Analysis and Optimization of Contact Stresses for Thin Coating Application to Antifriction Bearing

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Abstract— Coatings represent an important class of tribological materials that are used to reduce friction and wear in mating surfaces such as in bearing. The present study carried out for analysis of a contact stresses by using FEA then experimental work has been carried out to optimize contact stresses. Thin coating by physical vapour deposition method has done of material TiN and TiAlN for a different coating thickness. Surface roughness, SEM (Scanning Electron Microscopy), Hardness test and scratch test has been carried out. TiAlN gives high hardness result 3200 HV. Hence this will provide high wear resistant

Key words: Thin Coating, Contact Stresses, PVD Method, Wear Resistant

I. INTRODUCTION

With advances in materials research over the past 20 years, novel coating materials have been developed to substantially improve the performance and increase the lifetime of mating components.

These coatings, which often have material properties that are directional dependent in nature, can be harder or softer than their substrate counterparts. In applications such as machining, where material is being plastically deformed or removed, hard coatings are applied to one of the surfaces (cutting tool) to provide a barrier to abrasion and other wear mechanisms. Soft coatings, in contrast, provide a lubricant layer that separates surfaces and more evenly distributes the pressure within the contact region. In both hard and soft coating applications, the selection of coating material and thickness is often problematic for designers.²³

This can be attributed to the fact that analytical several studies have been carried out to explain the different factors to resist the failures such as elastic plastic stress and strain, material Properties and surface roughness in rolling sliding contact, and effects of nonzero coefficient of friction. Furthermore, recent study of rolling contact problems indicates that the peak of the contact pressure and the creep age significantly affect the wear rate of rolling components. Rolling contact bearings are widely used in rotational machinery to support shafts and separate rotating machine elements from stationary ones. In machine tool applications bearing precision is of vital importance to ensure accurate products and in chemical machinery corrosion resistance must be guaranteed. In aircraft and space vehicles high reliability and relatively long life are required of all assemblies and elements, including bearings. With the advent of the space era very demanding bearing operating conditions such as high vacuum, extreme temperatures (e.g. C230 to −150 °C), large temperature differentials, long life (both wear and fatigue life, usually 10–15 years without maintenance) and low frictional power are quite common

These ever increasingly stringent demands present great challenges for those responsible for the development and validation of new rolling contact bearing materials. In the present study for a a rolling/sliding antifriction bearing, analysis of contact stress has been studied and behaviour of material under contact stress has evaluated.

Contact stress near the contact region in the bearing is very high and it will fail the material. Thin coating of a TiN &TiAlN will give higher wear resistant and reduce friction and improve the performance of a bearing ¹²³

II. STUDY OBJECTIVE

The purpose of study is to study contact stresses by using FEA tool and study the effect of different coating material and coating thickness.

III. FINITE ELEMENTAL ANALYSIS

Using FEA tool contact stress has been evaluated by using standard FAG bearing data N-305-E-TVP

Fig. 1: N-305-E-TVP Standard Bearing Drawing

D=62, B=17, d=25, F=34, E=54
Db=55, da=32, Da=55, Dc=53, d1=38.1
CAD model has been created using ANSYS only and analysis carried out.

Fig. 2: CAD Model Design in ANSYS
A. Boundary Condition And loading Condition:
For analysis of this model all degree of freedom are constrained for outer race and revolute joint applied for inner race of a bearing. Remote displacement tool is used for analysis and high load 22 KN applied as per value given for N-305-E-TVP model.

ANSYS result maximum principal stress, total deformation and directional deformation obtained

![Maximum Principal Stress](image1)

<table>
<thead>
<tr>
<th>Maximum principal Stress MPa</th>
<th>Directional Deformation mm</th>
<th>Total Deformation mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1492</td>
<td>0.0027969</td>
<td>1.0278</td>
</tr>
</tbody>
</table>

![Directional Deformation](image2)

![Total Deformation](image3)

As per FEA analysis higher stress developed near the bearing races. As per standards bearing material is ASTM 52100 100cr6 which is yield strength is 1324 MPa and stress developed beyond this value hence material failure will be there. To avoid failure coating on the surface has been carried out which improve the wear resistant. Hard coating has done.

IV. EXPERIMENTAL WORK
Thin coating of a hard material that can be carried out by Physical vapour deposition method. Which provide excellent adhesion property. PVD is the abbreviation of Physical Vapour Deposition. It is a process carried out in high vacuum at temperatures between 150 and 500 °C. Coatings are extremely hard and inert. When applied to a material, these coatings result in hard, wear resistant surfaces that don't interact with the materials they contact. This reduces friction and greatly prolongs component life.

By using PVD coatings, you can get 10 times the tool life, or more, compared to an uncoated tool.

For surface preparation different bath has been done to avoid contamination, oil, dust etc.

Bath 1 is for pre-cleaning, where most of the contaminants are removed. The use of an oil separator is strongly recommended in this step. Bath 2 prevents carry-over of detergent and contaminants from Bath 1 to Bath 3, which leads to a longer useful lifetime for Bath 3. An additional advantage is that the product compatibility of the detergents used in Baths 1 and 3 is not critical. Bath 3 is for additional cleaning if the substrates are grossly contaminated or the detergents in Bath 1 are near exhaustion. Alternatively, Bath 3 can be used with an acidic detergent if there’s a need for a DE oxidation step in the process.

Coating carried out for two material TiN and TiAIN having different coating thickness.

Before coating has carried out chemical testing was carried out and hardness test was done for evaluation of a material 100cr6 and it will give satisfactory result. Hardness value measured is 59 HRC. Test result is as shown in the photograph of test certificate.

![Surface Roughness Graph of a Coated Sample](image4)

![Chemical Composition Table](image5)

![Surface Roughness Graph of a Coated Sample](image6)

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Hardness test carried out TiN and TiAlN give very high hardness value 2300 HV and 3200 HV respectively as per measured hardness on Vickers Hardness Tester.

Scratch cross test result by adhesive tape it indicates zero grade (fine coating) developed at the surface.

SEM (scanning electron microscopy) has carried out to observe the surface morphology of a different coating thickness as shown in images.

Fig. 7: Surface Roughness Graph for a Uncoated Sample 0.06 Micron

Fig. 8: SEM of A TIN Coating Thickness 3micron

Fig. 9: SEM of TIN Having Thickness 6 Micron

Fig. 10: SEM of TiN

Fig. 11: SEM of TiALN

Fig. 12: SEM of TiALN Thickness 6 Micron
VI. CONCLUSION

From the FEA Analysis it is concluded that,

1) Higher contact stresses will develop near the contact region these stresses will lead to the failure of a component. Contact stress can be reduced by improving wear resistant of a component.

2) Wear resistant can be improved by thin coating of hard material. Coating material and coating thickness are influencing parameters for improvement of surface wear.

3) From hardness test and from SEM result it is concluded that TiAlN material will give higher wear resistant compared to TiN.

VI. ACKNOWLEDGMENTS

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REFERENCES


[3] FAG bearing catalogue for bearing performance improvement


