Improving the load carrying capacity of Cylindrical Roller use in bearing by changing its profile

Mr. Ravi S. Bisane¹ Dr. A. V. Vanalkar² Prof. P.M Zode³
¹P.G Student ²³Professor
¹,²,³Department of Mechanical Engineering
¹,²,³KDKCE, Nagpur

Abstract— In Cylindrical roller bearing The end corners cylindrical roller are crowned to maximize load carrying potential, reduce edge loading, edge stress concentration and tolerate some minor misalignment. Cylindrical roller is also crowned in order to uniformly distribute the stress concentration and pressure over roller profile outer and inner raceways. The new proposed design of cylindrical roller relies on creating crown profile at both ends of a roller. The uniform pressure distribution should not cause the damage of materials. The proposed design of cylindrical roller will be analysis by using FEA and results will be compared with standard cylindrical roller profile. By using analysis and profile changing of the bearing improving the load carrying capacity of the bearing.

Key words: Cylindrical roller, crown profile, Crown radius, FEA, Load, Von-mises stress

I. INTRODUCTION

Conventionally, the crowning profile does not provided on the roller profile. The cylindrical roller profile has sharp end corners. The end of cylindrical roller didn’t crown as shown in fig.1. The line contact between cylindrical roller and raceways offers high loading capacity. But because of sharp corner end of roller there were always tear and wear takes place at the edges of roller and raceways. This produces friction, heat and noise generation in cylindrical bearing and hence bearing performance and life decreases.

Fig. 1: View of cylindrical roller bearing having sharp end corner roller.

Furthermore, to distribute the contact pressure uniformly in the longitudinal direction of the contact area, the roller ends are crowned and it has been considered to be the best profile. Named after its developer, this is called “Lundberg crowning profile” shown in fig.2. The crowning profile is shaped according to proper design then the uniform pressure distribution does not cause the damage distribution of materials.

Fig. 2: view of Lundberg crowned profile for cylindrical roller with proposed crown.

Thus the crowning profile should be optimized by considering sub surface stress components.

In this project, the cylindrical roller which are used for various tests and study are of cylindrical roller bearing NU 2206E and properties of bearing are given in below table. This type of cylindrical roller bearing is of NU, hence there is only radial force.

II. THEORY AND PRINCIPLE

A. Hertz Formulation for Line-Contact Conformity:

The Hertz line contact conformity formulation theory use to develop the uniform pressure distribution across the contact area of the cylindrical roller and raceways. With this, the uniform pressure distribution across contact area formulated. Also the Finite element analysis (FEA) will be used to design and analysis the cylindrical roller profile.

Fig. 3: Contact width of two contacting surfaces

The half-width b of the rectangular contact area of two parallel cylinders is found as:

\[ b = \frac{4P}{\pi (E_1 + E_2)} \frac{1}{L} \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \] ..................(1)

Where E₁ and E₂ are the moduli of elasticity for cylinders 1 and 2 and μ₁ and μ₂ are the Poisson’s ratios, respectively. L is the length of contact.

The maximum contact pressure along the center line of the rectangular contact area is:

\[ P_{\text{max}} = \frac{2F}{abL} \] ..................(2)

\[ \sigma = P_{\text{max}} \left(2 - \left( \frac{L}{b} \right) \right) \frac{1}{b^2} + 1 - 2 \left( \frac{L}{b} \right) \times 10^3 \] ..................(3)
Improving the load carrying capacity of Cylindrical Roller use in bearing by changing its profile

By using the equations (1), (2), (3), (4) and table no-3.1 for numerical calculation, the maximum contact stress for the cylindrical roller under application of 3500N radial load, the analytical result is given in table 1

![Graph showing Von-Mises Stress]

**Table 1: Analytical Results from Hertz’s Theory.**

<table>
<thead>
<tr>
<th>Load(F)N</th>
<th>Half-width (b) mm</th>
<th>P_{max} N/mm²</th>
<th>Deformation (\delta c) mm</th>
<th>Max stress (\sigma) Mpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>3500</td>
<td>0.09873</td>
<td>1504.5</td>
<td>0.00805</td>
<td>358.4</td>
</tr>
</tbody>
</table>

The maximum contact stress value obtained from analytical solution is used for the reference value for further work.

![Graph showing Total deformation]

**Table 2: Cylindrical Roller Bearing Specification.**

- **Roller bearing**: NU 2206E
- **Material for bearing**: SAE52100
- **Material density**: 7.85 g/cm³
- **Dimensions**: d=30mm, D=62mm, B=20mm
- **Radius of roller**: 10 mm
- **Length of roller**: 15 mm
- **Young’s modulus**: 208 GPa
- **Poisson’s ratio**: 0.30
- **Static Radial load**: 49KN
- **Dynamic radial load**: 50KN
- **Tensile Yield Strength**: 550 Mpa

The force applied on roller = total load ÷ No. of rollers in bearing = 49000 ÷ 14 = 3500N

This is the standard load on each roller.

### III. DESIGN AND ANALYSIS USING FEA

**A. Design:**

Design of the roller according to its profile load carrying capacity is improve.

Standard calculation of load and stresses relation shown in table no-

**B. Analysis Using FEA:**

Software used: The three-dimensional model of cylindrical roller profile is modeled with CREO 3.0 software and analysis is carried out on ANSYS 14.0

In analysis standard roller of a bearing is tested under heavy load. The primary dimensions and material properties considered for cylindrical roller are as given in Table-01.

**Analysis of Roller Up Tensile yield strength. (550 Mpa)**

In standard roller consist of sharp edge at end and in the proposed design consist of circular crowning radius = 1.23mm. material properties and loading conditions are same.

**C. Analysis of Standard Bearing Without Crown Radius**

Analysis of Roller up Tensile yield strength. (550 Mpa)

In standard roller consist of sharp edge at end material properties and loading conditions are same.

**D. Analysis of Standard Bearing With Crown Radius:**

Analysis up to the load at which standard bearing fails

In the proposed design consist of circular crowning radius = 1.23mm. material properties and loading conditions are same as considered in above model.

![Graph showing Von-Mises Stress with crown]
Improving the load carrying capacity of Cylindrical Roller use in bearing by changing its profile

IV. RESULTS

A. FEA Result Of Roller At Standard Load (3500N):

<table>
<thead>
<tr>
<th>Roller Design</th>
<th>Load(F)N</th>
<th>Von-Mises stress(Mpa)</th>
<th>Deformation (Δc)mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Crown</td>
<td>3500</td>
<td>350.92</td>
<td>0.008574</td>
</tr>
<tr>
<td>Crown</td>
<td>3500</td>
<td>262.28</td>
<td>0.008950</td>
</tr>
</tbody>
</table>

Table 3: FEA Results For The Structure Analysis Of Standardand Proposed Cylindrical Roller At 3500n

B. FEA Results Graph Of Roller At Varying Load:

Fig. 8: Graph.1. Load Vs Von-Mises Stress

From the experimental results given in TABLE.III and Graph 1 the proposed cylindrical roller with crown is the best design than the standard profile. It saves the material hence cost is less. Edge stress concentration is less as compared to typical roller. The stresses induced in it under the load are much less than Crown roller and standard roller.

V. CONCLUSION

The design of proposed cylindrical roller is relies on the uniform pressure distribution according to H. Hertz theory, reducing the edge stress concentration and it is achieved successfully. The loading capacity of proposed design of roller is more than the other roller of same material property as less stresses are developed in the roller under load. Edge stress concentration is less as compared with without crowned cylindrical roller. In proposed design, the contact stresses are uniformly distributed. The material is saved in proposed design and hence less cost is required for manufacturing process. Fatigue and dentations failure of roller get minimized as the proposed design is more stable than other roller design.

REFERENCES


