UDK 621.836.004.6:621.892.002.01

B. TADIĆ, B. IVKOVIĆ, P. TODOROVIĆ

RESEARCH

Theoretical Basis of Pin and Block Carrier Design at Tribometer Tpd-2000

Basis of theoretical analysis of pin and block carrier at various tribometers, are presented in this paper. Analysis mainly deals with the influence of carrier design solution to wear tracks and measuring error regularity, therefore related to reliability and comparability of measuring results. Detailed schematic representation and appropriate stability analysis of pin and block in carrier is related to the tribometer TPD-2000 that has been designed by Yugoslav Tribology Society, by Mechanical Engineering Faculty, Kragujevac and by P.P. "PRIZMA", Kragujevac.

Keywords: *pin and block carrier, wear tracks, stability, measuring reliability*

1. INTRODUCTION

Wear and friction processes of contact pairs within industrial system develop under very complex exploitation conditions. Exploitation conditions are mainly characterized by broad range of contact pressures and sliding velocities, as well as by various kinds of contacts. The most contact pairs existing in tribomechanical systems are of a line type of contact. Theoretically speaking, these contact pairs start their contact on line or more precisely, on elementary surface around which, a certain contact surface is formed, due to wear. Within real industrial systems, it is very hard and sometimes impossible to determine quantitatively the value for friction coefficient and the level of wear for contact pairs. Measuring of friction force and normal load, therefore determining of the friction coefficient, is done at special measuring devices, tribometers, designed specially for this purpose. Tribometers are aimed for simulation of real friction and wear processes, as real as possible. Broad range of demands tribometers need to fulfill have had the development of great number of various tribometer types, as a consequence. All today existing tribometer designs have many differences among which, the contact pair carrier design is just one of them. There are also differences in possible levels of applicable loading, sliding velocities, high temperature conditions of investigation, measuring systems applied, etc., if existing tribometers' designs are compared among each other. This paper deals with basis of some possible design solutions for pin and block carrier. Detailed schematic representation and basic theoretical analysis of pin and block carrier is related to the tribometer TPD-2000 that has been designed by Yugoslav Tribology Society, by Mechanical Engineering Faculty, Kragujevac and by P.P. "PRIZMA", Kragujevac

Dr Branko Tadić,
Dr Branko Ivković,
Mr Petar Todorović,
Faculty of Mechanical Engineering,
Sestre Janjić 6, 34 000 Kragujevac

2. ROLE OF PIN AND BLOCK CARRIER IN TRIBOMETER SYSTEM

Pin and block carrier has a very significant role in tribometer assembly, no matter what kind of design other vital tribometer elements have. Normal load transmission is done through the carrier onto the pin or block and further onto the disc that rotates with certain number of revolutions. Elastic deformations of shaft that is the disc carrier occur when loaded. These elastic deformations of shaft (Figure 1.), no matter of how big they are, make it difficult for contact pairs (pin and disc or block and disc) to fit to each other during the wear process.

Figure 1. - Position of shaft and disc when loaded

The shaft and the disc, when loaded, are not rotating around the fixed axes x. They rotate around the axes x_1, which is changing in time. In order to obtain the reliable results it is necessary that the normal load, Fn, is uniformly distributed along the width of disc, b. From this aspect, it can be concluded that pin and block carrier has a very complex role. Pin and block carrier role can be mainly seen in transmission of

load along the z_1 axis, which is changing in time. However, the law of z_1 axis change is, generally unknown, especially if other influences considered (clearances, shape errors and errors of parallelism and perpendicularity).

3. THEORETICAL ANALYSIS OF SOME POSSIBLE PIN AND BLOCK CARRIER DESIGN SOLUTIONS

One possible solution is the design with fixed pin or block position in carrier. This solution enables the normal load transmission along the predefined axis, z (Figure 1.). The presumption of this solution is to exclude the elastic deformations of the shaft - disc carrier. The reality of this presumption lies in the fact that the shaft - disc carrier can be designed as a very stable element within the drive assembly. However, regardless of this, the solution with fixed position of the second contact element (pin or block) has shown to be very unreasonable solution in practice, from aspect of reliability. Elastic deformations, shape errors, errors of parallelism and perpendicularity at contact pairs and clearances that are always present, bring to the non-uniform load transmission, which is reflected in irregular and very rarely repeatable wear track at pin or block. Wear track shapes at pin and block with fixed position in carrier are shown, schematically, in Figure 2.

Figure 2. Wear tracks at pin and block with fixed position in carrier

Nonuniform wear tracks and their non-repeatability is connected to the measuring error that is made due to the differences in positions of the resulting normal load and due to the differences in values and distribution of Hertzian contact pressure. Beside this, irregular and non-repeatable wear track unfavorably reflects to the friction force accuracy. Due to this, the measuring results obtained are unreliable and non-comparable.

The second possible solution for carrier is the free pin or block in carrier, that is, with existence of the clearing between the carrier and pin or block (Figure 3.).

Figure 3. - Clearing fit of pin or block in carrier

In this case, the carrier is vertically adjusted along the fixed axis, z (Figure 4.), and pin or block is in the carrier with clearance fit. The main characteristic of this solution, applied at certain number of tribometer design, is the assumption that the existing clearances will enable fitting of contact pair (pin and disc or block and disc) during the wear process. Compared to the fixed position of pin or block in the carrier solution, this solution is better, but still not enough reliable during working. Because of the existing elastic deformations of the shaft - disc carrier, shape errors and errors of parallelism and perpendicularity of contact pairs and because of existing clearances, in most cases the following situation occur: contact starts close to point "A" or point "B" and then one of the possible positions for pin or block in carrier is the displaced position shown in Figure 4.

Figure 4. - Load distribution on carrier and pin or block at the beginning moment

If the assumption is made that the load distribution is uniform along the line contact AB, what would mean that the contact pair fit properly to each other, the following conclusion can be valid:

force Fn_1 tends to swivel the pin or block around the point "C" by $M=Fn_1.x$ moment,

elevation of the carrier independently of the law of disc's motion is needed for pin or block to take up a new position, that is, for fitting of the contact pair and

fitting of the contact pair is done in conditions of sliding and rolling of pin or block in area around point "C".

From aspect of previously stated, a conclusion can be made that pin or block in carrier is not in equilibrium state. There is always a moment when that state is disrupted during the uniform distribution of load. Moment $M=Fn_1.x$ has tendency to move pin or disc away from point "C", but the law of disc's motion prevents it in most cases. As a consequence of unstable equilibrium state often comes appearance of irregular and unrepeatable wear tracks at pin or block.

Tribometer TPD-2000 has original design solution of the pin and disc carrier, whose schematic representation is given in Figure 5.

Figure 5. - Schematic representation of the design solution of the pin and disc carrier at Tribometer TPD-2000

Pin or block (position 1.) is fixed without the clearance in the carrier (position 2.) that is placed inside the basic carrier (position 4.) by means of angular bearing (position 3.). Normal load transmission is done through the basic carrier of pin and block onto the carrier (position 2.), from where it is further transmitted to the contact pair. Positioning axis runs through the point "A" that is through the center of the contact. Fitting of the contact pair is done by carrier swiveling (position 2.), together with the pin or the block, around the axis, which runs through the point "A" (center of the contact), being perpendicular to the plane of the draft (Figure 5.). In any position of the contact pair (Figure 6.), the static and dynamic equilibrium state of the system is enabled.

Figure 6. - Load distribution at carrier and at pin or block at Tribometer TPD-2000

On load distribution basis, the following can be concluded:

with uniform or any other load distribution at pin or block the system tends towards the stable equilibrium state,

the fitting of the contact pair does not require the vertical movement of the basic carrier independently of the disc's motion law and

moment of resisting to fitting is, in fact, the resistance of roller bearings, which is small and can be neglected because it really has no influence on regularity of wear tracks or on the reliability of measuring.

4. CONCLUSION

Relatively complex design solution of contact elements (pin and block) carrier is needed for reliable measuring of friction force. Due to theoretical analysis performed and measuring results obtained from various kinds of tribometers, the following can be concluded:

design of the carrier with fixed pin or block position cannot provide regular wear tracks and satisfying reliability coefficient of measuring results,

the solution with clearing fit of pin or block in carrier, also, in most cases, do not fulfill the demands of reliability and repeatability of measuring results,

to obtain the regular wear tracks and reliable and comparable measuring results, the carrier design solution needs to provide static and dynamic stability of contact pairs, what is not accomplished by the two previous design solutions.

The design solution that is shown in Figure 5. and in Figure 6. provides almost momentarily fitting of the contact pair, no matter of elastic deformations of the shaft - disc carrier, or clearances, or shape errors or errors of parallelism and perpendicularity at contact pair. One element of the Tribometer TPD-2000 design is the measuring lever that is connected to the pin and block carrier. Measuring lever is exposed to bending causing significant elastic deformations to occur at the lever, thus the elastic deformations of the shaft - disc carrier not being the only one existing in the system. However, the presented carrier design solution completely fulfilled demands, no matter of such a complex environment. Wear tracks are regular "line" tracks and comparability and reliability of measuring results are at the high level.

REFERENCES