Analysis of Carbon Nano Tube Reinforced Ceramic Roller Bearing as an Alternative to Conventional Roller Bearings

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Abstract

Nowadays, most of the automobiles use roller type ball bearing made up of steel. These bearings tend to produce more stress and arcing. When steel rollers are replaced with ceramic rollers they run with an advantage of no requirement for lubrication. But, it also ends up with high thermal stresses on the rollers confining its usage to lesser load capacity. So, carbon nano tube is reinforced with ceramic to avoid arcing and increase load bearing capacity and the structural analysis are done through ANSYS and the comparison is presented.

Keywords: Ceramic bearings, carbon nano tube, simulation, ANSYS, silicon nitride

I. INTRODUCTION

Ball bearings are one of the integral components in an automobile that helps in bearing axial and radial loads due to a moving element. Initially, steel roller bearings were used which required continuous lubrication and frequent replacement. To manage it, hybrid ball bearings were introduced that involved the replacement of steel rollers by Silicon Nitride (SiN_4) rollers. These rollers have lesser weight compared to steel rollers and that makes them compatible for high speed operations. They also reduce the centrifugal loading and skidding and thereby use less energy to allow the element to run faster. Since, ceramics are insulators by nature, these hybrid bearings prevent the arcing that usually occurs in steel bearings.

These hybrid bearings are light weighted when compared to the conventional steel ball bearings thus leading them to have low load bearing capacity. In order to integrate the advantages of both these ball bearings, during manufacturing, carbon nano tube is reinforced with ceramic rollers and the bearings are manufactured. A model of this new composition is made through SOLIDWORKS and the structural and thermal analysis of the bearing is made through ANSYS and the comparison is presented to proclaim its feasibility.

II. SOLID WORKS

Solid works is computer aided design software that provides better design of products, improved visualization, faster design iterations and create the design with much lesser errors. It also provides us to simulate the model and check it in real time scenarios. Structural analysis has been adopted in this paper to check the feasibility of the reinforced roller bearing.

A. Steel Roller bearing

Conventional roller bearings are of high hardness penetration and high strength. It is composed of 0.4% of carbon, 0.85% of manganese, 0.2 % of molybdenum and chromium of 0.95%.

Table – 1
Properties of steel roller bearings

Density	*8.03 kg/m^3*
Vickers hardness	*207*
Ultimate tensile strength	*655 MPa*
Modulus of elasticity	*205 GPa*
Poisson's ratio	*0.29*
Bulk modulus	*140 GPa*

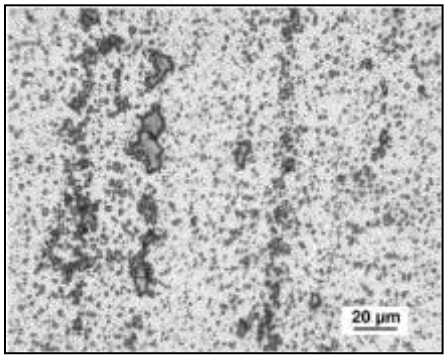

Fig. 1: Microstructure of Chrome steel

B. Carbon Nano Tube reinforced ceramic ball bearing

The reinforcement has taken place in the powder form. Carbon nano tube is added at 0.3% to the silicon nitride (Si_3N_4) powder and are sintered. Later, polyethylene glycol is added which is a milling surfactant and the mixture is dry pressed at 220 MPa and they are sintered at 1700ºC. A constant heating rate of 25ºC/min is maintained. The hub and outer ring are chrome steel, the cage is of copper and the rollers are of CNT reinforced ceramics.

Table – 2
Properties of CNT reinforced ceramic roller bearings

Density	*3.22 kg/m^3*
Bending strength	*678 MPa*
Modulus of elasticity	*233 GPa*
Poisson's ratio	*0.3*
Bulk modulus	*140 GPa*

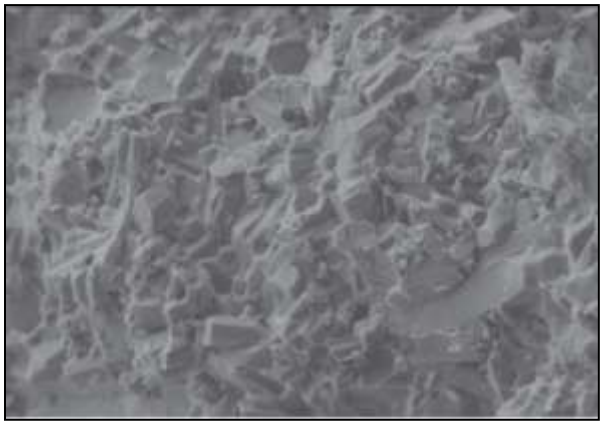
Fig. 2: Microstructure of carbon nano tube reinforced Si_3N_4

C. Model using Solidworks


Fig. 3: Roller bearing made into model using Solidworks

D. Model imported in Ansys

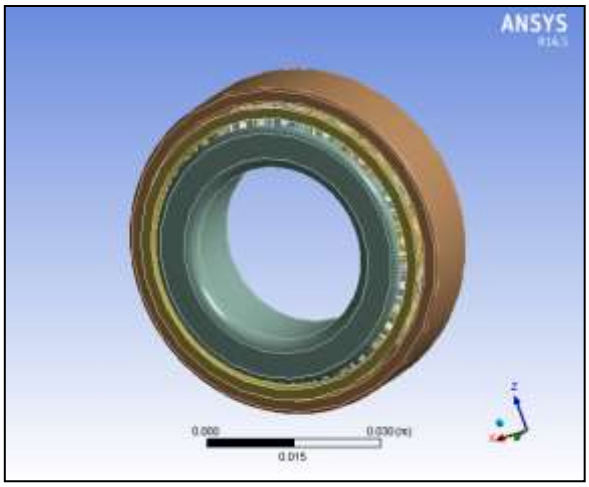

Fig. 4: Model imported to ANSYS

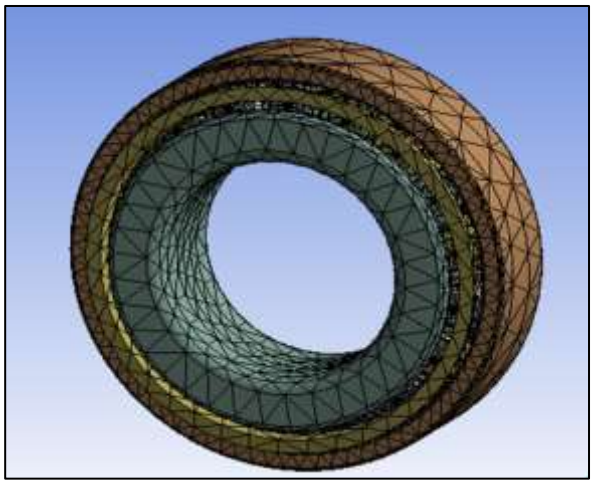

Fig. 5: Mesh generated

III. ANALYSIS

The model is subjected to the constant pressure of 100 Pa and a rotational velocity of 1000 rpm. The entire model gets stressed and the deformation and the maximum stress acting over the entire bearing model is visualized and presented.

A. Constrained Model

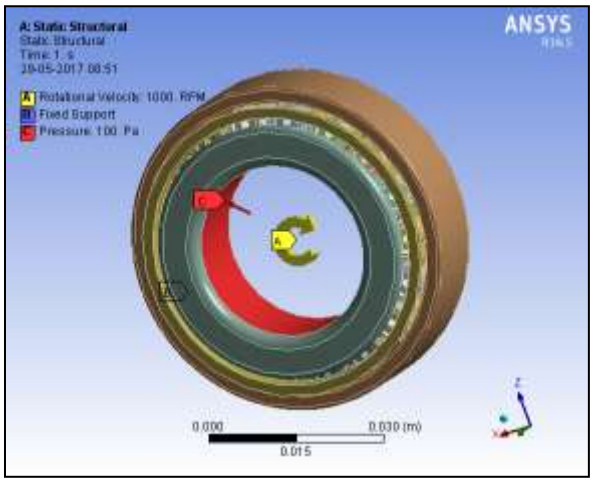

Fig. 6: Intital constraints specified

B. Steel Roller Bearing Total Deformation

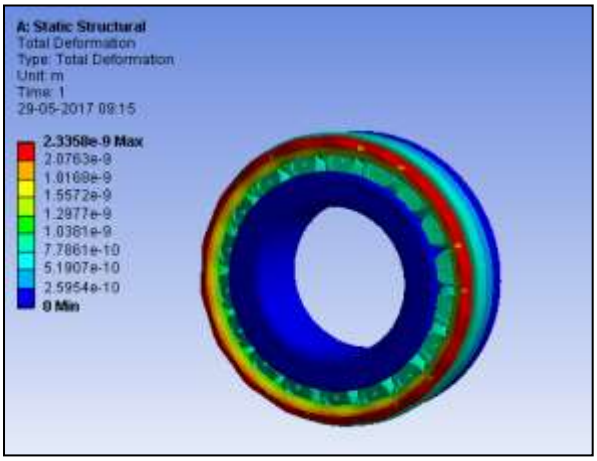

Fig. 7: Total deformation of steel roller bearing

C. *Maximum Stress*

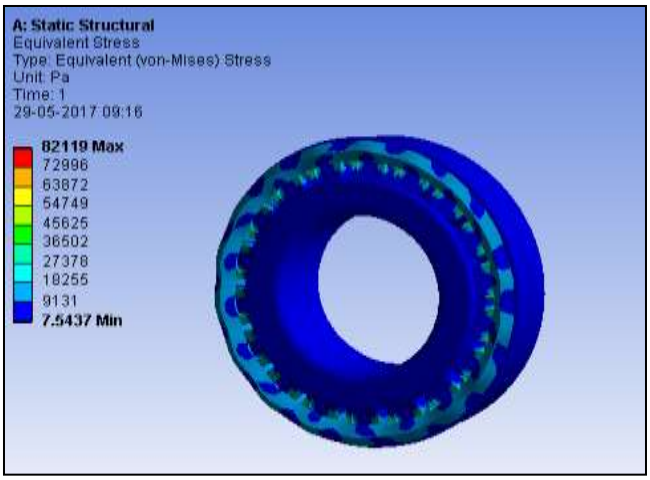

Fig. 8: Maximum Stress of steel roller bearing

D. *CNT reinforced Ceramic Roller Bearing Total Deformation*

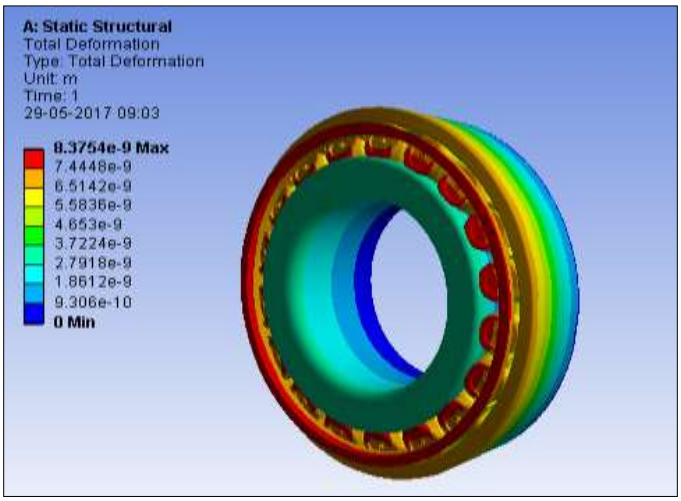

Fig. 9: Total deformation of CNT reinforced ceramic roller bearing

E. *Maximum Stress*

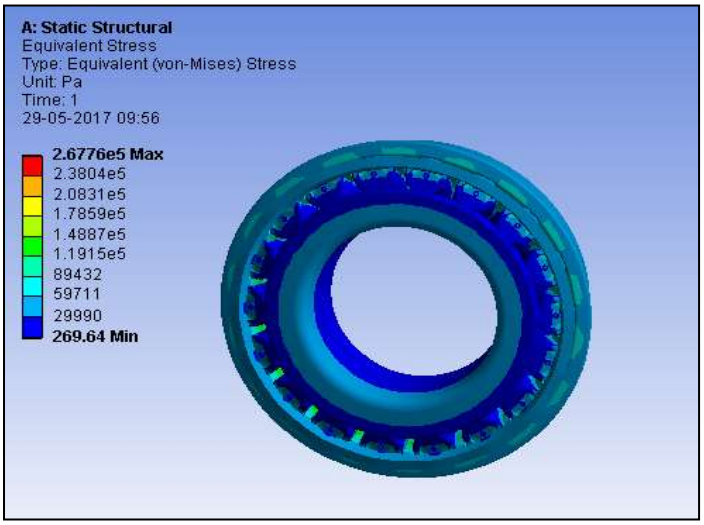

Fig. 10: Maximum stress of CNT reinforced ceramic roller bearing

IV. RESULTS

Table – 3
Comparison result

Bearing	*Total Deformation(m)*	*Maximum Stress(Pa)*
Steel roller bearing	*2.3358 E-09*	*82119*
CNT reinforced bearing	*8.3794 E-09*	*2.6778 E05*

V. CONCLUSION

The roller bearings are modelled and the structural analysis is presented for both steel and CNT reinforced ceramic roller bearings. The obtained results show us that CNT reinforced bearings have less deformation and high load bearing capacity and present a feasible alternative for conventional roller bearings. Future scope of advancement and specialization is also present in this study.

ACKNOWLEDGEMENT

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