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Innovative designs of angular contact ball bearings systems preload mechanisms

Innowacyjne mechanizmy wprowadzania napięcia wstępnego w układach łożysk skośnych

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Presented are two mechanisms to simplify preloading operations in angular contact ball bearings systems supporting rotating machines' shafts. The proposed systems also significantly improve its later adjustment during machine exploitation. In the presented solutions, the tensioning force of the bearing comes from a system of appropriately shaped elements with rotational-wedge surfaces, rotation of which makes them mutually extend and consequently obtain the tensioning force for the angular contact ball bearings.

KEYWORDS: bearing, design, shaft, machine

Bearings belong to typical machine components. It is also one of the most important construction elements, because its proper operation depends on a trouble-free operation of each device. Bearings extremely rarely occur individually. Usually, constructors place two or more to support each rotating element. With the increase in the complexity of the machine, the number of bearings installed in it increases, therefore it is extremely important to ensure optimal working conditions for each bearing in the device [2, 3].

There are several key factors that affect the time the bearings operate properly in the machine. These include: lubrication, loading forces, vibrations, temperature, presence of a corrosive environment. In the case of skid steer bearings systems, it is also important to guarantee the correct initial tension and to maintain it during the entire life of the device [1, 5, 6, 9].

In this paper, two mechanisms are presented whose task is to obtain the correct preload of the angular contact bearing system supporting the rotating machine shafts. They also allow for a significant improvement of its subsequent adjustment during the use of the machine, which is crucial to ensure long and trouble-free operation.

In currently used tensioning mechanisms of angular contact bearings, good access to the shaft housing is required in the place where it is necessary to adjust the initial tension of the bearing system operating in the machine. Such adjustment often involves disassembly of components mounted at the end of the shaft and subassemblies cooperating with the shaft. This is due to the construction of mechanisms, usually containing thrust washers or nuts and adjusting screws, whose replacement or adjustment requires the removal of the machine cover on which the bearing is based [7, 8].

In the presented construction solutions, adjusting the pre-tension of the bearing system requires only access to the built-in elements of the screw or control screw, which is advantageous in the case of tight fitting of the machine components. It is not necessary to dismantle any elements placed in the vicinity of the bearing or mounted on a shaft cooperating with the bearing [7, 8].

Construction description

The mechanisms were designed in Autodesk Inventor Professional. It is a parametric program that allows three-dimensional design of parts. It is possible to assemble them into subassemblies and ready machines. The program has a number of functionalities facilitating the design of machines, such as analyzes controlling the cooperation of components and component analysis of collisions, kinematics, dynamics and strength using the finite element method [4, 10].

In the first construction (fig. 1), a corona sleeve (4) and a crown cover (5) are arranged at the end of the shaft (2) located in the body (1), in which both these elements are in contact with the corresponding wedge surfaces, with the cover it is connected to the body by means of screws (6), and the sleeve is slidably mounted in the body between the cover and the outer race of the bearing (3). On the opposite side, the shaft is supported on a bearing (14) protected against pulling out the cover (15) from the body, which is screwed to the body with screws (6) [7].

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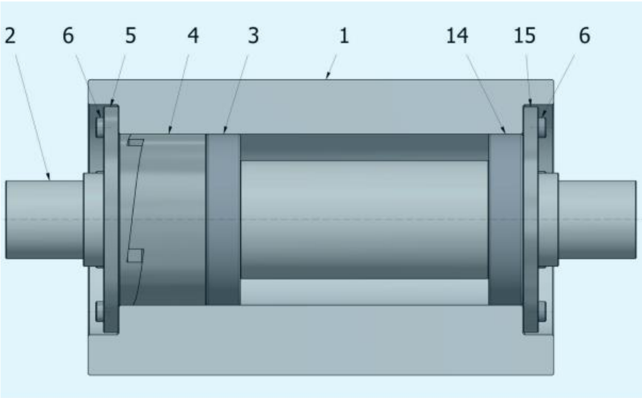

Fig. 1. The first mechanism for introducing the pre-tension

Fig. 2 shows the longitudinal section of the subassembly in the plane passing through the axis of the adjusting screw (10). The body and the corona sleeve have non-punched longitudinal holes in which the components are located. Each of them includes inserts (7, 8 and 11, 12) and a spherical element (9 and 13 respectively). The corona sleeve has a recess in the axis of the spherical element. The body is connected to the corona sleeve by an adjusting screw arranged in the through holes of the spherical elements, wherein the surface of the through-hole of the spherical element (9) in the crown sleeve is threaded. Non-opening longitudinal holes of the body and the crown sleeve as well as external inserts are terminated with threaded surfaces, which makes it possible to adjust the clearance between the respective inserts and spherical elements [7].

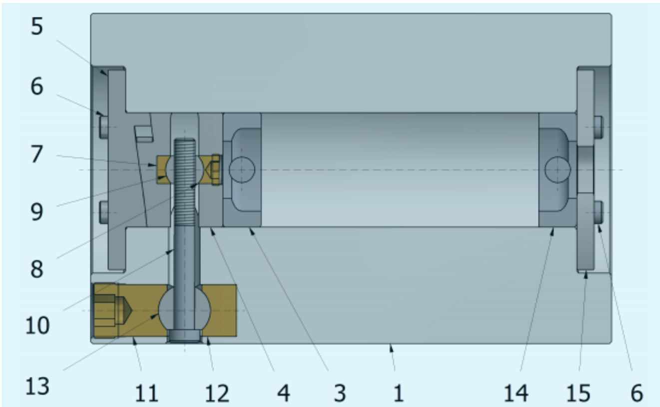

Fig. 2. Longitudinal section of the first preloading mechanism

Fig. 3 shows the cross-section of the subassembly in the plane passing through the axis of the adjusting screw. It shows exactly the milling in the crown sleeve, in which the adjusting screw is working. It should be remembered that the adjustment screw during operation tilts in both planes, which forces the use of ball-shaped elements that eliminate the unfavorable lateral forces of the tensioning control assembly during the rotational-sliding movement of the crown sleeve.

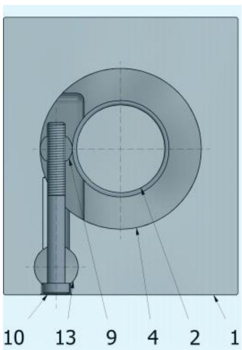

Fig. 3. Cross-section of the first preloading mechanism

In the second proposed construction solution (fig. 4), elements such as shaft (2), body (1), corona sleeve (4) and corona cap (5) are placed and connected with bolts (6) as in the previous subassembly. Also, the support of the shaft on the opposite side on the bearing (7) protected against pulling out the cover from the body (8) is identical to the previous system.

An important difference concerns the system that forces the crown sleeve to rotate. The corona sleeve, slidably mounted in the body between the crown cover and the outer race of the bearing, has a cut worm on a part of its outer side surface, and in the body is placed a control screw (9) based on a thrust sleeve (10) connected to the body by bolts (11).

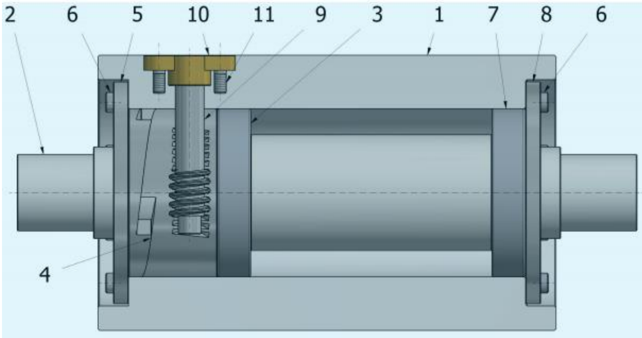

Fig. 4. View of the second preloading mechanism

In this way, the adjusting screw is secured against slipping out of the body under the influence of forces acting in the bearing tensioning subassembly. In addition, the worm wheel is cut in a way that allows it to properly cooperate with the worm despite the longitudinal movement of the crown sleeve [8].

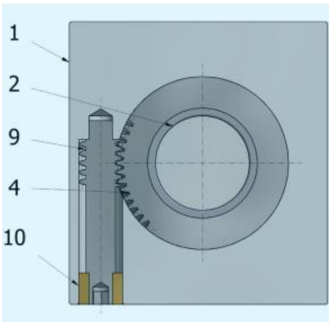

Fig. 5. Cross-section of the second preloading mechanism

Principles of operation

Fig. 6 presents the most important elements of the first proposed mechanism for introducing initial tension in skew bearing systems. The adjusting screw (10) maintains the corona sleeve (4) in the right angular position by working with the ball (9) and inserts. The rotation of the adjusting screw causes the corona sleeve to rotate with it, and its further tightening results in the *F*1 force shifting the spherical element. The spherical element, cooperating with the inserts (7) (not visible in fig. 6) and (8), affects the crown sleeve and causes moment M. The torque M causes rotation of the crown sleeve, which, due to the wedge ring surfaces (5) allows for obtaining the force *F*2 introducing proper initial tension of the machine shaft bearing system.

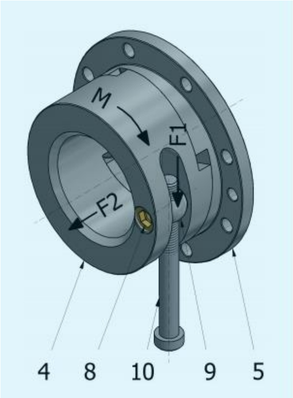

Fig. 6. Arrangement of forces and moment during the operation of the first mechanism

Modification of the preload of the angular contact bearing system is accomplished by tightening or loosening the adjusting screw [7].

Fig. 7 presents the most important elements of the second proposed mechanism for introducing initial tension in skew bearing systems. The adjusting screw (9) maintains the corona sleeve (4) in the right angular position, thanks to the cooperation with the scroll wound on it. Further rotation of the worm clockwise with the torque *M*1 causes the momentum *M*2 to be formed on the crown sleeve. The momentum *M*2 causes the crown sleeve to rotate, which, by working with the wedge surfaces of the crown cover (5), moves and makes it possible to obtain a force *F* that introduces the correct preload of the bevel arrangement of the machine shaft. Modification of bearing preload is carried out by turning the adjusting screw (9) to the left or right [8].

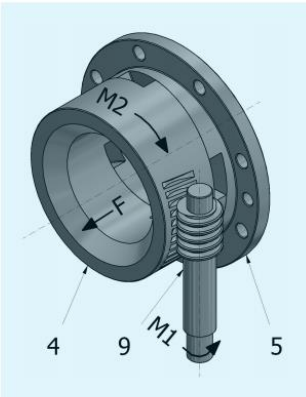

Fig. 7. System of forces and moments during the operation of the second mechanism

Conclusions

Proposed constructions of mechanisms for introducing the initial tension of the angular-contact bearing system supporting the rotating machine shafts are characterized by simplicity and compactness of the structure. For this reason, their use in subsequent machine models should not cause design problems or generate additional costs. This is especially important because these mechanisms significantly improve the comfort of operating the devices during their long-term use.

Structural changes presented in the described components do not cause a significant reduction in the spacing of the bearings supporting the shaft, thanks to which it is possible to preserve the stiffness of the structure planned during the design of the machine. In addition, the possibility of very precise adjustment of the pre-tension of the angular-contact bearing system allows obtaining subassembly performance parameters compliant with the machine's design assumptions. Due to this, the risk of failure is very real.

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