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Modelling And Contact Analysis Of Composite (FRP) Material Lamination On Cylindrical Roller Bearing

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Abstract- Fiber reinforced polymer (FRP) composites are an important class of tri-biological materials. They possess unique self -lubrication capabilities and low noise which make them suitable for applications like seals, bearings, gears and artificial prosthetic joints. The FRP composite bearings are ideal for high load low speed applications or where normal lubrication is difficult or costly. The friction and wear behavior of FRP composites varies with fiber orientation and sliding direction. For the purpose of fully utilizing the beneficial contact characteristics of FRP composite, it is necessary to obtain an in-depth knowledge of their contact behavior.

In this work, the compliance behavior of FRP composite bearings is studied. The frictional sliding contact between a FRP composite and a rigid parabolic cylinder is analyzed. The influence of sliding direction, fiber and matrix material combinations, volume fraction of the fiber, frictional coefficient and fiber ply orientation on the contact pressure distribution and the contact area for unidirectional FRP composite bearings are evaluated. A finite element model is developed using ANSYS and the results obtained from the analysis are compared with the analytical results. The influence of sliding direction on the contact pressure distribution for cross FRP composite bearings is studied and compared with unidirectional FRP composite bearing.

Index Terms- Keywords—FRP; Ansys; roller bearing

1. INTRODUCTION

Fiber-reinforced plastic (FRP) (also fiber-reinforced polymer) is a composite material made of a polymer matrix reinforced with fibers. The fibers are usually glass, carbon, agamid, or basalt. Rarely, other fibers such as paper or wood or asbestos have been used. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use.

FRPs are commonly used in the aerospace, automotive, marine, construction industries and ballistic armor.

Fig.1.1 roller bearing

A polymer is generally manufactured by step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers the result is referred to as a plastic. Composite plastics refer to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties. Fiber-reinforced plastics are a category of composite plastics that specifically use fiber materials to mechanically enhance the strength and elasticity of plastics. The original plastic material without fiber reinforcement is known as the matrix. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibers. The extent that strength and elasticity are enhanced in a fiber-reinforced plastic depends on the mechanical properties of the fiber and matrix, their volume relative to one another, and the fiber length and orientation within the matrix. Reinforcement of the matrix occurs by definition when the FRP material exhibits increased strength or elasticity relative to the strength and elasticity of the matrix alone.

2.0 Objectives

1. To simulate contact between two bodies accurately by verification of contact stresses between two surfaces in contact,

2. To found static analysis bending stress is at the root of the bearing and the results of the static analysis.

2. Von Mises Stress For Contact Pair.

3. Von Mises Stress for Composite

3.0 Modeling and Analysis of Bearing

3.1 Pro-E Model of Roller Bearing

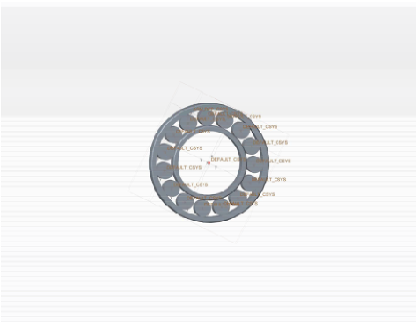

FIG. 3.1 Pro-E Model of Roller Bearing

4.0 STATIC ANALYSIS

Static Analysis used to determine displacements, stresses, etc. under static loading conditions. ANSYS can compute both linear and nonlinear static analyses. A static analysis can be either linear or nonlinear.

4.1 Rollers of a Bearing

Following figure shows the 3 d modeling is done of the rollers used in the bearing. The overall stresses are applied on the roller indirectly by sandwiching rollers in the two inner and outer rings.

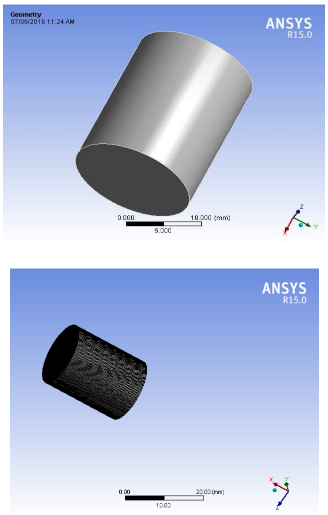

FIG. 3.2 Rollers of a Bearing

4.2 Inner Ring

Following figure shows the inner ring model of the roller bearing. Generally load applys on the bearing inner side on the inner ring by the shaft. We will show you the deformation effects occurs on the roller bearing.

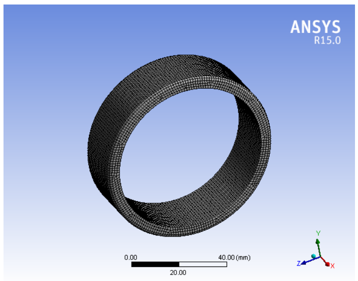

FIG. 3.3 Inner Ring

4.3 Outer Ring

Following figure shows the outer ring model of the roller bearing. Generally load applys on the bearing outer side on the outer ring by the applied load. We will show you the deformation effects occurs on the roller bearing.

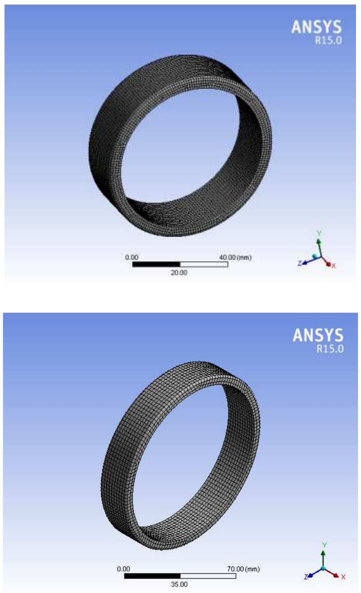

FIG. 3.4 Outer ring

4.5 Analysis on Ring

Following figure shows you the deformation occurs on the outer ring when load is applied.

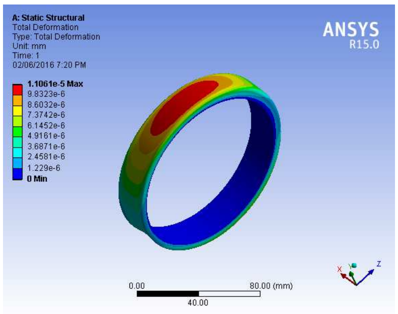

FIG. 3.5 Outer ring

4.6 Analysis on a roller.

Following figure shows you the deformation occurs on the roller when load is applied.

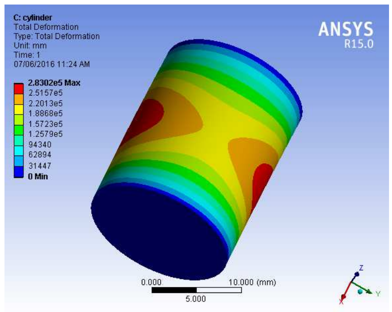

FIG. 3.6 Roller

4.7 Stress on an overall bearing

Following figure shows you the deformation occurs on the overall bearing when load is applied.

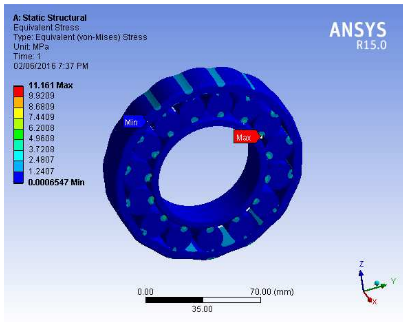

Fig. 3.4 Overall Bearing Analysis

5.0 ANALYTICAL CALCULATIONS

5.1 Rating life:

Rating life is defined as the life of a group of apparently identical ball or roller bearings, in number of revolutions or hours, rotating at a given speed, so that 90% of the bearings will complete or exceed before any indication of failure occur. Suppose we consider 100 apparently identical bearings.

$L1 / L2 = (P_2 / P_1)^a$

5.2 Basic load rating: It is that load which a group of apparently identical bearings can withstand for a rating life of one million revolutions.

5.3 Equivalent radial load: The load rating of a bearing is given for radial loads only. Therefore, if a bearing is subjected to both axial and radial load, then an equivalent radial load is estimated as,

$P_e = XVP_r + YP_a$

- From the sheet Power = 36kW,
- Stroke length = 150.6 mm,

Speed = 4800rpm.
P = 2πNT/60 (by reference 10)
T=36*1000*60/2 □N
T = 71.65 N.m
Now,
Torque = Force * Crank Radius
71.65 = Force * stroke length / 2
=> Force = 951.4 N
Here for a pure cylindrical roller bearing axial force F_a= 0.
Fr = 951.4 N
F_a / Co = 0 and F_a / F_r = 0. Now for P_{eq},

Therefore, $P_{eq} = (XF_r + YF_a) \times S$

1. Here Fa= 0 and X=1, S= 1.
2. Peq. = Fr = 951.4 N

During a single revolution of the wheel, point A will experience a cycle of stress values varying from zero (when point A lies well outside the contact zone) to a maximum state of stress (when A lies within the contact zone and on the line of action of the 800 lbf force.) We expect point A to "feel" the effects of a semi-elliptical contact pressure distribution as point A moves into and through the contact zone. Thus, we need to calculate the contact stresses for a depth of z = 0.015 inch, which we expect to lie within the contact zone.

6.0 RESULT ND CONCLUSION

This chapter reveals about comparison between theoretical, Finite Element Analysis, and experimental analysis. The usage of bearings with a lamination of FRP material on the inner side of the outer race of the roller bearing which holds good for a durable operation even in criticalities when operated with whole steel outer race. This usage of FRP also reduces the weight of the bearing which positively affects the power usage of the engine.

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