**ANNALS of the ORADEA UNIVERSITY.**

**Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007**

# STUDY ON ROLLING FRICTION COEFFICIENT FOR THERMAL-CHEMICAL TREATED STEEL SURFACES

**Rodica COZMA**
"Transilvania" University of Braşov, Department of Product Design and Robotics
e-mail: rocozma@rdslink.ro

**Keywords:** rolling-friction coefficient, balls, nitriding, nitrocarburizing , experimental results

**Abstract:** The study shows static friction coefficient variation of the ball bearing for some bearing configurations. The experimental studies have been done using a high precision prismatic meter with different balls and different diameters on the same groove configurations. The study states also the obtained tables of experimental results and the variation diagrams of the friction coefficient depending on ball diameter.

## 1. INTRODUCTION

The ball sliding bearings are well used in different specialties of mechanical and mechatronic engineering, due to multiple advantages towards sliding bearings. So, friction and adhesion wear are much reduced, the precision of positioning is high, the phenomenon of "stick-slip" is absent, there is the possibility of increasing the movement speeds, high rigidity and the possibility of making the sliding bearings by modules. Also, these sliding bearings are remarked by decreasing of friction force, therefore the decreasing of power needed for action, because of uniformity of movement at small speeds and because of high sensibility at precise movements.

The paper tries to establish an equivalent friction coefficient value for different types of hertzian contacts (ball on nitrided or nitro-carburized plane steel surface) for rolling start-moving conditions.

## 2. EXPERIMENTAL DETAILS

The experimental researches were realized on a high precision tribometer, on which it was set a device representing the ball sliding bearings. This tribometer works on the inclined plan principle. The tribometer has a simple design and an easy, fast, secure and precise utilization. On the mobile part of the tribometer a device is putted, composed of two plates, which have a relative sliding movement one upon the other by some balls. The tribometer and the device are presented in [1], also being described the used methodology. It were used eight types of the sliding bearings, realized with some plates realized on high precision and some balls, having the diameters between 8 and 26 mm.

The ball bearing realized like this is set on mobile part of the tribometer on prisms. The determination of the mobile part inclination for the moment when the sliding begins is made indirectly by measuring the distance $L_s$ between pins and both the mobile and the fix plates of the tribometer [1] (fig. 1), according to a non-linear relation, such as $\alpha = \alpha(L_s)$. The value of the friction coefficient is read directly from the tables of apparatus, according to the distance between pins.

To increase the precision of measurements, it was installed a caliber, whose detector touches the pin on the mobile part of the tribometer.

Within the frame of this work, it has been designed and manufactured special pairs of rolling motion couples, made from V320-Bohler Australian designation heat treatable steel. After that, some of them were nitrided (at 525ºC) and nitro-carburized (at 560ºC) in gaseous conditions. The rolling-friction tests supposed different arrangements of the half-couples and balls. The relative motion between the half-couples has been achieved with three identically balls, and the point contacts in three different contact zones. In order to establish the rolling-friction coefficient for all the thermochemical treated surfaces, a typical method such as the inclined plan slop, was used.

*Fig. 1. Tribometer with prisms*

## 3. EXPERIMENTAL RESULTS

Table 1 presents the experimental values from roughness $R_a$ and Vickers hardness for all the sample categories, after removing of extreme values for each kind of measurement.

*Table 1. Roughness $R_a$ and Hardness HV for the Sample Surfaces*

| Sample surfaces | Roughness $R_a$ [μm] | Vickers Hardness $HV_{0.050}$ |
|---|---|---|
| Nitrided | 0.48 | 756 |
| Nitro-carburized | 0.38 | 788 |
| Untreated | 0.11 | 238 |

Table 2 presents the rolling-friction coefficients established by the two inclined plane slope methods.

A, B, C, D, E, F were the following couples:

A: Untreated half-couple with longitudinal v-guide paths on the rolling-friction surface (fixed) – Balls – Plane untreated half-couple;

B: Plane untreated half-couple (fixed) – Balls – Plane untreated half-couple;

C: Nitrided half-couple with longitudinal v-guide paths on the rolling-friction surface (fixed) – Balls – Plane untreated half-couple;

D: Plane nitrided half-couple (fixed) – Balls – Plane untreated half-couple;

E: Nitro-carburized half-couple with longitudinal v-guide paths on the rolling (fixed)-friction surface – Balls – Plane untreated half-couple;

F: Plane nitro-carburized half-couple (fixed) – Balls – Plane untreated half-couple.

***Table 2. Average values of rolling-friction coefficient μ for different kind of couples and for different ball measurements***

| Balls diameter | Average values of rolling-friction coefficient μ | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| 8 | 0.0024 | 0.0023 | 0.0033 | 0.0032 | 0.0034 | 0.0026 |
| 10 | 0.0022 | 0.0019 | 0.0034 | 0.0033 | 0.0033 | 0.0027 |
| 12 | 0.0021 | 0.0018 | 0.0032 | 0.0030 | 0.0033 | 0.0028 |
| 16 | 0.0023 | 0.0022 | 0.0035 | 0.0035 | 0.0034 | 0.0032 |
| 18 | 0.0025 | 0.0023 | 0.0034 | 0.0033 | 0.0033 | 0.0030 |
| 20 | 0.0021 | 0.0020 | 0.0034 | 0.0032 | 0.0030 | 0.0027 |
| 22 | 0.0018 | 0.0016 | 0.0033 | 0.0031 | 0.0022 | 0.0018 |
| 26 | 0.0013 | 0.0012 | 0.0031 | 0.0022 | 0.0021 | 0.0016 |

Figures 2, 3 and 4 presents (for untreated, nitrided and nitro-carburized samples), the dependencies between rolling-friction coefficient and couples characterized through different ball sizes. The graphic dependences denote, for all cases, that increasing the ball diameters in rolling-friction couples leads to a slightly decreasing of the friction coefficient values.

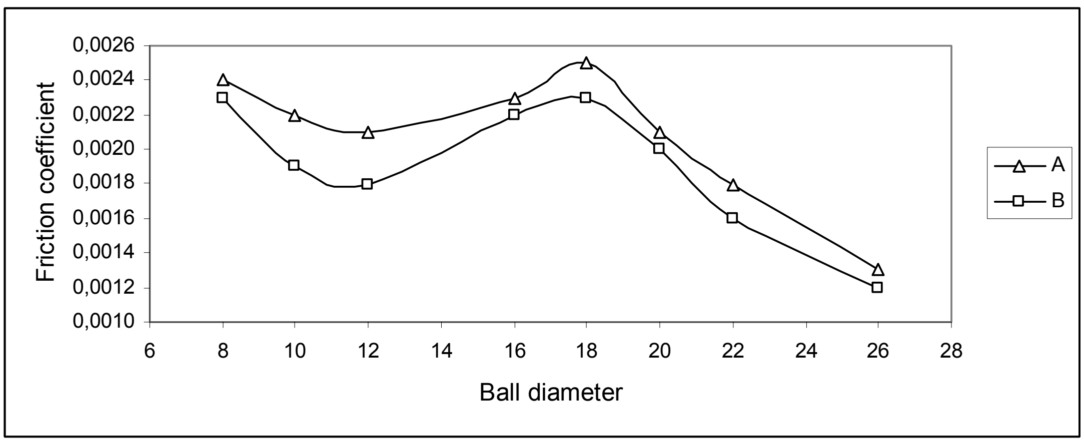


***Fig. 2. The rolling-friction coefficient for different ball sizes (sample A and B)***

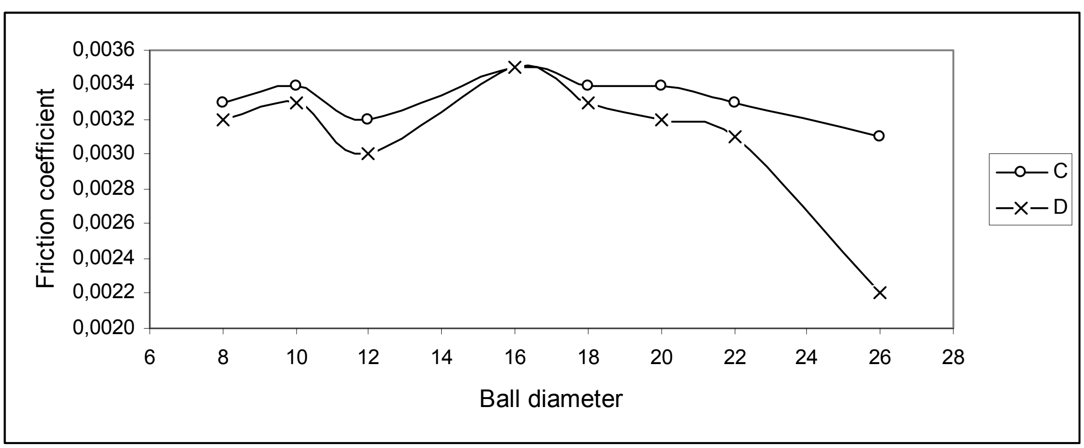


***Fig. 3. The rolling-friction coefficient for different ball sizes (sample C and D)***

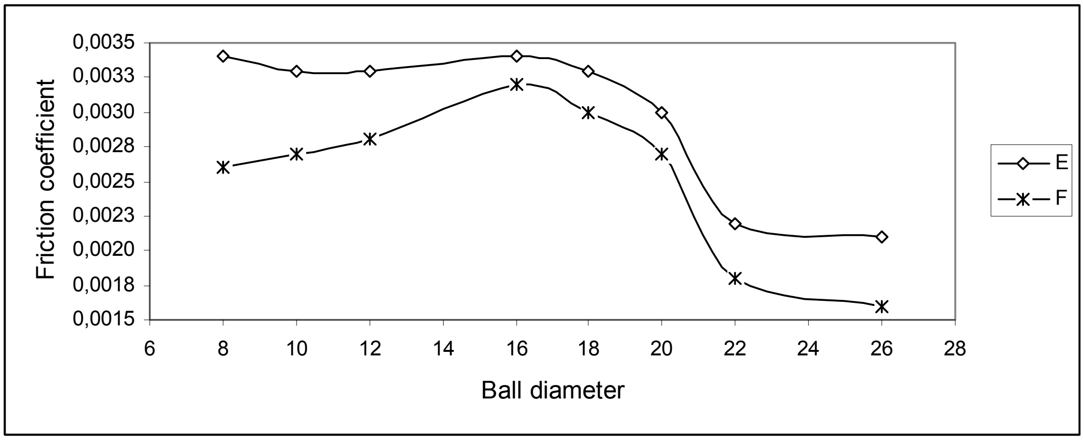


***Fig. 4. The rolling-friction coefficient for different ball sizes (sample E and F)***

For all three graphic represented cases, smaller friction coefficient values were observed for plane half-couples on the rolling-friction surface. This is very important if we are thinking that in these cases, the contact is produced in two points for each ball, not three like in the other case. Anyway, this aspect could be explained through the only two rolling-friction point surface not three like in the other case. Thus the effect of front resistant wave could be reduced because it is developed only on the limited with.

## 4. CONCLUSIONS

Generally, it have been observed the smallest values of equivalent friction coefficient for the non-treated surfaces in comparison with the nitrided and nitro-carburized ones.

Using longitudinal v-guide paths on the rolling-friction surfaces it could be reached friction conditions lower than on the plane rolling-friction surfaces. The nitrided surfaces were characterized by friction coefficients higher than the nitro-carburized ones.

The minimum static friction coefficient values were registered, in all the cases, when the contacts have been achieved with balls of maximum diameters (26 mm).

Regarding surfaces topography, the nitriding treatment seems to develop the highest roughness values. In fact, we could say, that starting from the same untreated substrat roughness ($R_a$ = 0,11 μm) both surface treatments lead to an increasing of the final roughness.

Anyway, the roughness increasing after nitriding is a little higher than after nitro-carburizing. This could be contribute to a little increasing of the friction coefficient and if the final polishing is not taking into account, this aspect is very important for some practical applications that imply hertzian contact.

## REFERENCES

1. Cozma, R., Bobancu, S., Cioc, V., Aparate şi dispozitive pentru determinări tribologice. Editura Matrix-Rom, Bucureşti, 2005, ISBN 973-685-873-1.
2. Munteanu, D., Munteanu, A., In Journal of the Mechanical Behavior of Materials, 8(4), 331, 1997.