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STUDY OF THE BEARING FRICTION INSIDE ON A MOBILE COUPLING JOINT

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Abstract: The mobile couplings are used in movement and torque transmission between two main shafts usually and have a wide application in transportation and machining systems. These mobile coupling must undertake the shafts misalignments that could appear, usually in the transversal plane and in the longitudinal plane. The friction which appears in coupling's joints between the involved parts has an important influence on their dynamic behaviour, wear and lifetime. A solution to reduce the friction inside the mobile coupling is to place bearings in joints. The paper presents some general aspects on mobile tripod couplings and following this, using the inside relative movement in joints between parts and corresponding adequate bearing, the friction coefficient is studied. There are considered two cases for the studied radial ball bearings: a sealed one and a non-sealed one. The measurements are accomplished by using a tribometer for different radial loadings and rotational speeds of the inner ring of the bearings. In the final part of the paper, the results present the exploitation conditions of the bearings which assure small frictional loses. According to the obtained results, in order to gain small frictional loses, the mobile tripod coupling with external contacts are suitable to be used in the case of high loads, with small influences on the frictional behaviour of the rotational speeds.

Key words: bearing, friction coefficient, mobile coupling, radial force, tribometer.

1. INTRODUCTION

The mobile couplings have a wide area of applicability in fields like machine tools and transportation due to their properties to undertake angular or radial misalignments by transmitting the motion with small differences between the input and the output shafts, based also on their quasi-homokinetic properties [1-4].
One of the simplest known mobile coupling types that may undertake the mentioned misalignments is the tripod mobile coupling, [1, 2]. As structure, this coupling type consists in two main elements: the input shaft and the output shaft, as is presented in figure 1. Between the shafts, there are the coupling contact joints.
According to the actual tendencies, in order to create a green world, the investigation of the frictional behaviour inside of the mobile coupling is a part of the investigation of the frictional behaviour of the mechanical transmission existing in systems like machine tools and transportations. The mobile coupling mechanical behaviour influences the frictional loses of the main mechanical transmission.
The scientific literature presents many researches oriented on the investigation of the friction phenomenon in the mobile couplings. In [5] is studied the friction in automotive drive shaft joints. The tests were performed under different experimental conditions: the joint angle, the torque, the plunging velocity and the rotational angle. The results show that high values of the joint angle offer higher internal averaged friction coefficients; this averaged friction coefficient is not influenced by the plunging velocity and by the rotational angle [5]. Also, a kinematic and static model for mobile tripod joints with spherical end of the spider, reliable for any friction coefficients, is developed in [6].
The aim of paper [3] is to elaborate a dynamic friction model for a mobile tripod coupling, based on theory and tests, which allows predicting its frictional behaviour under different conditions as the plunge's velocities, the joint angles, the applied torques and the lubrication.
The lubricant pressure and film behaviour is studied in [7] depending on the frequency and amplitude of the reciprocating motion of the plunge for a mobile tripod universal joint; the conclusions show that the film thickness increases with the increase of the amplitude and the frequency of the plunge's alternative motions.
In [8] is studied the tribological behaviour of a constant velocity mobile joint used in the transmission of the vehicles. The conclusions offer information about the degradation of the grease which lubricates the joint. A four ball tester and a linear oscillation testing machine is used in [8] in order to study the friction, wear and the grease degradation for constant

velocity joint used in the transmission of vehicles that travelled various distances.

Regarding the experimental studies oriented on the frictional behaviour of the mobile tripod couplings, the literature presents mainly global friction coefficients averaged for the entire mobile coupling. The aim of the present paper is to make an experimental research of the friction which appears in the bearings mounted inside on a mobile tripod coupling as it is presented in figures 1 and 2 [9, 10]. The motion from the input shaft 1 is transmitted to the output shaft 2 through external contacts. The mobile tripod coupling, apart of other tripod couplings, has external contacts and due to that is characterised by constructive simplicity and low production costs.

The experimental research is performed for the bearing types (radial ball bearings, sealed and non-sealed) where the elements being in contact are mounted. Figure 2 shows a constructive solution of the tripod mobile coupling with external contacts, where the bearings can be identified for the input part (figure 2a) and for the output part (figure 2b) as well.

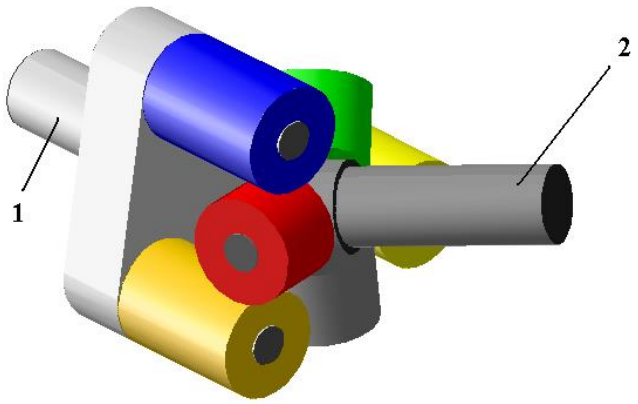
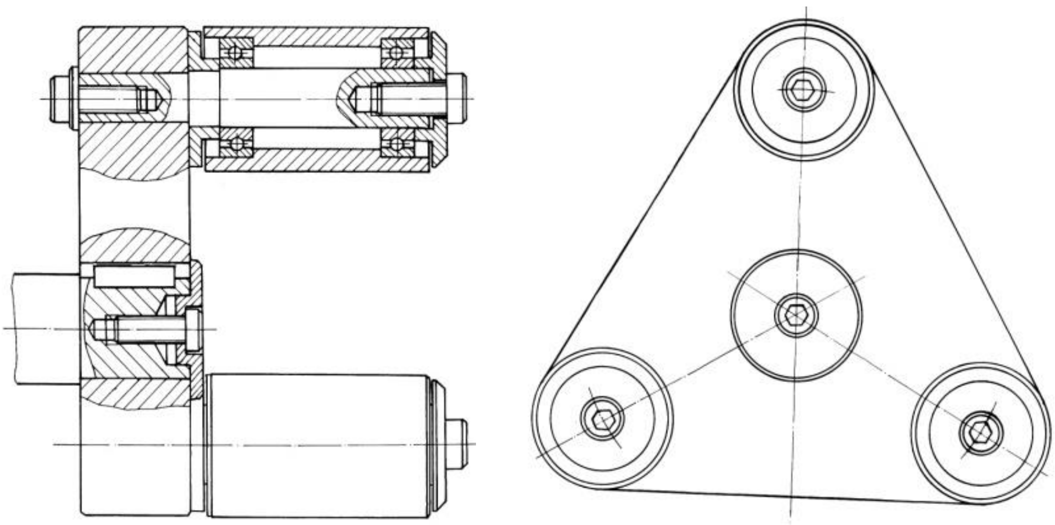
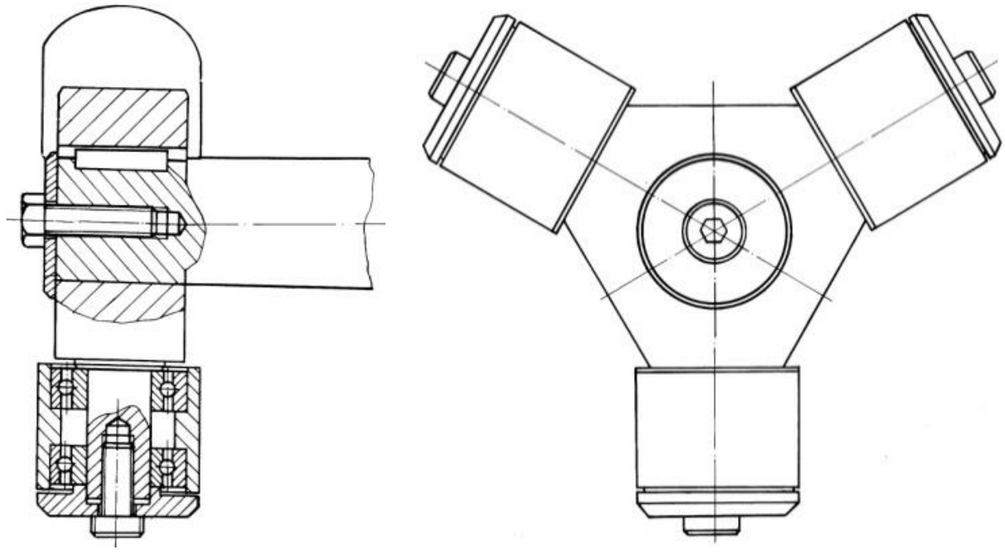


Fig. 1. The general view of the mobile tripod coupling with external contacts



a) The input part of the coupling



b) The output part of the coupling

Fig. 2. The mobile tripod coupling constructive solution with external contacts

2. MATERIALS AND METHODS

The tests are performed on the tribometer shown in figure 3. The tribometer allows forces measurements about the vertical and the horizontal directions between (1-1000) N with an accuracy of 50 mN, [11]. The vertical stroke of 150 mm can be accomplished with speeds between 0.001 and 10 m/s and a resolution of 50 nm [11]. The lateral stroke of 75 mm can be adjusted with speeds between 0.01 and 10 m/s and a resolution of 2 μm, [11].

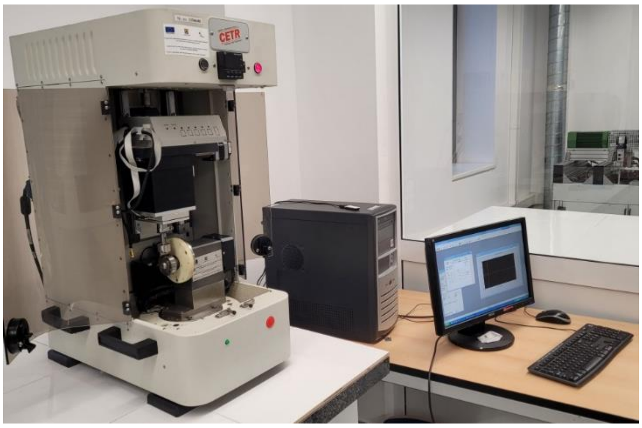


Fig. 3. The tribometer

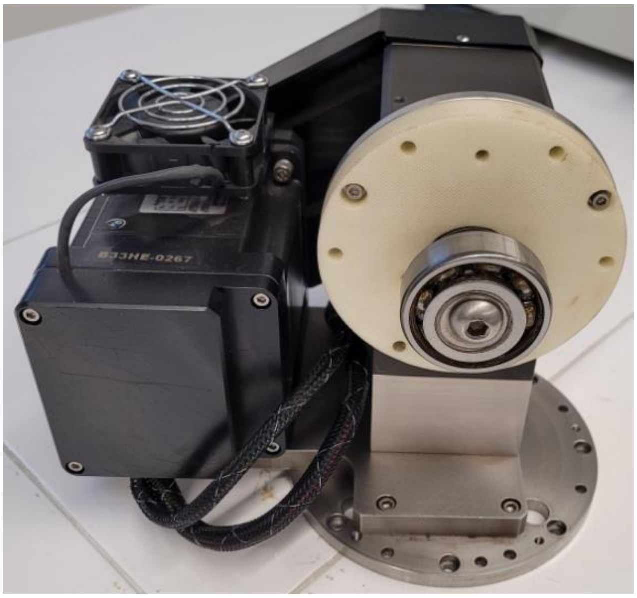


Fig. 4. The block on ring module

The tribometer is equipped with a block on ring module as it is presented in figure 4. The module allows force measurements between 1 N and 1000 N with an accuracy of 1N, [11]. The rotational are performed 2 ways, up to 3000 rpm, [11].
For the tests are used ball bearings, sealed and non-sealed with the inner diameter of 20 mm from the 6204 series (figure 5a); their inner diameter was used in order to allow their mounting on the mobile coupling. The radial force is applied through a steel made block (figure 5b). The entire system mounted on the tribometer is presented in figure 6.
Considering the functioning conditions of the studied mobile coupling, as test parameters are considered the radial forces between 100 N and 400 N and the rotational speeds between 500 and 2000 rpm [10, 12].

a) b)

Fig. 5. The tested bearings

Fig. 6. The testing system

3. RESULTS AND DISCUSSION

The variation of the global friction coefficient with the radial force at a rotational speed of 2000 rpm is presented in figure 7. The value of the friction coefficient, for both bearings, decreases with the increasing of the radial force, due to better contacts between the component elements. Higher values are noticed in the case of the sealed ball bearing, due to the supplementary friction between the sealing elements and the other ball bearing components.

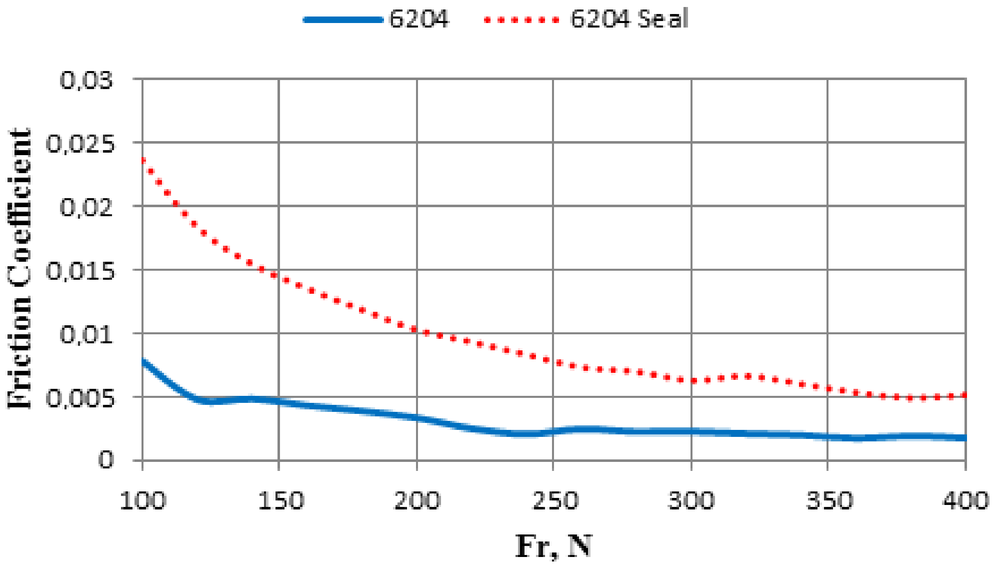


Fig. 7. The friction coefficient variation with the radial force at 2000 rpm

The variation of the global friction coefficient with the rotational speed at a radial force of 500 N is presented in figure 8. The value of the friction coefficient, for both bearings, increases slowly with the increasing of the rotational speed, due to the effect of the centrifugal force. Like in the case presented before, higher values are obtained in the case of the sealed ball bearing.

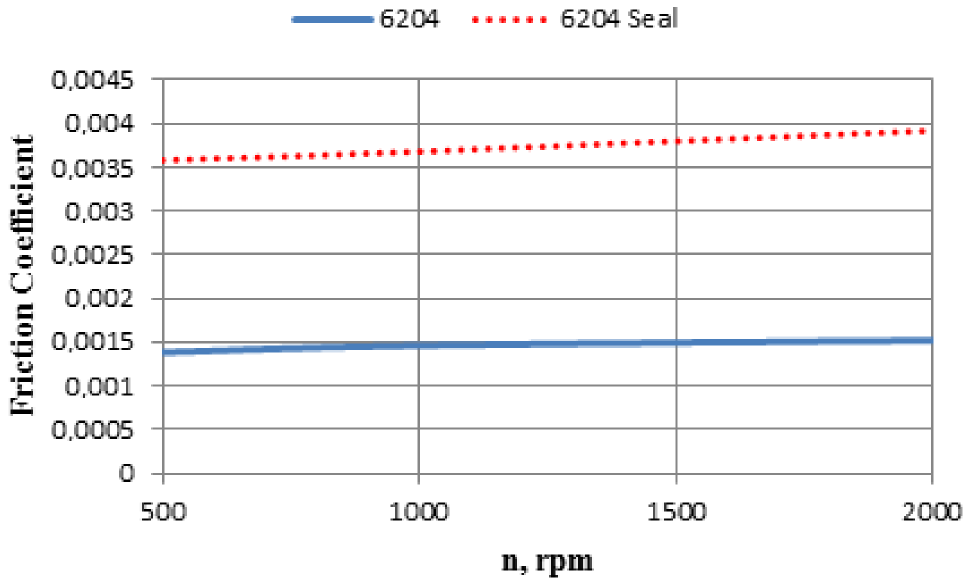


Fig. 8. The friction coefficient variation with the rotational speed for a radial force of 500 N

The values obtained for the friction coefficients fit into the value presented in the references - for instance, in the case of the deep groove radial ball bearing the value is between 0.001 and 0.0015, depending on the bearing joint working conditions, [13].

4. CONCLUSIONS

The study of the frictional behaviour in the mobile couplings is important in order to identify the exploitation conditions which assure low friction loses; one of the applications is represented by the bearings used in the construction of mobile tripod couplings with the external contacts.

By using modern test rigs as tribometers, the frictional behaviour of non-sealed and sealed radial ball bearings used in the construction of a tripod mobile coupling can be evaluated. According to the obtained results (which fit into the similar results presented in the literature), in order to gain small frictional loses, the mobile tripod coupling with external contacts are suitable to be used in the case of high loads, with small influences on the frictional behaviour of the rotational speeds.

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