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THE IMPACT OF THE SEAT SUPPORT SUBASSEMBLY WARPING ON LOADS DISTRIBUTION IN SLEWING BEARING DURING BODYWORK ROTATION

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1.Introduction

The significant problem in the rotation node of machine design is to provide a suitable stability of rolling system so as to obtain evenly transfer of loads through the rolling elements, without excessive concentration and accumulation which reduces the load capacity of the bearing, cause an increased wear and a significant decrease in durability [1, 7]. Thus, in the calculation of the bearing load capacity is important to determine the exact distribution of loads. Correctly identified load distribution allows to determine the load levels of the track and parts of rolling elements, the appropriate choice of contact parameters, affects the growth of durability [8]. Due to the fact that the slewing bearings mounted on the working machines are designed for the maximum permissible load conditions of the bearing elements, the exact calculation of the slewing bearing load is very important [2, 4]. It should be keep in mind that in many devices, damage or destruction of a coronary bearings have to shut down the machine out of service for a long time and generates high repair costs.

In this paper investigated the effect of deformation of the bearing seat for the supporting subassembly on the internal load distribution. The results are presented for different positions during the rotation of the machine bodywork. Deviation from flatness of the bearing seat and points of the maximum load of rolling elements were also specified.

2.Subject of research

The subject of the research is to analyze the influence of the seat support subassembly warping on the internal load distribution in the slewing bearing (Fig. 1b) installed on-site support structure shown in Fig. 1a. The test subassembly consists of a support ring mounted on the longitudinal members made of metal sheets welded together, forming a closed box sections. The ring girder in the form of a thick-walled sleeve flange is used to attach the bearing. The analyzed structure of the lower support frame has two planes of symmetry.

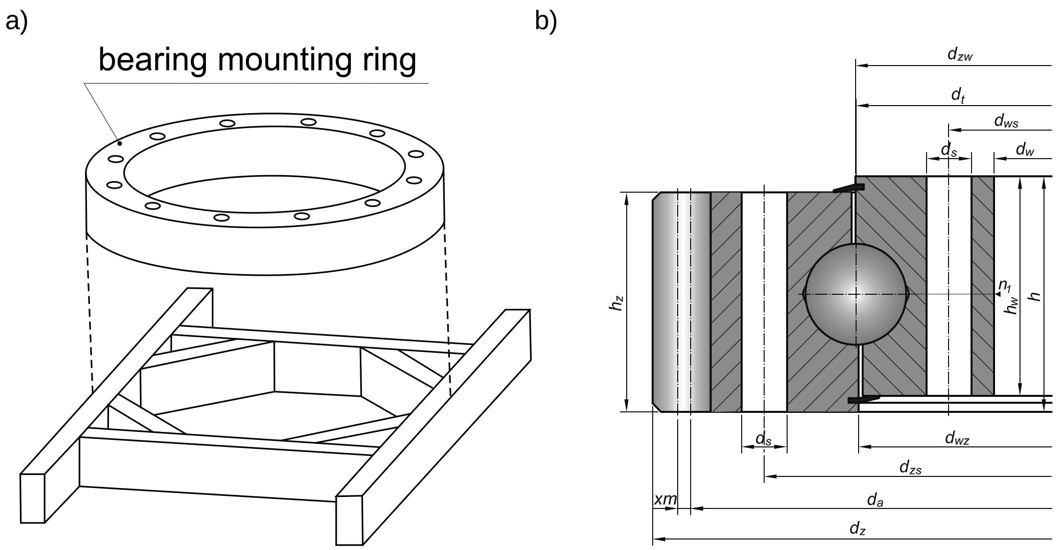


Fig. 1 *The design of the support subassembly (a) single row ball slewing bearing with four-point contact (b)*

For the calculations catalog single row ball slewing bearing with four-point contact was assumed (Fig. 1b) [9]. In this bearing there is one row of balls and each ball cooperates with two pairs of track. There is therefore two rows of computing. This row where the load of balls is the result of interaction of axial force Q and overturning torque M, is called the carrier row, second row where the load is the difference between interactions of force and torque - supporting row. The study analyzed a bearing with the following parameters:

- rolling diameter d_t = 1400 mm,
- balls diameter d = 40 mm,
- number of balls z = 84,
- coefficient of balls adhesion to track k_p = 0,96,
- nominal contact angle α_0 = 45°,
- track hardness – 54 HRC,
- the number of fastening bolts – 36 bolts M24-10.9 in each ring.

3.The numerical model

The slewing bearing is a complex structure. The numerical model of the bearing is made with a MES. In the bearing there is a significant number of contact zones (often hundreds). To avoid an unacceptable increase in the size of the numerical model, the bearing rolling elements are replaced by so called superelements [6]. The main portion of the superelement is rod element with non-linear characteristic, which is determined on the basis of so called characteristics of substitute contact zone [3]. Also relevant is the method of the screws modeling. In this study, it was assumed that the screws are modeled using special beam elements, which can be attributed established preload. For discretization of the bearing rings and also to the plate and ring girder undercarriage were used 8-node 3D-SOLID type elements. Discretization of stringers in support components was made using shell elements SHELL type (Fig. 2). Geometric models included only the most important elements that affect the stiffness of the support frames.

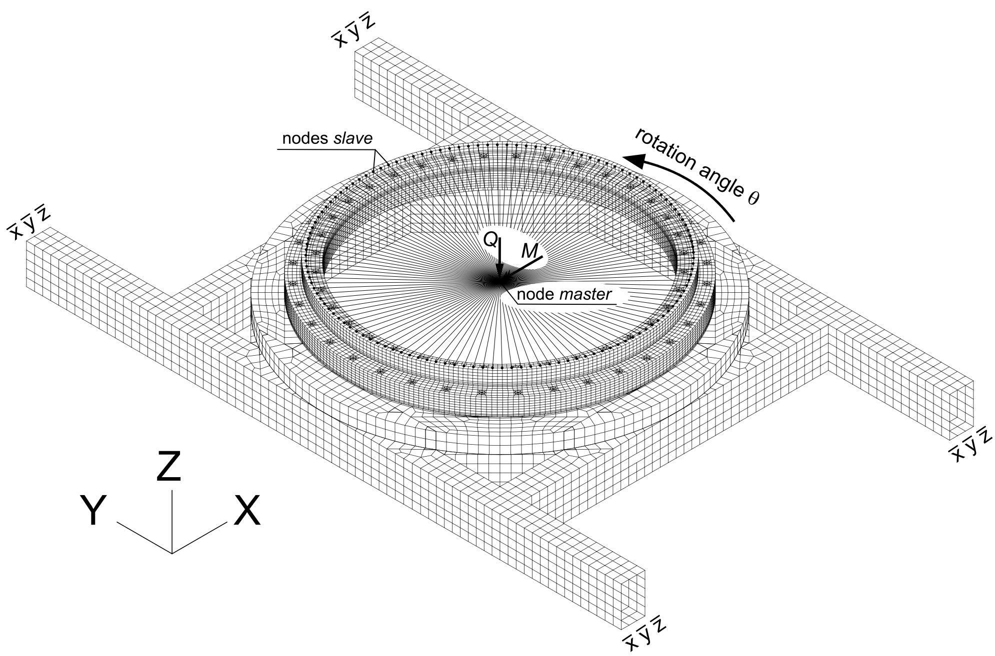


Fig. 2 *FEM model of the subassembly support and slewing bearing with boundary conditions marked*

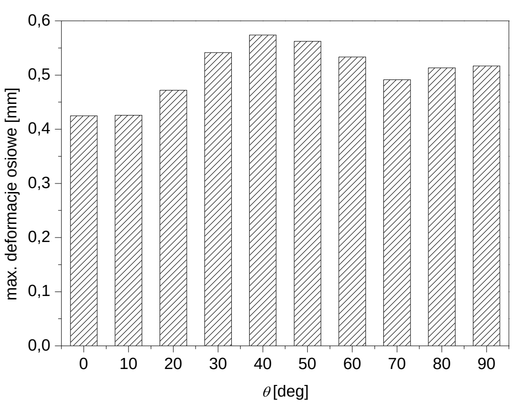
One of the built-bearing girders, which is associated with the support component, called the girder support. To the second beam, called the girder load, applying a load. It is assumed that the nodes on the marginal plane moving with it, ie. being coplanar under load. This can be accomplished by adding additional type of constrain nodes imposed to the grid nodes of the upper surface of the load beam. This is illustrated in Figure 2. Between the corresponding surfaces of the bearing rings and its seating surfaces contact conditions was defined. Designed model allows the rotation of the body relative to the chassis at any angle in the range of 360º.

4.Identification of the deformation of the seat support subassembly and load distribution in the bearing

Using a numerical developed model, the calculations of quasi-real internal load distribution of the ten positions of the chassis, graduated in the range of 10° to 90°, due to the symmetry of the chassis. In the case of asymmetric structure analysis should be performed 360º. Weight that is assumed to calculate the axial force Q = 200 kN, and overturning torque M = 2000 kNm.

Figure 3 shows the maximum deformation of the seat subassembly in the rear of the support ring of the bearing. To determine the values of these deformations used finite element displacement nodes located on these surfaces and set the plane approximating the location of these points. Calculating the distance of these points from the plane approximating the determined maximum deviation from flatness (warping) surfaces. The maximum values of these deviations are approximately 0.6 mm. The individual values of these deviations, for the most unfavorable position of the body (θ = 40°) shown in Figure 3b. It is worth noting that the global slewing bearings manufacturer Rothe Erde company, allows for the bearing seats components supporting warping up to 0.3 mm [9]. Taking into account the results obtained as well as the load distribution in the bearing, which is uneven course, it can be concluded that the part support, there is an appropriate design of the support frame for a machine loaded adopted forces.

a)



b)

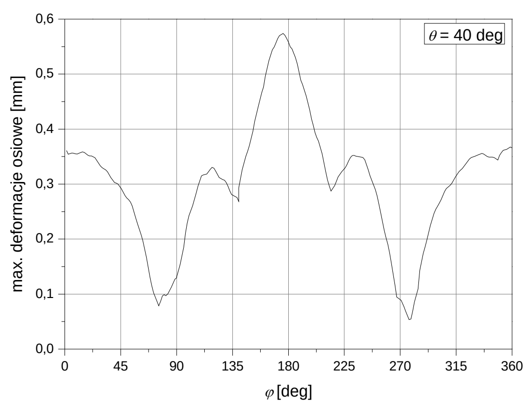


Fig. 3 *The maximum deviation from flatness (warping) of the seat subassembly to different positions of the supporting body during rotation (θ = 0÷90°) (a). The deviation from flatness (warping) around the perimeter of the seat support subassembly (b)*

Examination of the internal load distribution in the bearing for the different positions of the body relative to the chassis working machine allows to evaluate the quality of the support subassembly, and identify critical points in the design of the chassis. In Figure 4a shows the maximum load as a function of the rolling elements of the position of the load beam. The presented results can be seen that the highest load bearing race are for body position angle of about 30° to 40° (Figure 4b). Figure 5 presents the distribution of the forces which carry out specific screws that secure the bearing rings to the building structure.

a) b)

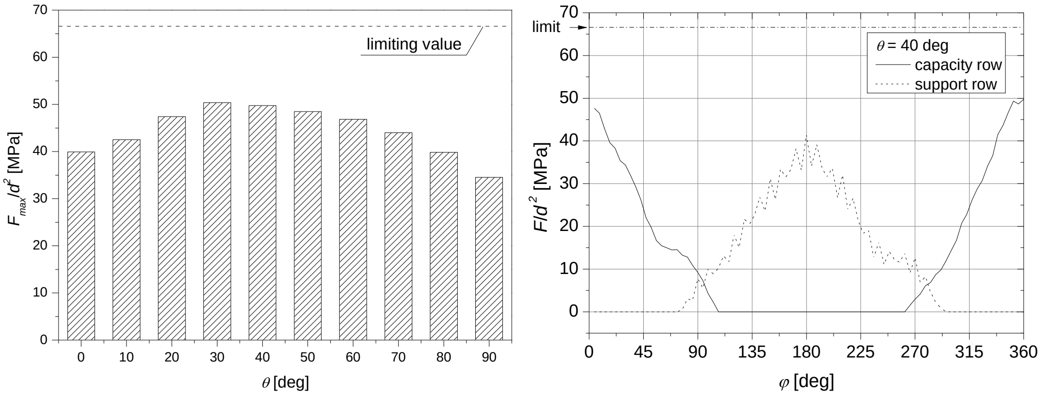


Fig. 4 *Maximum load of bearing rolling elements for different positions of the support subassembly (θ = 0÷90°) (a). Internal load distribution in the bearing support subassembly for position (θ = 40°) (b)*

a) b)

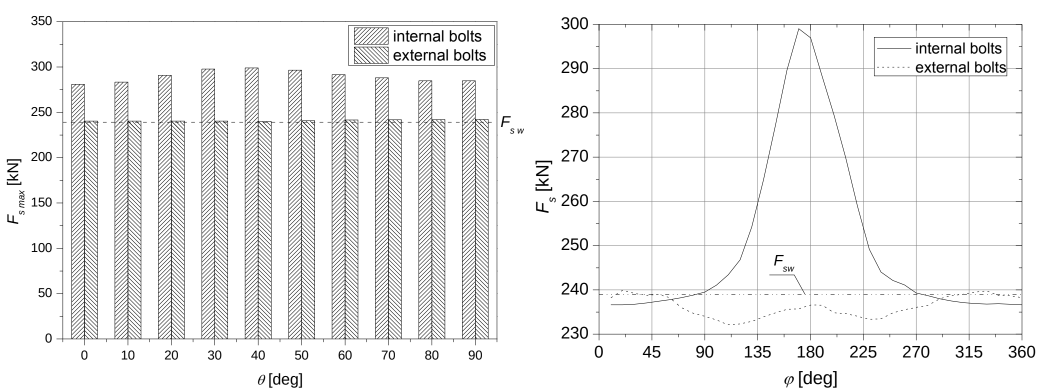


Fig. 5 *The maximum force in the bearing fixing bolts for the different positions of the support subassembly (θ = 0÷90°) (a). Loads of individual screws around the perimeter of the bearing support subassembly for position (θ = 40°) (b)*

Also in this case, the most unfavorable position is at an angle slew of θ = 40° (Fig. 5a). It is also worth noting that the most loaded mounting screws are bearing inner ring (Fig. 5b).

5.Conclusion

The results of calculations for the design of the test show that, even for the most unfavorable position of the machine body during its rotation, no limits of load bearing race or bolts have been exceeded. However, the deformation of seats, which achieve higher values than those recommended by the manufacturers of bearings permits to conclude that adopted for the analysis of the external load is too large for the machine. Therefore, when designing solutions to shape the framework supporting the machine, it is advisable to carry out a very careful analysis of not only the dimensions of the bearing, but the stiffness of the support frames and connections of the subassemblies (in this case, screw connections) [5].

The analysis demonstrates the validity of numerical methods in practical engineering calculations. It allows for precise the distribution of forces transmitted by each bearing rolling elements. Such modeling allows for quick verification of all or technological design changes introduced to both the bearing geometry and up to the building structure.

Literature

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Summary

The impact of the seat support subassembly warping on loads distribution in slewing bearing during bodywork rotation

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In this paper, the effect of deformation of the bearing seat for the supporting subassembly to the internal load distribution was examined. The results are presented for different positions during the rotation of the bodywork of the machine. Specified deviation from flatness of the seat and identifies critical position of the carrier beam of the teste machine.