Plastic Behavior of the Oil Sealing Ring in a Bearing Support

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Abstract: Bearing supports of steam turbines contain of many parts. One of these parts is an oil sealing ring. Oil sealing ring has function isolate the hot oil vapor inside the bearing support from mixing it with outside air. When some leakage occurs it is a sing of insufficient function of the ring. This leakage was observed on a power plant after certain operation in short time duration. The reason was plastic deformation of the sealing ring. But the main reason why it went through the plastic phase was unclear.

Keywords: temperature; elastic-plastic; deformation.

1 Introduction

The FEM analysis was done to clarify the reason and it helped to modify the design for the future operation. Numerical simulations were performed in the ANSYS 16.0 software as a multistep analysis with external temperature load and with appropriate boundary conditions. The results were compared to measured values on a disassembled oil sealing ring.

2 Analysis Setup

The 3D model was simplified for the purpose of the numerical simulation. The analysis consists of two models. The larger model – an assembly was used for definition of the temperature field and the smaller model – a part was used for the elastic-plastic static structural analysis. The larger mesh consisted of 3,035,122 mostly tetrahedral elements, the smaller model consisted of 429,048 tetrahedral elements. First approach to set up the analysis was consideration a frictional contact in casing split. It showed up a problem in this setting with highly distorted elements in the contact area. After a few unsuccessfully convergent solutions was done simplification to use upper quarter of the ring only with vertical plane of symmetry and without the problematic contact.

2.1 Temperature Field

The temperature analysis was done as the first step of the calculation. The boundary conditions were not accurate on the beginning of the simulation. Any temperature of the affected part was measured. The reliable sign of the temperature was the surface color of the oil sealing ring. The mass loss of the sealing edge helped to set up the temperature conservatively at 700 °C. The mass loss was caused by contact of sealing edge with the rotor. More thermal boundary conditions were calculated and added to the analysis. The final steady state temperature field of the assembly is on the Fig. 1. The steady state field is a simplification itself in respect of real conditions which occurred in limited time on the power plant.

The temperature analysis was done one more time with slightly different geometry. The difference was in the shape of the sealing edge (Fig. 2). The width of the sealing edge 0.3 mm was extended to the high of 2 mm. This geometry difference caused diverse temperature field (Fig. 3). The temperature difference on the end of the sealing ring (close to sealing edge) between the original and the modified geometry was around 50 °C.

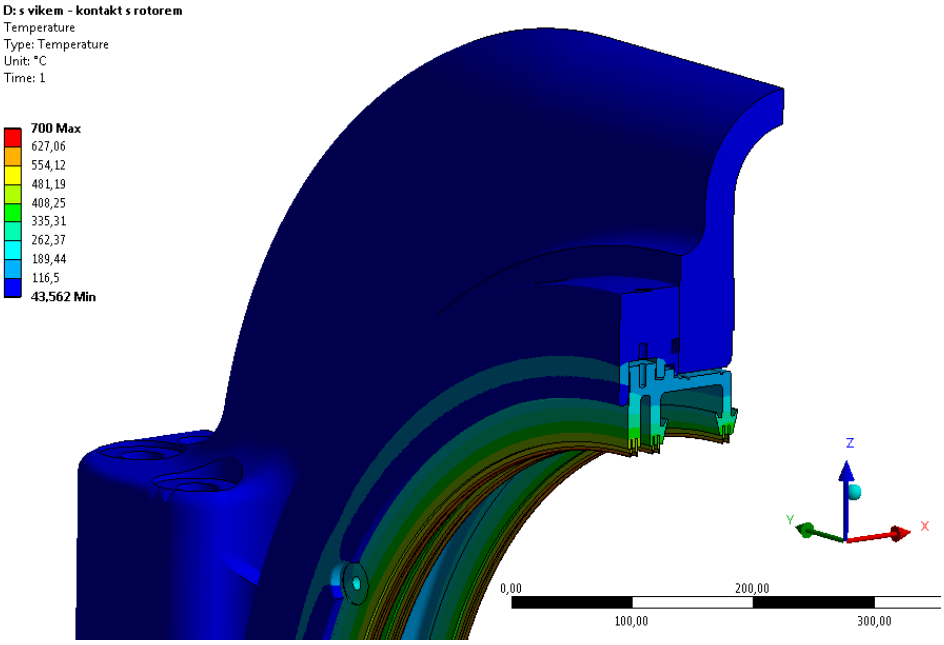
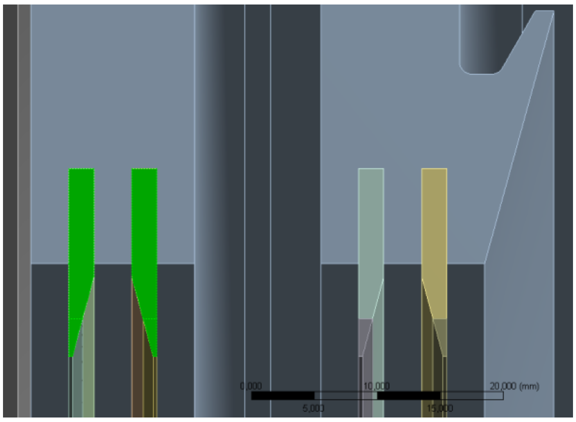
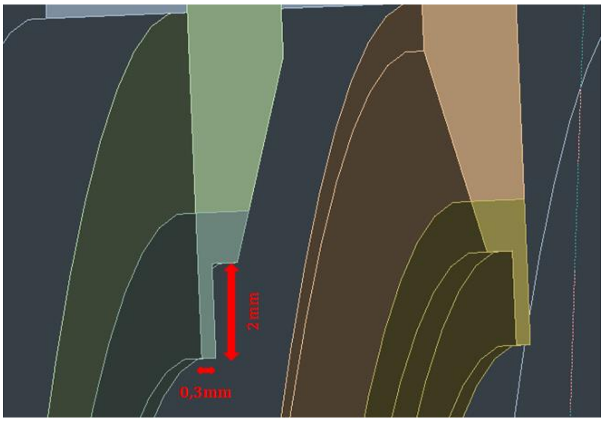


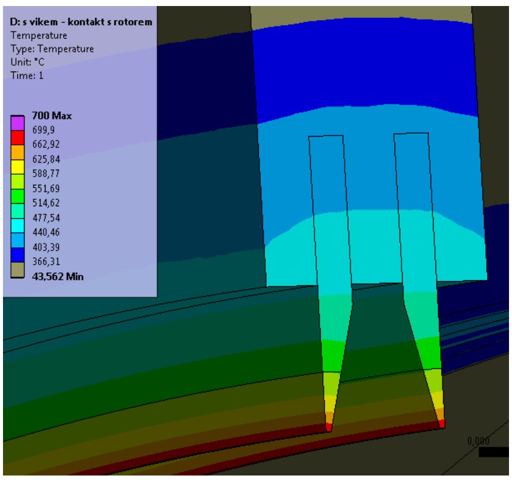
Fig. 1: Temperature field of the assembly


a) Original design

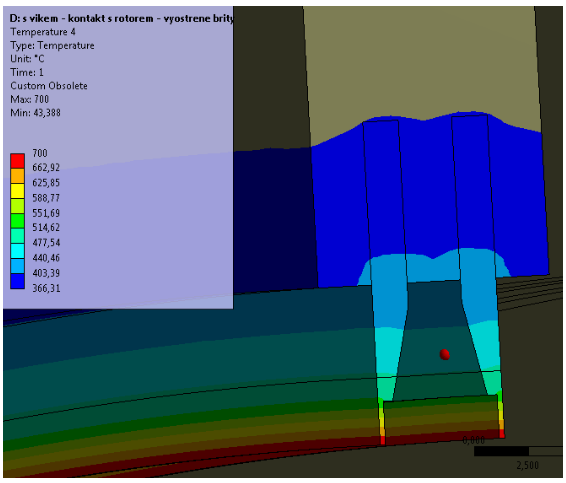


b) Modified design

Fig. 2: Design of the sealing edge



a) Temperature field – original design



b) Temperature field - modified design

Fig. 3: Temperature field

2.2 Static Structural Analysis

The temperature field was made for the assembly included the oil sealing ring. The static structural analysis was focused on the ring only. The analysis was set up from two load steps with different sets of boundary conditions. The ambient pressure on all parts was basically atmospheric and therefore it was neglected. The temperature field was imported in the first step. The next step was used for unloading of all external boundary conditions. Displacement of the oil insert and gravity remained only. The displacement was set up in respect of real conditions, especially in respect of the temperature field of the sealing ring adapter, which surrounded and supported the oil sealing ring. Due to the temperature change the support location moved. This change reflected the displacement boundary condition: A (Fig. 4). Another displacement was set in the casing split. A small area was set as frictionless with Z position locked: B (Fig. 4). In the second step (without external temperature field) total deformation and strain were observed. Static structural analysis repeated once again with different geometry described above (2.1 Temperature field) with the same set of boundary conditions.

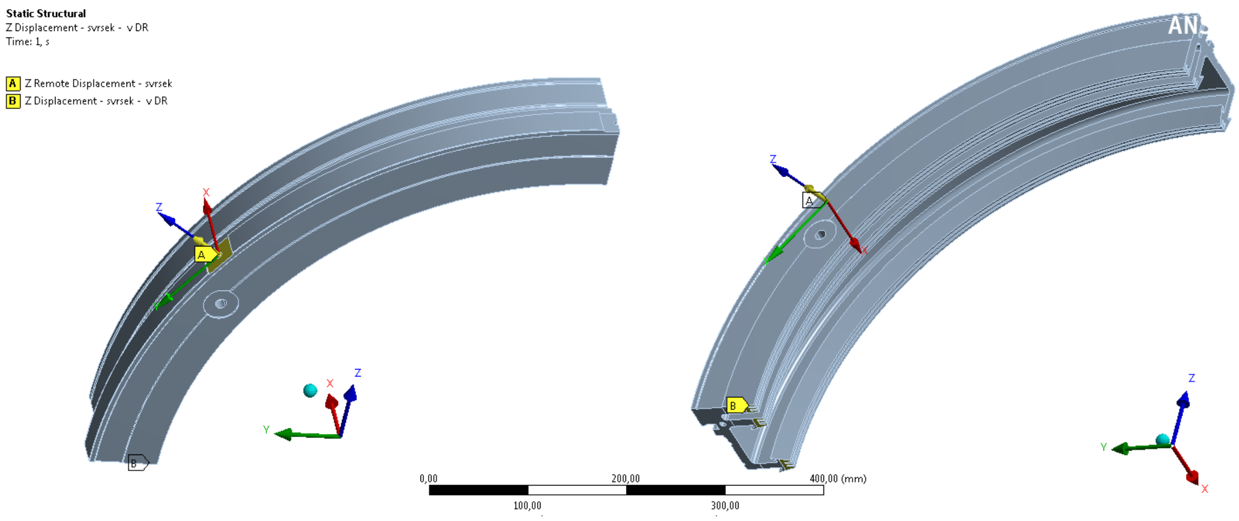


Fig. 4: Boundary condition - displacement

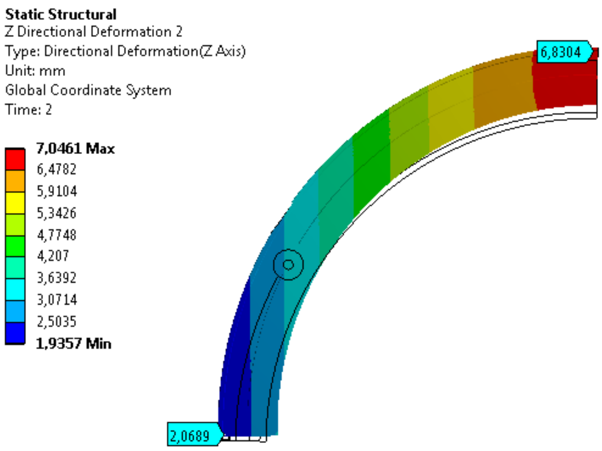
2.3 Material Properties

Oil sealing ring includes 1.0553 steel material properties with bilinear hardening model of plasticity. Sealing edges inside sealing rings are made from brass. Another part of the assembly is an adapter and a cover. Cover is made from material 1.0553 and the adapter has the same material properties as sealing ring.

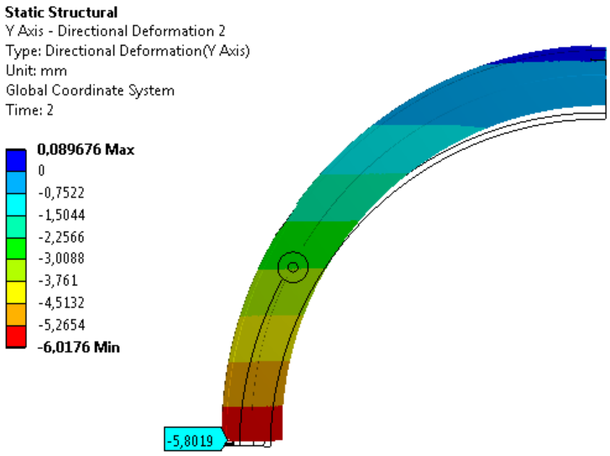
3 Results

Ovality of the oil sealing ring was taken as a result and compared with real measured dimensions. Difference between final shape and original shape was calculated. Fig. 5 represents the shape after the elastic-plastic deformation. Ovality of the ring is calculated as vertical diameter minus horizontal diameter. The result from the analysis is 21.12 mm. The measured ovality was 16.56 mm. The result is up to 27 % higher than in reality. The result with modified geometry is 14.94 mm. It is up to 29% reduced value in shape deformation in comparison of previous FEM result.

The driven mechanism of the shape change is shown on Fig. 6. Plastic deformation is caused by the displacement and by conducted heat from the rotor during time of contact.



a) Vertical plastic deformation



b) Radial plastic deformation

Fig. 5: Final shape after elastic-plastic deformation

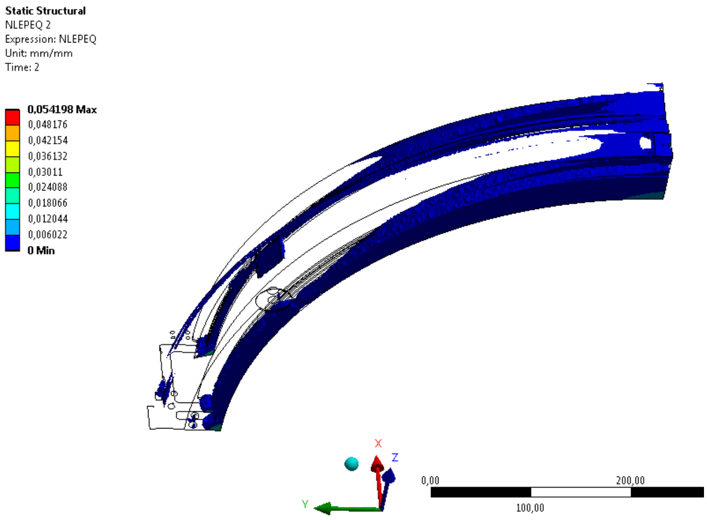


Fig. 6: Plastic area

4 Conclusion

The results from the numerical simulation were compared with the measured dimensions. The result from the static analysis has approximately 27 % higher values than measured on real oil insert. If we consider unclear and simplified boundary conditions in the analysis it is basically good result which proofed the main driven mechanism of the plastic deformation.

The result with modified geometry is up to 29 % lower than the result with original geometry. The changed design of the sealing edge has impact on absorbed heat in the sealing ring from the rotor during contact. It happens in limited time and therefore it is not fully covered in steady state thermal analysis which was done. Despite this fact these gained results show the benefit of the new design. Also the application on a power plant confirmed the improvement.

References

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[2] Retrieved from: https://support.ansys.com