass at different normal loads and sliding velocity.

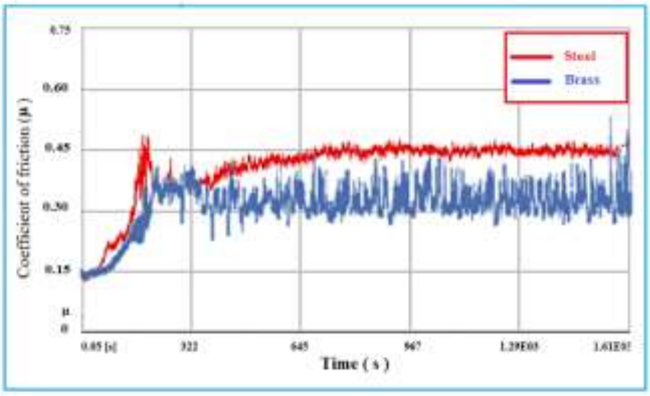

Fig. 2. Variation of Coefficient of friction of Steel and Brass with respect to time at Normal load: 5N; sliding velocity: 0.04 m/s.

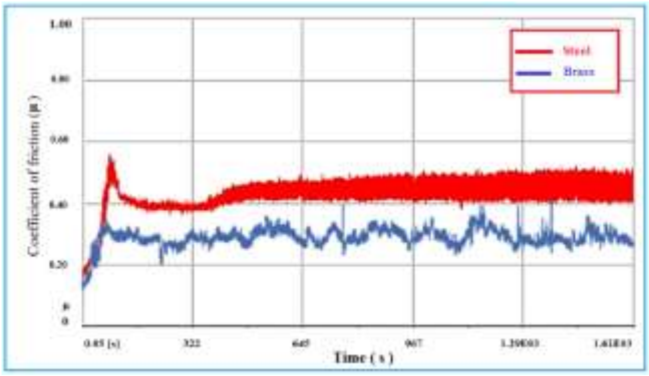

Fig. 3. Variation of Coefficient of friction of Steel and Brass with respect to time at Normal load: 10N; sliding velocity : 0.04 m/s.

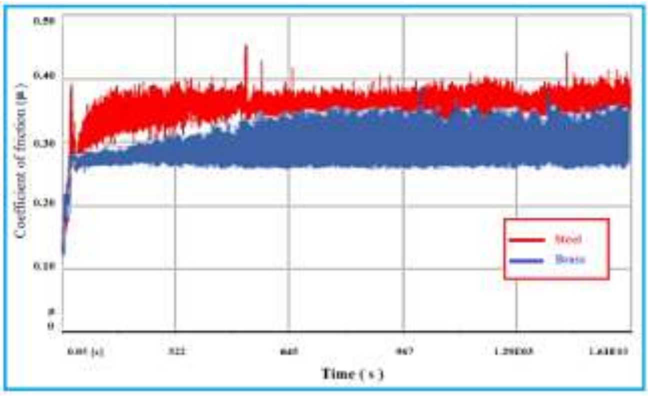

Fig. 4. Variation of Coefficient of friction of Steel and Brass with respect to time at Normal load: 5N; sliding velocity: 0.15 m/s.

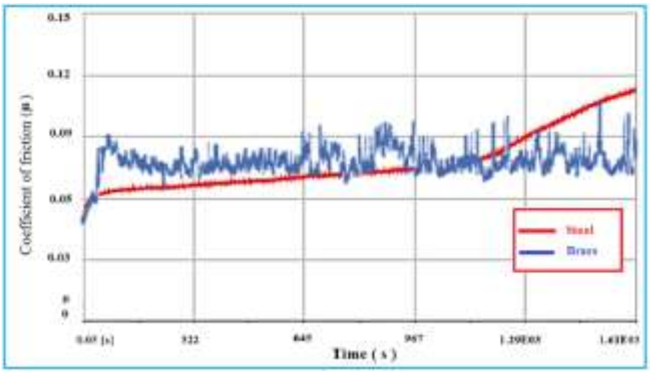

Fig. 5. Variation of Coefficient of friction of Steel and Brass with respect to time at Normal load: 10N; sliding velocity: 0.15 m/s.

The evolution of the coefficient of friction shows three phases: during the first phase we see an increase in the coefficient of friction (short rapid growth phase) then the second corresponds to the fall then in the third phase it increases slightly before stabilizing at a certain value. Contrary to hard steel, there are only two areas on the curves of coefficient of friction of the brass alloy. So are much more stable. They then increase slowly to stabilize until the end of the test. It should be noted that this final value is less than the coefficient of friction of steel. trend curves are shown below. In case of starting of wear in process, film due to oxidation takes initiation to break the area of contact and as a consequence, deposition film deformed to create real metal to metal contact. The other considerable factors such as, ploughing formation, chip like abrasive metallic formation within the pin and disc impacting area and surface condition such as waviness, texture or roughness of test sample, increased frictional force generated with wear in process.

Finally, the properties incorporating material loss processes are not changed with time and friction remains unchanged to maintain constant level. Similar trends are observed for all curves. The analysis of results confirm that wear in process periods for unchanged constant level are not similar for observed applied loads. During friction process, for low, mid and high range of applied load, steel-steel precise combinations are attained unchanged level. In fact, it can be realized that the applied load from low to high range, wear in process period to attain an unchanged level is small. The observations are in agreement with the observation of other researchers [5-7].

B. *Caracterization of wear*

Several experiments are carried out to observe the effect of normal load and sliding speed on wear loss of steel-steel pair. Curve of Fig. 6 shows the variation of wear loss with the variation of load and speed. From this figure, it is observed that wear loss increases with the increase of normal load and sliding speed. This is due to the fact as the normal load increases frictional heat generates at the contact surface and hence strength of materials decreases. Furthermore, it this decrease is due to a detachment of material from the pion following the friction of rough surfaces (pion-disk) in contact. Or the asperities of the two surfaces interpenetrate under the influence of the normal load and sliding speed of the disk causing the tearing particles of matter.

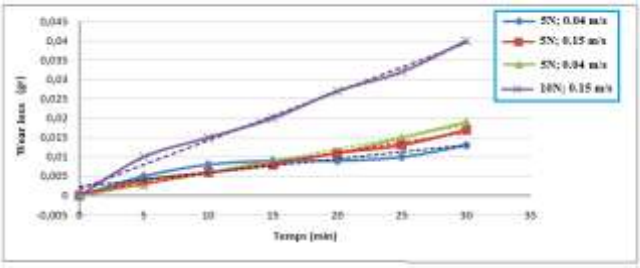

Fig. 6. Wear loss with respect to time at different normal load and sliding velocity of steel-steel pair

C. *Specific wear rate*

From the table below it can be deduced that steel has better strength, if the normal force increases the wear rate decreases, this is the case for steel 2 and 4 compared to Steel 1 and 3 and if the rotation speed of the disc increases the wear rate increases.

TABLE I. SPECIFIC WEAR RATE OF STEEL-STEEL PAIR.

Material	Specific wear rate (10^{-9} cm^2/N)	
	Brass	***Steel***
Sample N° 1	7.0340	0.5486
Sample N° 2	6.7377	0.5110
Sample N° 3	20.9636	1.2154
Sample N° 4	10.6345	3.2639

D. *Worn Surfaces*

Figure 7 and 8 shows the optical pictures of the worn surfaces for different combinations of sliding steel and brass. From these photographs, it is confirmed that the higher the normal load less rougher steel and brass surfaces for different sliding pairs are observed. In contrast, the higher the sliding velocity more rougher the steel and brass surfaces are seen. It can be noted that these observations are also ensured by measured roughness values of steel and brass for different combinations. The optical microscopy studies of wear surface show abrasive and adhesion wear on the surface of steel and brass for different combinations. The debonding/pullout of the particles are also seen. The particle reinforcement significantly improved wear resistance.

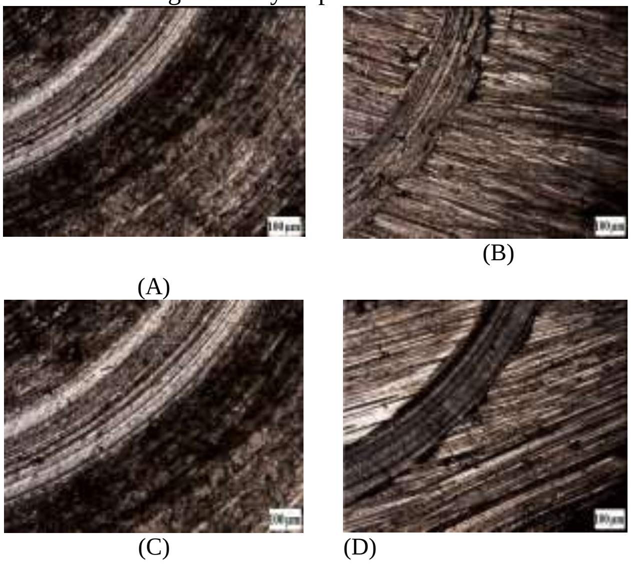

Fig. 7. Optical microscopy of worn surfaces of Steel for (A) 5N-0.04 m/s (B)10N, 0.04 m/s (C) 5N-0.15 m/s (D) 10N-0.15 m/s.

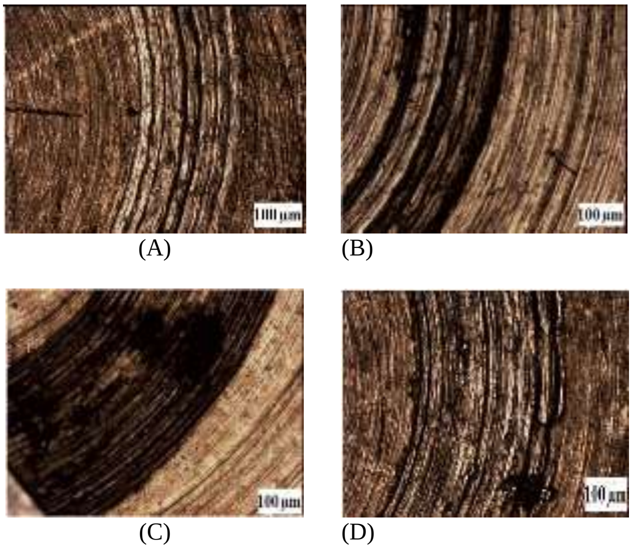

Fig. 8. Optical microscopy of worn surfaces of Brass for (A) 5N-0.04 m/s (B)10N, 0.04 m/s (C) 5N-0.15 m/s (D) 10N-0.15 m/s.

IV. CONCLUSIONS

The results obtained allowed us to draw the following conclusions:

· wear loss increases with normal load and sliding speed of the disc and present the same look for steel and brass alloy.

· The measurements taken show that this wear is deeply influenced by the sliding speed compared to the normal load.

· Wear loss increases with slip distance and their trend line follows a logarithmic law.

· The coefficient of friction decreases with the increase of normal load and sliding speed of the disc.

ACKNOWLEDGMENT

Several experiments in this work were conducted outside our laboratory for that, the authors would like to thank: LSDM laboratory (USTHB University).

REFERENCES

[1] M. A. Chowdhury, and M. M. Helali, “The effect of relative humidity and roughness on the friction coefficient under horizontal vibration", The Open Mechanical Engineering Journal, vol. 2, pp. 128- 35, 2008.

[2] M. A. Chowdhury, M. M. Helali, and A.B.M. Toufique Hasan, "The frictional behavior of mild steel under horizontal vibration", Tribology International, vol. 42, pp. 946- 950, 2009.

[3] M. A. Chowdhury, S. M. I. Karim, M. L. Ali, "The influence of natural frequency of the experimental set-up on the friction coefficient of copper", In: Proc. of IMechE, Journal of Engineering Tribology, vol. 224, pp. 293- 298, 2009.

[4] M. A. Chowdhury, D. M. Nuruzzaman, M. L. Rahaman, "Influence of external horizontal vibration on the coefficient of friction of aluminium sliding against stainless steel", Industrial Lubrication and Tribology, vol. 63, pp. 152- 157, 2011.

[5] M. A. Chowdhury, and M. M. Helali, "The effect of frequency of vibration and humidity on the coefficient of friction", Tribology International, 39, pp. 958-62, 2006.

[6] M. A. Chowdhury, and M. M. Helali, "The Effect of amplitude of vibration on the coefficient of friction", Tribology International, 41, pp. 307- 14, 2008.

[7] M. A. Chowdhury, M. K. Khalil, D. M. Nuruzzaman, and M. L. Rahaman, "The effect of sliding speed and normal load on friction and wear property of Aluminum", International Journal of Mechanical & Mechatronics Engineering, vol. 11, pp. 53-7, 2012