ACTA TECHNICA CORVINIENSIS
– Bulletin of Engineering
Tome IX [2016] , Fascicule 2 [April – June]
ISSN: 2067 – 3809

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THE GEOMETRIC ANALYZES OF SIZED BEARING IN EXPLOITATION

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Abstract: The main goal of the research presented in this paper is an analysis of the ball bearings 6206 piston compressors. Ball bearings, that transmit the load are very critical for the safe and efficient operation of rotating machines. In this paper presents analysis of through testing of wear of ball bearing of elements, wear the inner track, the outer tracks and balls, and the final goal was to present the resulting tribological processes. Purpose of monitoring the the state of wear balls was used the micrometer. Other place of testing performed of implemented measures were visual control.
Keywords: reliability, ball bearing clearance, wear, temperature

INTRODUCTION

During exploitation technical systems leads to irreversible changes in the system caused by various processes: friction, wear, corrosion, deformation, effects of the environment and the like. [1]. Deviation of system characteristics of the projected value is considered a cancellation of the system, the most common case of such cancellation elements are balls on of rolling bearings, the inner tracks and outer tracks. Cancellation system is manifested by the appearance of temperature, noise and vibration systems.Gliding of the balls is a function of lubrication, tolerance of balls in the cage, the angular rotation and lateral forces, surface quality, as well as speed and load. Lubrication has a dominant influence on the gliding of the ball. Glide occurs due to the resistance forces on the ball, which was created by the viscous resistance force of lubricant, and is greater than the slip moment to point contacts. This attempt was aimed at easier access to obtain the theoretical model to study the effect of defect size, load and speed of the bearing vibration and predict spectral components. To preserve the production process and avoid minimum failures in the process, it is necessary to maintain the equipment and critical machine parts. The development of rotating machines with ball bearings goes very quickly and improvements are focused on increasing the reliability of machines and their versatility. Improved reliability of ball bearings is to operate in special environments such as corrosive environments, high temperatures, high speed, and high vacuum environments, have become very important [2].

It can be said that the performance bearings affect key functions, such as durability, noise and vibration behavior of the compressor. In a study conducted by Kim and Han [3] an analytical model the behavior of dynamic coupling of the piston and crankshaft was developed and compared to the model of terminal bearing. Same study presents a numerical procedure which combines the Newton-Raphson method and pattern of repeated excessive burden.

Having in mind the above mentioned, this study aims to investigate the tribological behavior of ball bearing 6206 with emphasis on the occurrence of temperature, wear, deformation in terms of lubrication and provide new information and knowledge. The influence of load, movement speed and the friction and gliding, on the tribological behavior of bearing wear intensity was analyzed with the exploitation of research.

MATERIAL AND METHODS

Changes of geometric sizes of the bearing in exploitation

The paper presents justification of monitoring characteristics of piston compressors, which are used to suck gas from a tank, pipe or the environment and suppress them (with the more significant increase of of pressure) to the second tank, piping, or generally to some of consumers [4].

Piston compressors applies clips that run directly via the piston mechanism pretending rotary motion of the rotor in the oscillatory linear motion [5]. The exploitation of the system was limited to a visual assessment of behavior of the system as well dynamic measurements of geometrical the process parameters [6].

In order to study bearings in a piston compressor included the effects of a particular damage to ball bearings SKF 6206, are shown in individual damage on the inner ring, outer ring, and balls that occurred during exploitation, established after the dismantling of bearings on the desk (Figure 1). Important geometric characteristics of ball (roll) bearing are diameters of rolling slopes, and the mid diameter of the bearing. They can be expressed by the geometric characteristics of the rolling tracks. On the geometry of the bearing, influencing factors are, material quality of the balls and tracks, surface quality balls and tracks, the way of maintenance, lubricant type, the conditions under which bearing exploits, etc..

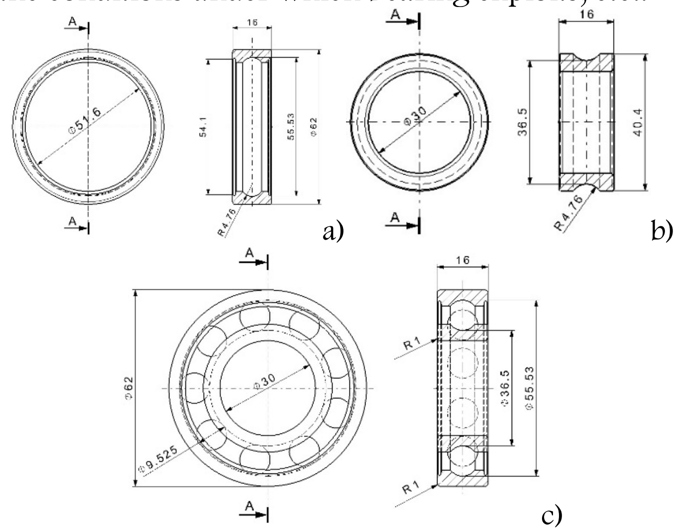

Figure 1. Geometrical size rolling ball bearing SKF 6206
a) The outer bearing ring, b) The inner bearing ring,
c) Damage to the outer and inner ring

The outer ring of the physical new beds 55.53 is measured at the beginning with a tolerance of ± 0.010μm, while the ring physical defective bearing extended to 55.56 mm. The inner ring of the new bearing is 36.5 ± 0.010μm, measured at the beginning, before exploitation 36.49 mm after exploitation-defective to 36.46 mm. From the above analysis it can be seen that the inner ring is worn out (Table 1).

Also track ball represents a measure of geometrical conformity of runs and balls in a plane passing through the (time) axis bearing (also called the center line or rotational axis), which line passes through the center bearing normal to the plane and transverse to the track.

In Figure 2 are presented the dimensions of single row of ball bearing, diametrical diameter balls, and tolerance obtained after of measurements [7].

Table 1. Shows the values of the new geometry of the bearing, as the deformed bearing

Geometry the bearing according to SKF	Values after defect	
Bearing outside diameter -D	62 mm	61.995
Bearing bore diameter -d	30 mm	29.998
Bearing width- B	16 mm	16.01
Ball diameter - d_k	9.525 mm	9.441
Contact angle - β	0°	0.8′
Number of balls - n	9	9
Weight balls - G	3.55 gr	3.48 gr
The inner diameter of the outer ring track - $D_{a\,max}$	55.53 mm	55.56
The diameter of the bearing outer track opening - $d_{a\,min}$	36.5 mm	36.46
Mass-bearing weight - G_1	200 gr	195gr
Basic static load rating, radial - C_0	11.2kN = 11200 N	
Basic dynamic load rating, radial - C	20.3 kN= 20300 N	
Limiting speed - n_G	15000 r/min	
Reference speed - n_B	24000 r/min	
The radius of curvature $r_{min} = r_{a\,max}$	1 mm	
Fatigue limit load, radial - C_{ur}	0.475kN= 475 N	
Modulus of elasticity bearing of materials	E=2.06.10 ^{11} Pa	
Poisson coefficient	μ=0.3	

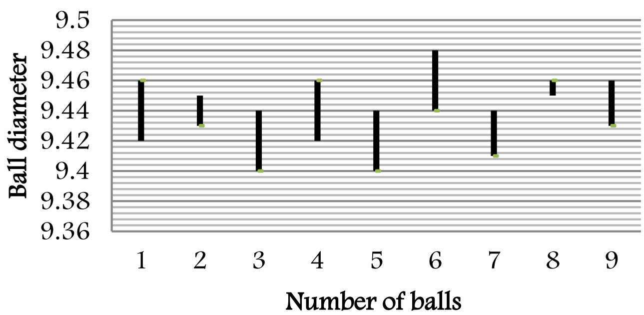

Figure 2. Changes in size balls after dismantling the bearing

Radial ball bearings have some effect from axial effect because they are designed to have a diameter tolerance. Also figure 2 shows that the radial bearing with the touch due to axial movement of the inner and outer rings is applied when it is not measurable force. Measurement of the balls was performed after dismantling bearings on test bench of examination of bearings, using a micrometer with an accuracy of 0.025 mm. By measuring the balls we determined deviation dimensions of balls compared to the standard value of 9.525 mm, which can be seen in Figure 2 „Diagram of ball dimensions".

RESULTS AND DISCUSSION

Types of damage in ball bearing is certainly the contact between the rolling elements and the ring or rings in the unloaded condition in point or line [8, 9]. Under load leads to elastic deformation at the contact point, so that the load transfer is realized by the small contact surfaces. Therefore, in spite of very high strength and hardness of the material parts of the bearing, as well as careful preparation, installation and maintenance, after a period of time leads to fatigue and damage to the contact surfaces [10]. The damage is the result of local contact overload and manifested first appearance of micro cracks just beneath the surface. In the future work of micro-cracks extending to the surface, which creates small holes and fissures. This damage is called pitting. Damage during work flow rapidly, and then leads to the separation of large metal parts, which is particularly acute in the inner ring of the bearing. The damage caused by unstable operation of bearing is followed with impacts and increased noise, which eventually leads to the violent rupture of the ring.

Due to variations in shape and dimensions of the bearing parts, in addition to rolling in bearing there and to a lesser extent gliding. It has the effect of abrasive wear of the bearing, in combination with further pitting damages desktop beds. Given that this damage ultimately lead to failure of the bearing, to perform tests in order to determine the operating time to the appearance of fatigue. The test consists in setting up a large number of bearing on the same test tables, and their work under the same conditions relating to the load, frequency of rotation and lubrication.

As the analysis of the results can be seen, the elements tribomechanical system of roller bearings can be caused by different types of wear and damage. On one bearing can occur at the same time several kinds of wear and tear, but, as a rule, one of the resulting species is dominant and it will fundamentally determine the future direction of development of tribological processes and finally the life of the bearing.

Which forms of wear occur, and which will be the dominant form, depends on many factors. Fatigue wear (pitting) is one of the most common and also the most typical kind of bearing wear. It is characterized by the appearance of wells in the initial stage and the destruction of the contact surfaces in the final stage of the process. Fatigue wear are exposed to all the elements of bearing: rolling elements, racks, the backrests of the inner ring.

Depending on a number of influencing factors, pitting may howl in different places on elements of tribomechanical bearing systems. Figure 3 shows the appearance of pitting on the inside of the track rolling bearings. It is obvious that pitting was not affecting the whole rolling surface but only a part, however, wear analysis shows that it is a devastating pitting.

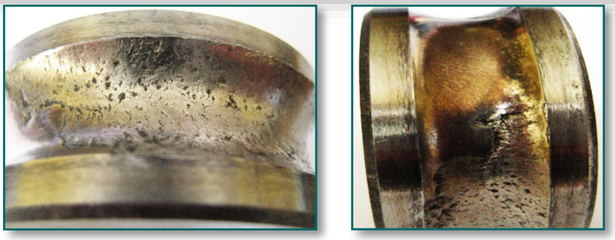

Figure 3. Fatigue wear (pitting) on the outer surface of the bearing inner track

Fatigue abrasion damage from fatigue cracks that occur below the surface are very rare. Damage caused by fatigue, occur more often on the surface of the components inside the rolling contact, as a result of inadequate lubrication or contamination. The causes of damage can not be recognized for a long time, until the damage advances. Fatigue can be recognized as spot damage in the material inside the rolling track ball bearing. Fatigue wear occurs on the outer rolling track and on the ball (Figure 4).

Fretting corrosion is the type of wear that occurs at low oscillatory displacements of one surface over another in terms of action corrosive environments. The conditions in which they arise are: small amplitudes of composite elements (within a few tens of micrometers) and in connection with the aggravated taking of wear debris from the zone of contact; low speed, relative displacement of coupled elements (a few millimeters per second); the presence of oxidation external environment (eg, oxygen, air) chemical reactions that causes oxidization of the contact surface with the consequences of their destruction.

Figure 4. Pitting on the outside rolling track ball bearing and the ball

Figure 5. Fretting corrosion on the outside rolling track of ball bearing [11]

Wear at fretting-corrosion differs from fretting wear - wear that occurs most often in small oscillatory relative movements. The main difference is that fretting occurs in the absence of oxidizing environments in the development of chemical reactions without material contact surfaces and wear debris with oxygen. In addition to the fatigue wear on certain parts beds it is evident fretting corrosion. In Figure 5, the case of fretting corrosion.

Tracking of features mentioned mechanical systems amounted to a visual assessment of the behavior of the system as well as the measurement of vibration and temperature of the system in operation with the use of the projected dynamic process parameters [12, 13].

The outer ring of the physical new bearing 55.53 is measured at the beginning with a tolerance of ± 0.010μm, while the ring physical defective bearing extended to 55.56 mm. The inner ring of the new bearing is 36.5 ± 0.010μm, measured at the beginning, before mining 36.49 mm after exploitation-defective to 36.46 mm. So the inner ring is worn out.

Results of diagnostic research during the test of bearings on a laboratory table have pointed to the very complex conditions that have resulted in a variety of mid-functioning mechanical systems. The reasons why the bearing life of bearings in exploiting condition results differs from test results obtained in laboratory conditions and why the level of exploitation bearings assemblies of mechanical systems is more complex, should be sought in the following assertions: insufficient level of technical maintenance (primarily in the lubrication performance which has to be carried out in accordance with the manufacturer's bearings, which are all the same and performed periodically).

CONCLUSION

Diagnostics of the ball bearings of piston compressors for the given conditions of use and indicated primarily on all the shortcomings of the said assembly of mechanical systems in the process of exploitation, on basis of which the proposed measures are the possibilities for further exploitation (through a lifetime of ball bearings) in order to increase the reliability of piston compressors. The damage can occur in rolling elements of bearings due to defects in material, crack on the contact surfaces due to material fatigue, or defects or cracks on the rolling elements. The changes in the geometry of the bearing cause impulses when there is contact between the damaged area.

Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin", Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[14].

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