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PRESS-FIT EVALUATION AND STUDY OF DISPLACEMENT IN TEMPERATURE CHANGES

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Abstract: The article is devoted to bearing analysis, which has a specific shape. The outer ring is the body directly and the inner ring is the case. To determine optimal radial clearance or overlap are used the thermal / structural analysis. The article is logically divided into two parts. In the first analysis, was monitored the impact of the press-fit of the case into the body. In the second analysis, there are presented attained results in graphical outputs of displacements in the orbits at different operating temperatures. At the end of the article were evaluated and researched individual effects on bearing deformation.

KEYWORDS: radial displacements of ball and roller raceways, thermal analysis, structural analysis, bearing, basic reference rating life

1 Introduction

Purpose of the presented press-fit calculation was the investigation of displacements behavior of outer ring raceways at temperatures +20°C, -30°C and +120°C. Housing was a body with non-constant radial stiffness because of ribbed shape. Therefore this study has to support design of radial clearance and describe influence of its displacements after press-fit at each temperature load [1, 4, 5, 6, 7, 8]. For calculation of thermal displacement of other components in the bearing: balls, rollers, shaft; there is used analytical method based on linear thermal expansion theory for symmetric bodies. FEA Calculation was provided using software MSC Marc with following models. Bore-diameter of housing and outer ring diameter represents the critical interference: minimum diameter of bore and maximum diameter of outer ring. The dimensions of the outer and inner rings are shown in Table 1.

Table 1: Diameter outer and inner rings

Name	*Diameter (mm)*
Outer ring (*Or*)	30,000
Inner ring (*Ir*)	29,927

Overhang (Pr) of the bearing before press-fit was calculated according to the equation (1).[2]

$$\mathrm{Pr} = \frac{\frac{Or}{Ir}}{2} = \frac{\frac{30{,}000}{29{,}927}}{2} = 0{,}0365\ mm \qquad (1)$$

where *Or* is diameter outer ring and *Ir* is diameter inner ring

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2 Model for thermal / structural analysis

Analysis model in the Fig. 1 was modified due to eliminate unnecessary details and was set up in FEA environment. Housing was meshed by using approx. 110000 of 3D elements type: TETRA 4 (4 nodes tetrahedron). Outer ring of bearing was meshed by using approx. 42000 of 3D elements type: HEX 8 (8 nodes hexahedron) [3]. Boundary conditions are following: Housing was fixed and outer ring of bearing has defined displacement to press-fit outer ring into final position. Analysis was carried out by using implicit solver.

Press-fit was performed at initial temperature 20°C. After press-fit was applied thermal load steps. Subsequently decrease of temperature at minimum -30°C and increase at maximum temperature 120°C. In each load step was recorded radial thermal-structural displacement.

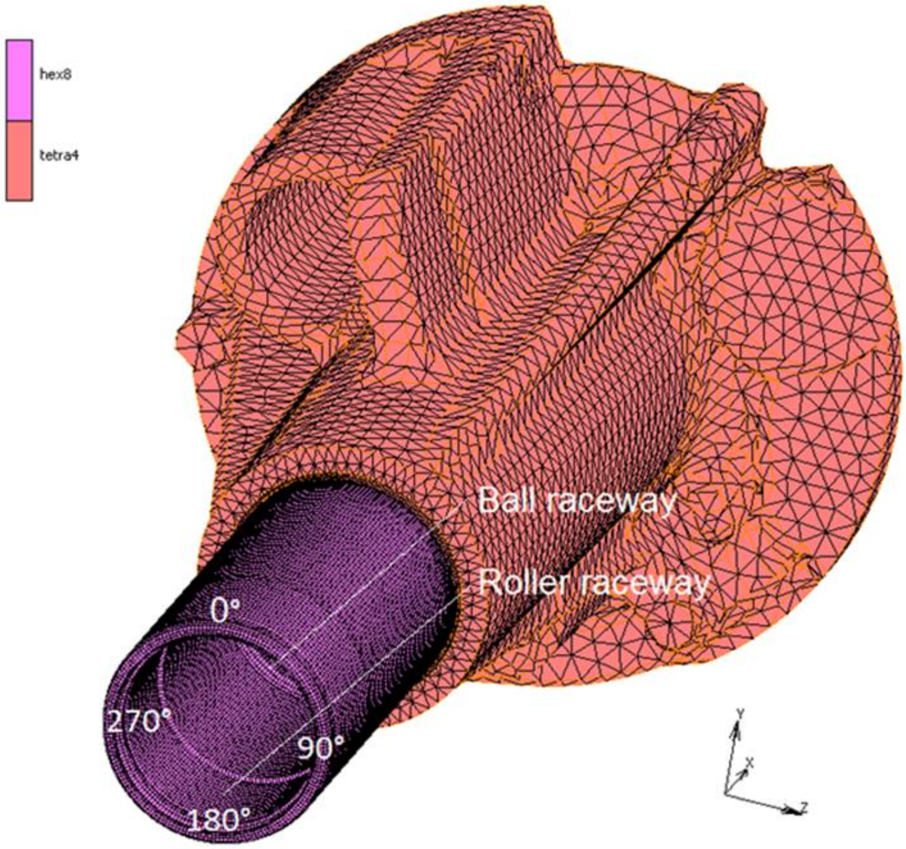


Fig. 1 Model for thermal / structural analysis.

3 Material model

For the calculation of aluminum part was used bilinear material model of AlSi9Cu with the Young's modulus E= 69.000 N/mm², yield strength R_e=140 MPa, Ultimate strength R_m=240 MPa, Elongation A_{50mm}=1%, Poisson's ratio μ=0.3 and linear thermal expansion coefficient α=21x10^{-6} °K. [3]

4 Results from numerical solution

From the Fig. 2 is obvious that there were positive displacement at aluminum body and negative displacement at outer ring of the bearing. Radial displacement or deformation of ball and roller raceways were exported into the polar graphs shown in Fig. 3 and Fig. 4. Red curve correlate with local radial stiffness of the body.

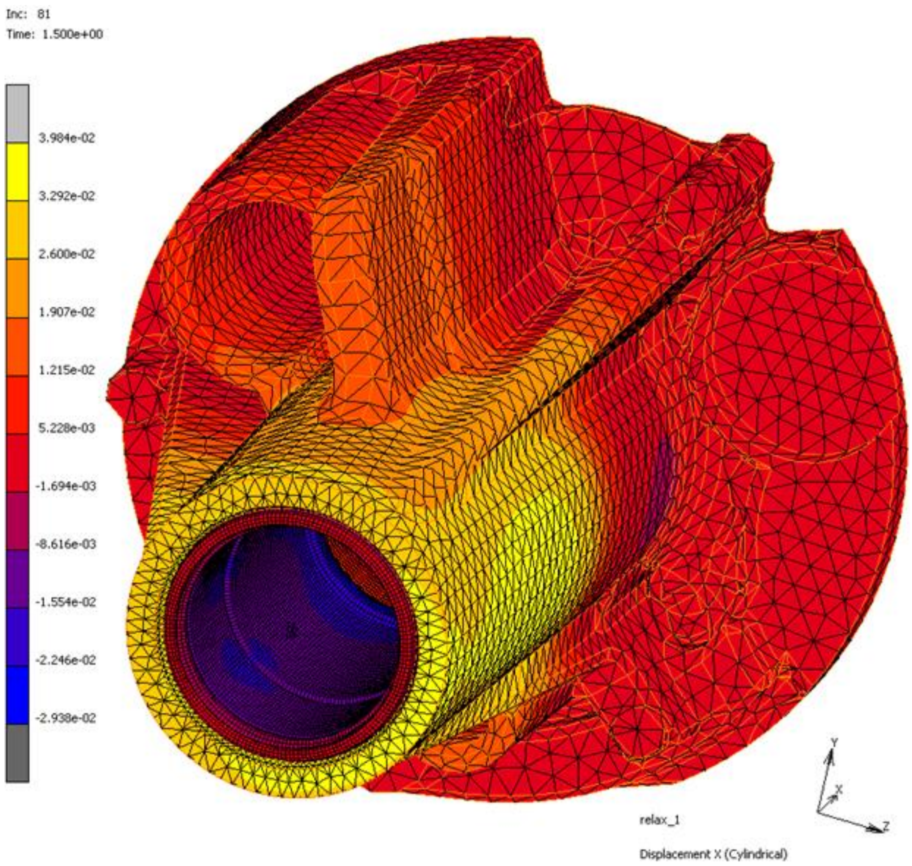
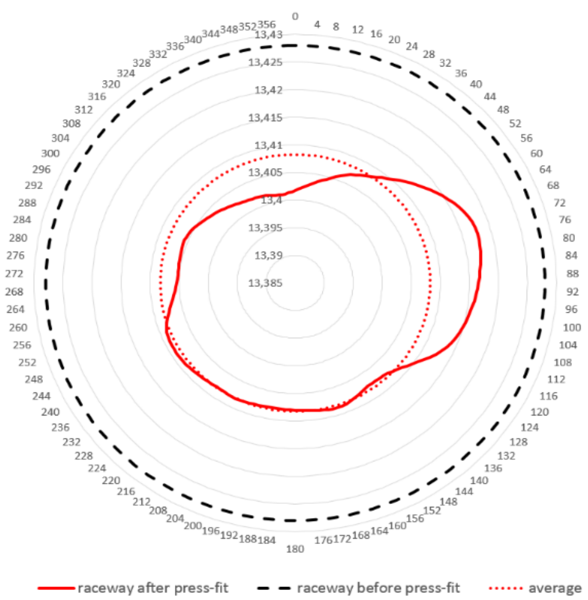


Fig. 2 Radial displacement at 20°C.



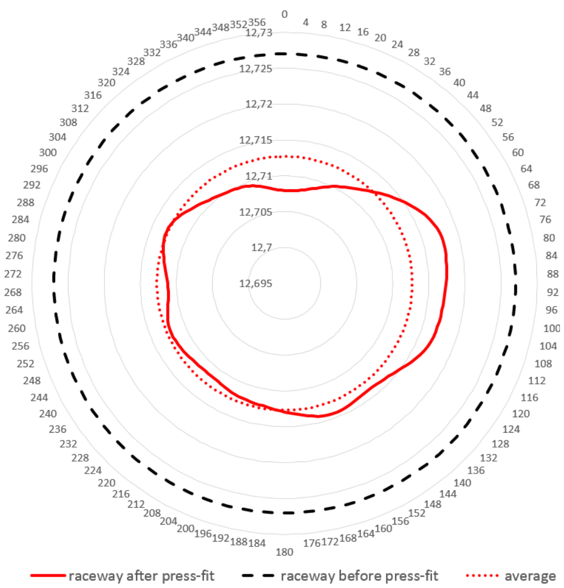


Fig. 3 Ball raceway deformation at 20°C. Fig. 4 Roller raceway deformation at 20°C.

These issues were obtained for all the required temperatures. All results were written in Table 2 and the graphic results shown in the Figure 5.

Table 2: Design and assessment of radial clearance or overhang

Temperature		***-30°C***	***20°C***	***90°C***	***120°C***
component		***Radial deformations***			
Ball		-0,00371	0,00000	0,00520	0,00743
Roller		-0,00278	0,00000	0,00390	0,00557
Ball raceway of shaft		-0,00827	0,00000	0,01158	0,01654
Roller raceway of shaft		-0,00931	0,00000	0,01304	0,01862
Ball raceway of outer ring		-0,06695	-0,03948	-0,00456	0,01036
Roller raceway of outer ring *		-0,05439	-0,02860	0,00230	0,01575
	+ *Clearance*	**+ *Clearance or overhang -***			
Ball raceway	Min. 0,033	-0,01825	-0,00648	0,00646	0,01196
	Max. 0,048	-0,00325	0,00852	0,02146	0,02696
Roller raceway	Min. 0,033	-0,00651	0,00440	0,01447	0,01899
	Max. 0,048	0,00849	0,01940	0,02947	0,03399
	before press-fit	after press-fit			

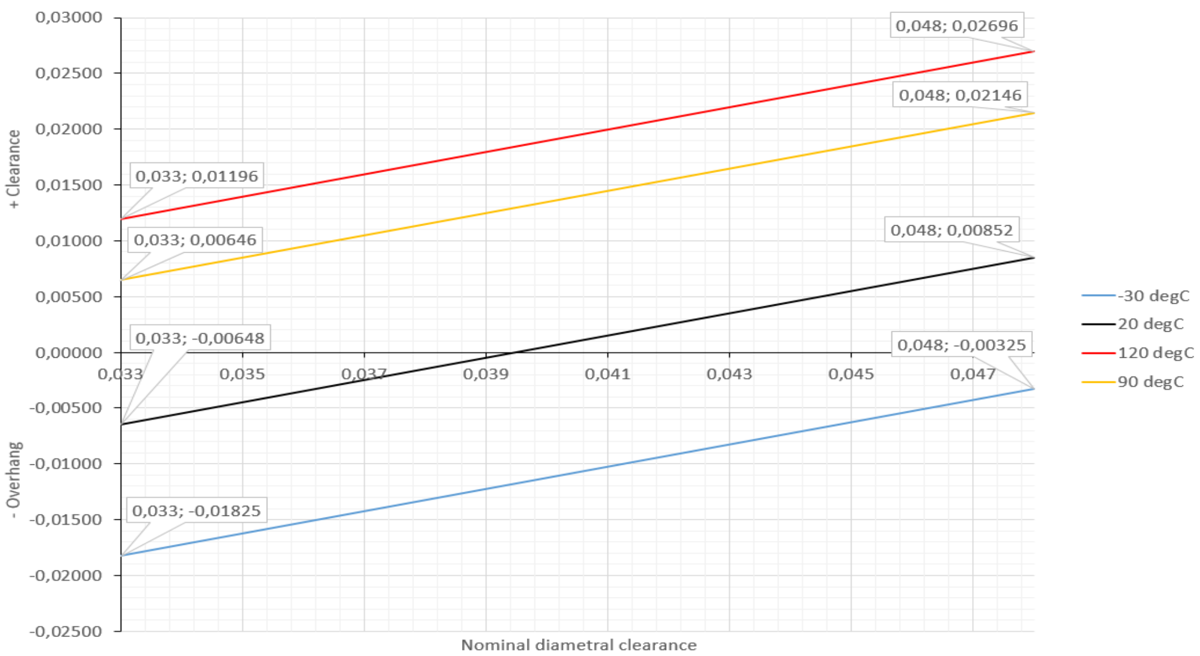


Fig. 5 Ball raceway press-fit effect on radial clearance; X-axis: Diametral clearance before press-fit; Y-axis: clearance or overhang after press-fit

In Fig. 6 was showed blue curve as a function of reference rating life according diametral clearance and overhang. From the result was obvious, that worst overhang -0,0182 mm at -30°C, was on the border of usability.

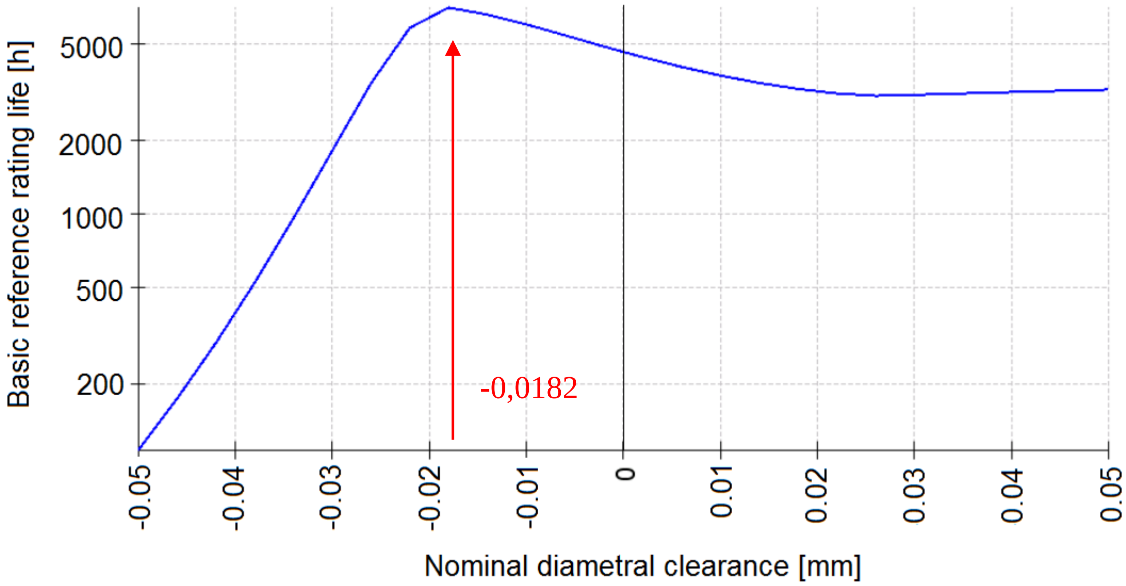


Fig. 5 Basic reference rating life of ball raceway as a function of diametral clearance or overhang

5 CONCLUSION

Performed FEA calculations show radial displacements of ball and roller raceways after press-fit into housing at 20°C and after temperature loads -30°C and +120°C. As well as outer ring is analyzed also thermal displacement of other component of the bearing are calculated analytically.

Calculated displacements and designed radial clearance are used in equation for final evaluation of clearance or overhang after press-fit at each temperature load. Using radial play 0,033 ÷ 0,048 mm for both raceway, the optimal range for use was achieved (Fig. 5). Critical point was at -30°C when ball raceway is assembled with minimal clearance 0,033 mm and bore of aluminium body is minimal. In terms of functionality, Fig. 6 shows, that overhang -0,0182 is on the border of usability.

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