# VIBRATION ANALYSIS OF BEARING IN ROTARY SCREW COMPRESSOR

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***Abstract: A rotary screw compressor is a type of compressor in which it is used in large industrial application and high power tools. In a rotary screw compressor thrust bearing problems are the most common problem. In this case study the compressors presumed to run more than 70000hours.the thrust bearing used was a single row angular contact ball thrust bearing located on each rotor. Damage occurred on the inside bearing of the male rotor. The inner race and balls damage as the outer race which was cause by fatigue. The spallings and abrasion were occurred in race ways, this was the typical failure pattern for compressor with long operating hours. All these determined by vibration analysis, static analysis and fatigue analysis.***
***Keywords: finite element analysis, modal analysis, static analysis, bearing life.***

## I. INTRODUCTION

A rotary-screw compressor is the type of compressor that uses the rotary-type positive-displacement mechanism. These are mainly used to replace piston compressors where large volume of high-pressure are needed, either for large industrial function or to operate high power tools. Screw compressors are broadly utilized today as a part of modern application for pressure of ammonia and different gasses. Straight forward in ideas, the screw geometry is hard to picture that numerous individuals utilizing screws today have just a rough thought how they really function. The actual working of their operation will help in applying them accurately, staying away from pointless issues in operation and accomplishing the best general framework plans. A common twin-screw compressor comprises of male and female rotors mounted on course are situated to their position in a rotor lodging which holds the rotors in nearly resistance crossing barrel shaped bores the rotors fundamental shape is a screw string, with changing quantities of lobes on the male and female rotors. The driving gadget is for the most part associated with the male rotor with the male driving the female through oil film. In refrigeration, four or five lobed male rotors by and large drive six or seven projection female rotors to give a female rotor speed that is to some degree not exactly the male speed. A few outlines associate the drive to the female rotor with a specific end goal to deliver higher rotor speeds in this way expanding displacement. At that point, this expands stacking on the rotors in the region of torque exchange and can lessen rotor life.

*Modal analysis*

Modal analysis is the study of the dynamic behavior of structures under external exertion. Vibration is about frequencies. By its nature, vibration involves repetitive motion. Each involves of a complete motion sequence is called a cycle. Frequency is defined as complete cycles in a given time period. One cycle per second is equivalent to one Hertz. Then the results from a Natural Frequency or Modal analysis include displacements, these displacements will be used only to view the mode shape. That is, the magnitude of the displacements is relative to each other. The natural frequency is a theoretical result due to unspecified dynamic loads, so the results cannot obtain for loads and boundary conditions but results will get without boundary conditions and loads.

*Static analysis*

Static analysis is a method of determining the behavior of structure and components on the application of load neglecting the inertial effects. In this analysis we determine the displacements, stresses and reaction forces in a given components which is subjected to loads. In static type of analysis includes whether the structure can with stand all the loads acting on such as buildings, vehicles, machinery, bridges, furniture, and the component doesn't induce damping effects and inertia. The unknown nodal displacements of the components are easy to find out by using the static analysis. In finite element method the fundamental concept is to discrete the model in approximate any quantities such as pressure, temperature and displacement. In many problems the analytical solutions are difficult or impossible to obtain the solution, for those cases we used the finite element method to find the approximate and easy solutions of that problem. A node defines each element and it serves as a link between the two elements. The polynomial equation is used for the continuous quantity is approximated over each element.

*Finite element method*

It is well known numerical method used to solve multi physics problem were governing differential1equations are available. Since FEM is a piece wise approximation it consists of discritisation process in order to convert infinite degree of freedom to finite degree of freedom for solving multi physics problems in an approach that solution can be obtained with minimum error. This method is extremely easy for the problems with complex geometry, load and boundary condition for which the analytical solution may be difficult to obtain.

## II. PROBLEM DESCRIPTION

In a rotary screw compressor thrust bearing problems are the most common problem. The 600HP screw compressors under use presumed to run more than 70000 hours. Damage was observed in bearings after running for about 40000 hrs. From the preliminary investigation, it was found that, the bearing were worn-out in inner race and balls damage as the outer race which was cause by repetitive loading. The spallings and abrasion were occurred in race ways, this was the actual failure pattern for compressor with long operating hours. All these determined by vibration analysis and static analysis.

*Methodology*

- Creation of CAD Model of the ball bearing used in rotary screw compressor using CATIA v5.
- Assigning Materials and properties for the generated cad modeling ABAQUS.
- Meshing will be done using ABAQUS tool.
- Loads and Boundary conditions can't be applied for modal analysis.
- Static analysis of the FE Model with Loads and BCs using ABAQUS.
- Extraction of results after completion of analysis and documentation using ABAQUS.
- Theoretical calculation will be done related to
- Analysis.
- Finally compare with the results.

*Modelling*

- In this section, modeling of bearing structure has been done using CATIA v5 modelling software.
- The bearing structure is consists of inner race, outer race and ball bearing.
- For model simplification, all ball bearing consider as single structure.
- The model is divided into three section to know the displacement and stress.
- The outer diameter is 120mm inner diameter is 90mm and ball diameter is 22mm of bearing.

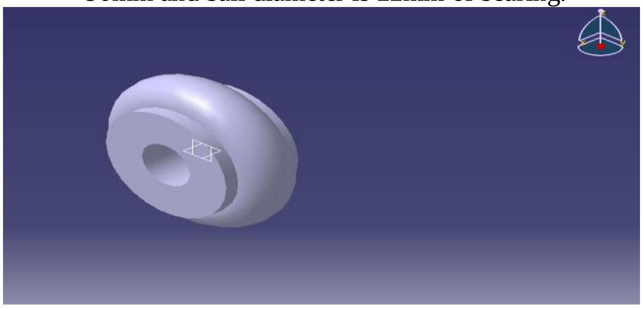

Fig 2.1 Geometric model of inner race and ball bearing.

This is model of inner race and ball bearings assembly shown in figure 2.1

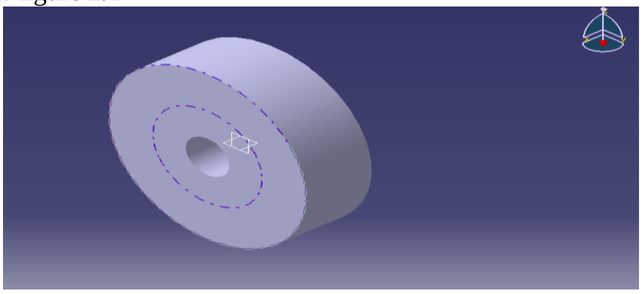

Fig 2.2 Geometric 3D model.

Figure 2.2 gives the geometric complete details of the bearing model.

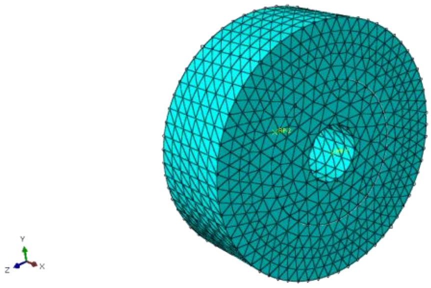

Fig 2.3 Finite Element Model of the bearing.

Figure 2.3 shows the Finite Element model generated for the geometric model of the bearing structure using 3D Tetra elements. These elements are selected because the complex size of the structure. Each component is considered as a separate entity and then joined using assembly part which combines three separate models into single assembly model.

## III. BOUNDARY CONDITIONS AND LOADING

For the modal analysis there is no need of boundary condition and loading then for the static analysis we have to define boundary condition and loading. For static analysis boundary condition given at the one end only for the outer race and loading will define on the another side to the inner race with ball bearings with a moment.

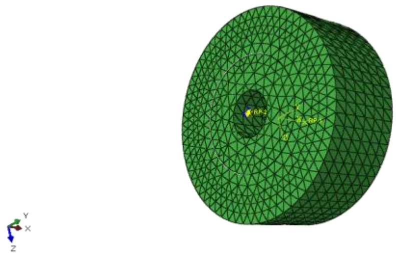

Fig 2.3 Geometric model of boundary condition.

The boundary given at the left portion of bearing model at the outer race.

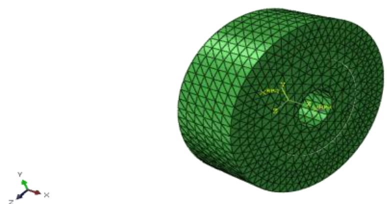

Fig 2.4 Geometric model of load condition.

The load is applied on the bearing is given by moment at x axis then applied at inner race and ball bearing.

## IV. RESULT AND DISCUSSION

The result will be get it by theoretical calculations, modal analysis and static analysis.

Theoretical calculations for the design of bearing.

According to information provided the Basic Dynamic Radial1Load Rating (Cr) is 57252N, Radial load is 20,000n, axial load is 8000N.

  

$$L_{10}=(10^6/60n)*(c_r/p_r)$$

$L_{10}$ = hours(h).
n = Speed(rpm)
$c_r$ = Basic dynamic load rating.
$p^r$ = Dynamic equivalent radial load.

$L_{10}$=24803*3
$L_{10}$=74409 hours.

Modal analysis

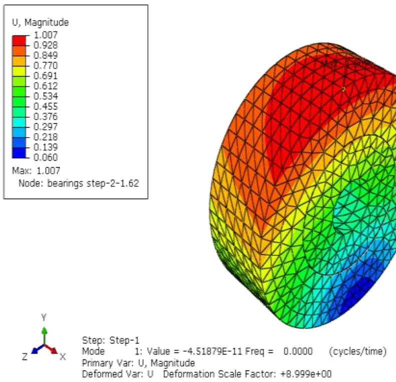

Fig 4.1 Frequency mode.

By a finite element method the modal analysis will be done,then the results will be zero up to sixth mode after that it will give positive values. From this we will know about the mode shape at different levels without any boundry condition and loadings.

Static analysis

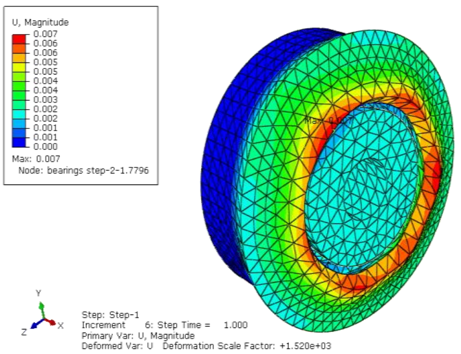

Fig 4.2 Representation of Displacement.

The magnitude of displacement is 0.07 shown at the outer periphery of the bearing.

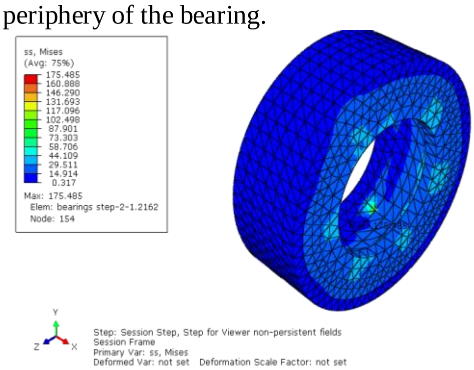

Fig 4.3 Representation of Stress.

The stress is shown at the periphery of the bearing and maximum occurred stress is 175.48 Mpa.

Result interpretation

TABLE 4.1 Results

| No. | Description | Theoretical value | Numerical value | Error % |
|---|---|---|---|---|
| 1 | Displacement | 0.07 | 0.07 | 0 |
| 2 | Stress | 174.54mpa | 175mpa | 1 |
| 3 | Life of bearing | 74409hr | 75600hr | .984 |

From above table the errors are less than 5 percentage then the theoretical and numerical results will match with each other less than 2 percentage of error.

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REFERENCES

[1] Contact fatigue is a surface-pitting-type failure,W.A. Glaeser and S.J. Shaffer[1996].
[2] Study of Rolling Contact Fatigue R.K. Upadhyay , L.A. Kumaraswamidhas, Md.Sikandar Azam [2013].
[3] Study of Rolling Contact Fatigue R.K. Upadhyay , L.A. Kumaraswamidhas, Md.Sikandar Azam [2013].
[4] Total deformation of thrust ball bearing & contact stress b/w ball & raceways & its effect on fatigue life of thrust ball bearing. Prabhat Singh[2014].
[5] An Overview of Bearing Vibration Analysis Vibration Analysis rp singh [1993].
[6] Abaqus documentation altair simulia script version 6.13.
[7] Hyper view 12.0 documentation guide.

  