To Conduct Fluid Structure Interaction & Test The Feasibilty of Metal Matrix Composite for Journal Bearing

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***Abstract**: Journal bearings have been used in rotating equipment since the invention of the wheel. The objective of current research is to conduct FSI (fluid structure interaction) studies on journal bearing using CFD. The CAD design of journal bearing is developed in Creo parametric design software and FSI simulation is conducted in ANSYS simulation package. The CFD analysis and structural analysis is conducted on journal bearing to determine the pressure induced and stresses induced on it. Different materials are tested for feasibility in journal bearing and MMC's have shown encouraging results.The total deformation induced on P100/6061 Al MMC journal bearing is found to be 41.4% lower than conventional steel journal bearing. The total deformation induced on Boron/Al MMC journal bearing is found to be 13.33% lower than conventional steel journal bearing.

***Key Words**: Journal Bearing, FSI*

1. INTRODUCTION:

The purpose of bearing is to reduce friction between parts which are in relative motion to each other. The two major categories of journal bearings are rolling element bearings and hydrodynamic journal bearings. The major function of journal bearing is to "carry load between a rotor and the case with as little wear as possible" [1].

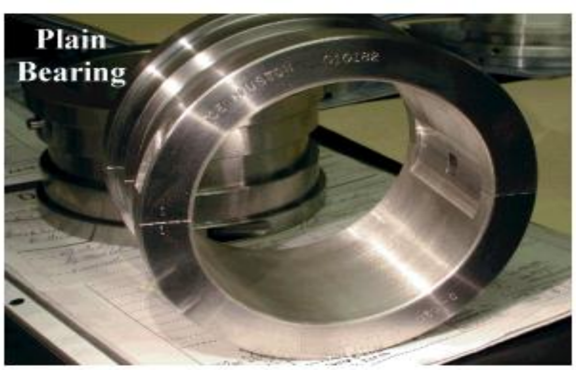

Figure 1: Typical Plain Journal Bearing

The bearings are found in various kinds of machineries used on daily basis i.e. wrist watch, computer disk drive and also in various machineries operating at low speeds and at high speeds.

2. LITERATURE REVIEW

Li et al. [1] have conducted numerical investigation on journal bearing using techniques of Computational Fluid Dynamics. Using CFD, the effect of shear cavitation on bearing performance was investigated. The study was conducted by varying viscosity, eccentricity and speed of operations.

Novotny´ et al. [2] have conducted numerical thermo-hydrodynamic investigation on journal bearing using CFD. The CFD analysis was conducted at different rotor speeds. The CFD simulation results have shown that CFD results over predicted certain output parameters such as pressure and stress as compared to analytical model.

Fedorynenko et al. [3] have conducted analytical and experimental testing on hybrid bearing design. The research findings have shown that hybrid bearing design have better performance with 1.5 times reduced total energy loss (in hydrostatic mode).

Fillon et al. [4] have conducted numerical analysis on hybrid bearings to determine temperature field and pressure field. The dimensions of recess depth taken for the analysis is "nominal value – h = 2 mm" and "recess diameter (nominal value – d = 170 mm)". The research findings have shown that small reduction on temperature field is obtained and the "performance of hybrid bearings is improved with the recess presence, while the thermal properties are preserved or slightly enhanced" [4].

Wasilczuk et al. [5] have conducted experimental investigation on hybrid bearing. The research findings have shown that large viscosity of oil results in lower temperature due to greater frictional losses.

3. OBJECTIVE

The objective of current research is to conduct FSI (fluid structure interaction) studies on journal bearing using CFD. The CAD design of journal bearing is developed in Creo parametric design software and FSI simulation is conducted in ANSYS simulation package.

4. METHODOLOGY

The CAD model of journal bearing is developed using sketch and extrude tool. The film geometry is also modeled in design modeler.

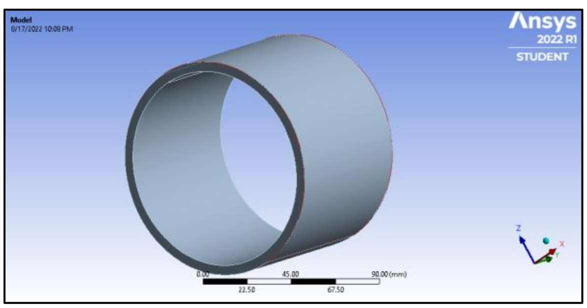

Figure 1: CAD model of journal bearing

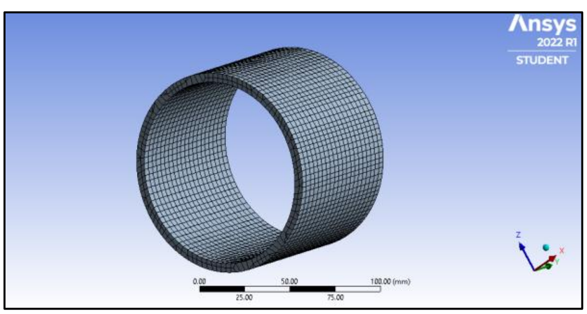

Figure 2: Meshed model of journal bearing

From meshing, the number of elements generated is 3980 and number of nodes generated is 22221. The growth rate is set to 1.2 and transition ratio set to .272.

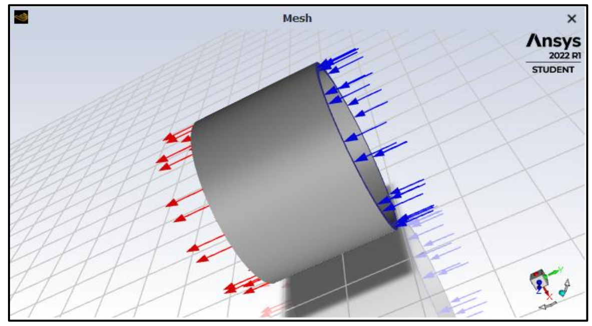

Figure 3: Loads and boundary conditions

The loads and boundary conditions involve defining material type, material property. The energy model is turned ON. The solver type is set to pressure-based model. The material type is defined for the analysis.

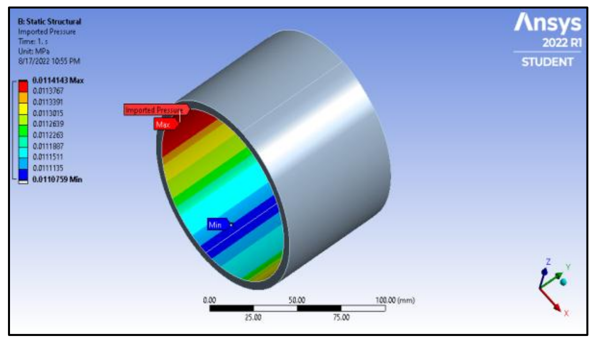

Figure 4: Loads and boundary condition on bearing

The pressure load is obtained from CFD analysis and is mapped on inner surface of the bearing

5. RESULTS AND DISCUSSION

The CFD simulation is conducted to determine pressure induced on journal bearing.

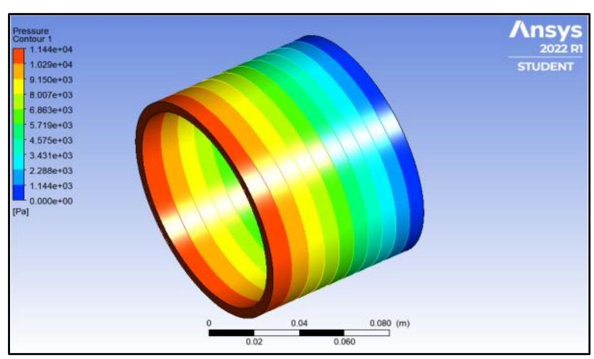

Figure 5: Induced pressure on bearing

The induced pressure distribution increases from one free end to other free end which is represented in blue color contour for low pressure and red colored region for high pressure magnitude.

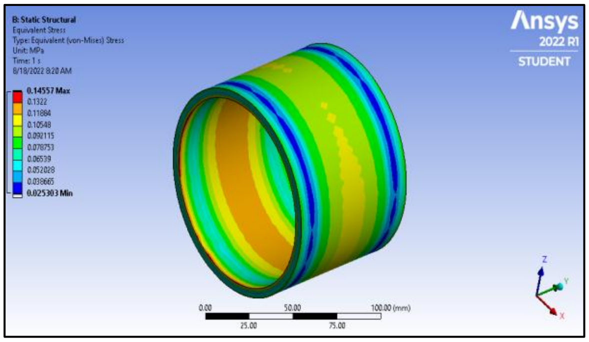

Figure 6: Equivalent stress plot on bearing

The equivalent stress plot is generated on bearing as shown in figure 6 above. The maximum equivalent stress is obtained on the open free ends of bearing. The equivalent stress distribution pattern is in close agreement with the equivalent stress distribution shown in literature. The maximum equivalent stress obtained is at the corner edge of the bearing with .14557MPa.

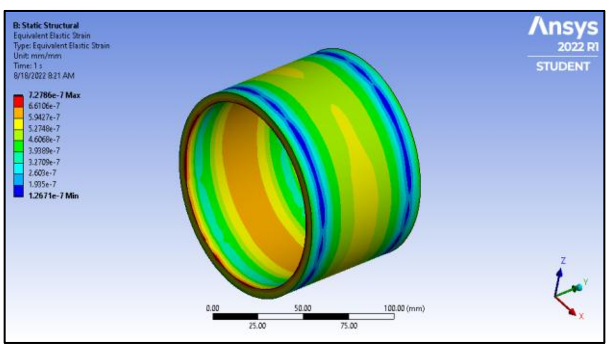

Figure 7: Equivalent elastic strain plot on bearing

The equivalent elastic strain plot is generated on bearing as shown in figure 7 above. The maximum equivalent elastic strain obtained from the analysis is 7.27mm/mm. The total deformation plot is generated for bearing made of P100/6061 Al as shown in figure 7. The maximum deformation is obtained at the center of the bearing.

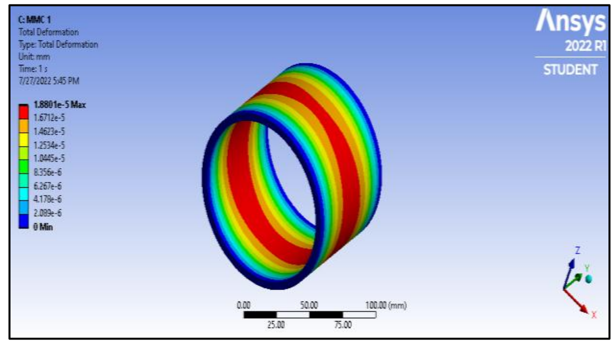

Figure 8: Total deformation on bearing with P100/6061 Al material

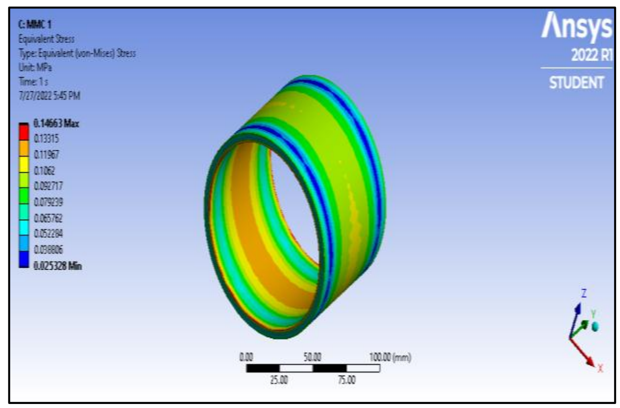

Figure 9: Equivalent stress on bearing with P100/6061 Al material

The equivalent stress plot is generated on bearing as shown in figure 9 above. The maximum equivalent stress obtained is at the corner edge of the bearing with .14663MPa.

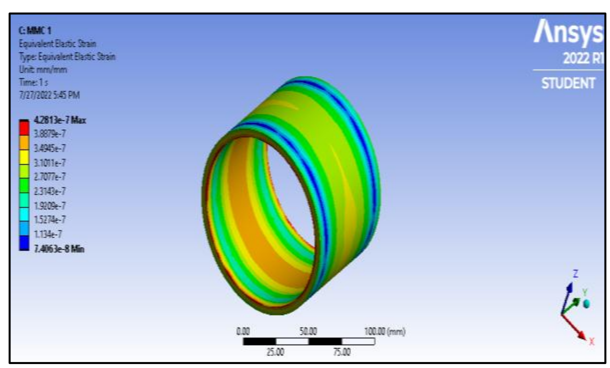

Figure 10: Equivalent elastic strain on bearing with P100/6061 Al material

The equivalent elastic strain plot is generated on bearing as shown in figure 10 above. The maximum equivalent elastic strain obtained from the analysis is 4.28mm/mm.

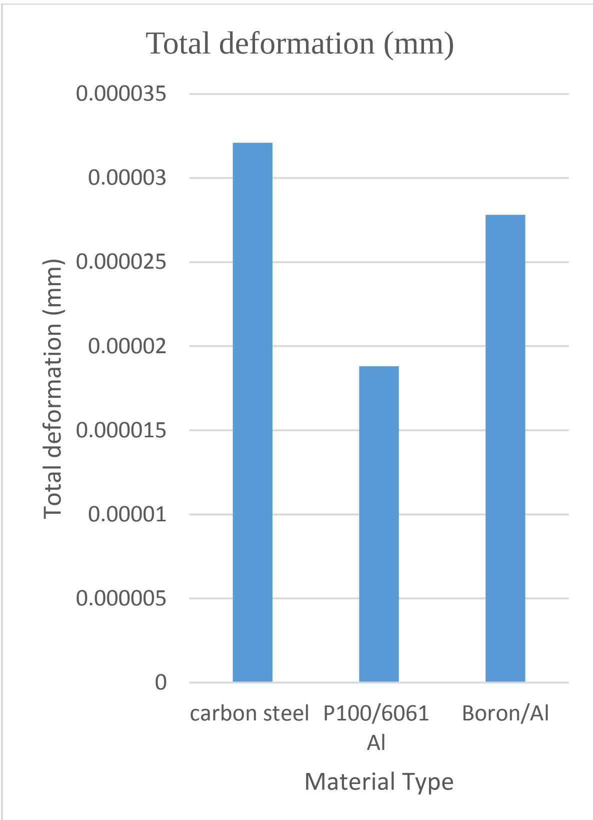

Figure 11: Total deformation comparison

The total deformation comparison plot is obtained from the analysis as shown in figure 11 above. The maximum deformation is obtained for carbon steel with magnitude of .0000321mm and minimum deformation is obtained for P100/6061 Al bearing with magnitude of .0000188mm.

6. CONCLUSION

The FSI (fluid structure interaction) is a viable tool in analysis of journal bearing. The CFD analysis and structural analysis is conducted on journal bearing to determine the pressure induced and stresses induced on it. Different materials are tested for feasibility in journal bearing and MMC's have shown encouraging results. The detailed findings are:

1. The total deformation induced on P100/6061 Al MMC journal bearing is found to be 41.4% lower than conventional steel journal bearing.
2. The total deformation induced on Boron/Al MMC journal bearing is found to be 13.33% lower than conventional steel journal bearing.
3. The equivalent stress obtained for carbon steel bearing is found to be lower as compared to P100/6061 Al MMC journal bearing and Boron/Al MMC journal bearing.

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