Selection of High Performing Material in Flexure Bearings for Linear Compressor Applications using Fea

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***Abstract*-The function of bearing is to allow relative motion between two machine components. In case of simple ball bearing one machine component that is shaft mounted in inner race and other machine component that is bearing housing mounted on outer race. The shaft is rotating member and bearing housing is stationary member. Thus the rotating motion of shaft is not transmitted to bearing housing. In other words it can be said that there is relative motion between two parts. The bearing in which there is relative motion between two part by flexing or bending is nothing but flexure bearing. Both require relative motion to happento ensure least frictional losses. In flexure bearing one element of bearing surface is allowed to deform on application of load,the surface goes back to its original position on removal of applied load. The deformation of material subjected to condition due to applied load is within the limit of elasticity. This eliminates the wear, vibration and frictional losses. However, the deformation has to be limited. Flexure bearing finds application in precision and micro machining applications and some medical applications having very low relative motion.**

The present work reported in this paper is specific to the selection of a best material among the selected material for flexure bearing used in linear compressor. This paper proposes FEM as tool to find the equivalent stress.Selection of material is one of the most important steps in the process of design. The best material is one which will serve the desired objective at minimum cost.

Keywords- Flexure bearing, FEA, Linear compressor, Analysis.

1. INTRODUCTION

A flexure bearing is a bearing which allows relative motion by bending a load element.

FEA has been conducted usingAnsys 14, with a view to observe, apart from the stress distribution characteristics such as equivalent stress, axial stiffness. 3D model of flexural bearing has been developed in Catia. After development of geometric model finite element mesh is to be created and appropriate boundary conditions are to be imposed. Present work can be summarized in analysing the flexural bearing in following tasks, Static analysis of flexural bearing with different material, determine axial stiffness, stress distribution etc.The performance of an engineering component is limited by the properties of the material ofwhich it is made, and by the shapes to which this material can be formed. Under somecircumstances a material can be selected satisfactorily by specifying ranges for individualproperties.

2. MATERIAL SELECTION

The choice must be made early in the design process. Then we can do the detailed design work using the correct material properties.

Different materials has been selected on the basis of its property, availability, machinability and cost.

On the basis of above requirement following material has been selected for flexure bearing

1. Stainless Steel 301
2. Stainless Steel 304 [3]
3. Copper (cold drawn)
4. Beryllium copper UNS C17000
5. Beryllium copper (heat treated) UNS C17200 (TH02)

3. CATIA MODEL OF FLEXURE BEARING

It is in the form of a thin flat metal disc having three spiral slots, yielding three spiral arms which bear the radial and the axial loads. Each spiral sweeps an angle of 480º.The outer diameter of disc is 69 mm and P.C.D. of outer clamped holes is 59 mm. The central hole is having 3 mm diameter while outer clamped 12 holes having diameter 6 mm and thickness ofdisc is 0.3 mm [1].The spiral arm is having equal cut of thickness of 0.8 mm.

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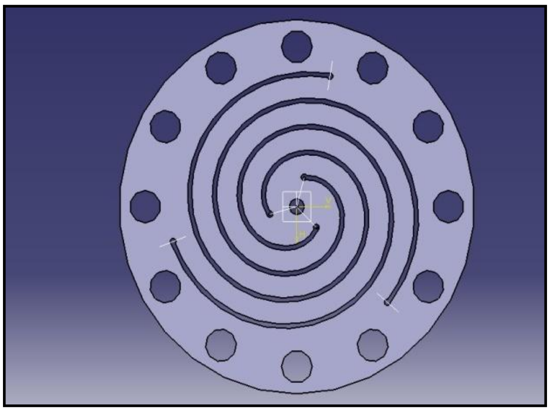

Fig. 1 Catia model of flexure bearing

4. ANALYSIS OF FLEXURE BEARING IN ANSYS

Ansys 14 is used to calculate equivalent stress by applying different material. Boundary conditions are as follows

1. The thickness of plate taken as 0.3mm
2. As the displacement of the piston in the linear compressor is 5 mm from mean position so displacement was taken 5 mm at the central hole for analysis. [2]
3. Clamping 12 holes as fix support.
4. Meshing has been done as “fine”

As the following materials are used for springs so analysis has done for these materials

1. Stainless steel 301
2. Stainless steel 304
3. Cold drawn copper
4. Beryllium copper UNS C17000
5. Beryllium copper UNS C17200 (TH02)

1. Material – Stainless steel 301

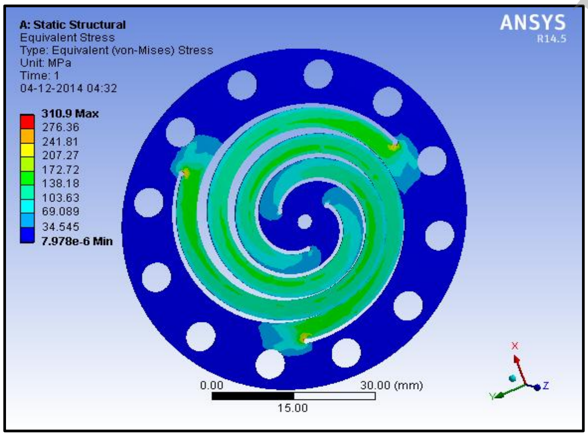

Fig. 2 Ansys model for SS 301

Above figure shows the Ansys model for stainless steel 301. The values of stresses induced in the various regions of the material has been shown in the image.

2. Material – Stainless steel 304

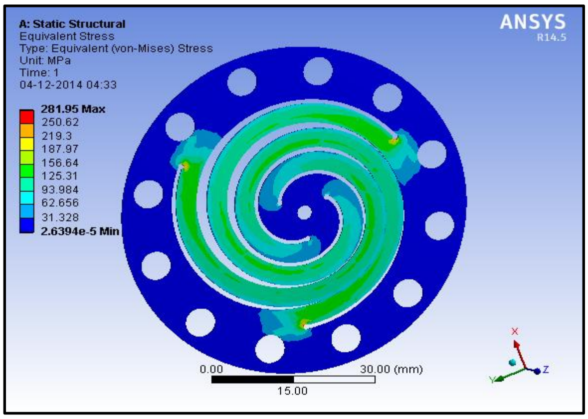

Fig. 3Ansys model for SS 304

Above figure shows the value of equivalent stresses developed in flexure bearing.

3. Material – Cold drawn copper

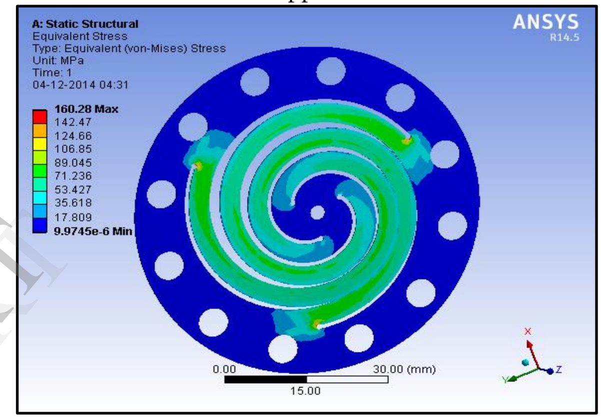

Fig. 4Ansys model for cold drawn copper

Above figure shows the value of equivalent stresses developed in flexure bearing and location of maximum developed stresses

4. Material – Beryllium copper UNS C 17000

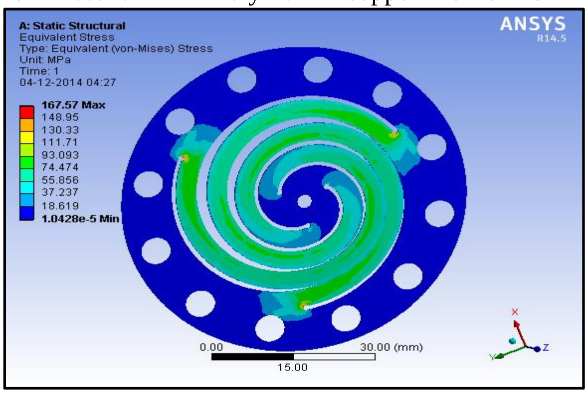

Fig. 5 Ansys model for BC UNS C 17000

Above figure shows the value of maximum stresses developed in the flexure.

5. Material – Beryllium copper UNS C 17200 (TH02)

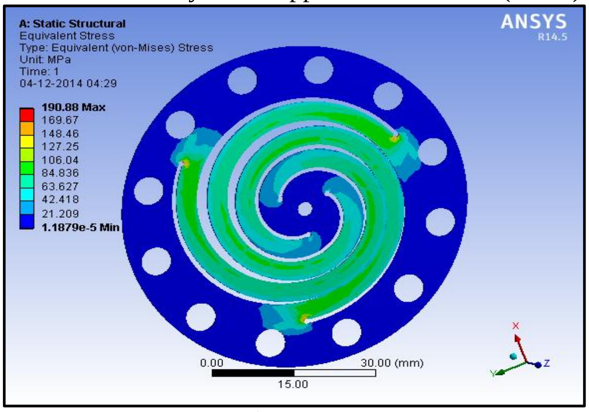

Fig. 6 Ansys model for BC UNS C 17200 (TH02)

Above figure shows value of maximum stresses developed and area of maximum stresses and minimum stresses.

4.1 Table of comparison of equivalent stress for 5 mm displacement and 0.3 thickness for different materials

Material	1	2	3	4	5
Equivalent Stress	310.9	281.9	160.2	167.5	190.8
Yield Strength for material	205	215	333	221	1100

From above table it has been concluded that cold drawn copper is having minimum stress but material is safe only if induced stresses should be below its allowable stress. While designing a component it is necessary to ensure sufficient reserve strength in case of an accident. It is ensure by taking factor of safety.

Factor of safety = Failure Stress / Allowable stress

Allowable stress for ductile material is obtained by

$\sigma = Syt / Fs$ or $\sigma = Sut / Fs$

For ductile material with external fluctuating forces, endurance limit is criterion for it.

With reference to "Machine Design" by V. B. Bhandari Vol.II FOS taken as 1.5

Now considering FOS above table shows following values of equivalent values.

4.2 Table of comparison of equivalent stress and allowable stress considering factor of safety.

Material	1	2	3	4	5
Equiv. Stress	310.9	281.9	160.2	167.5	190.8
Tensile Yield Strength	205	215	333	221	1100
Factor of safety	1.5	1.5	1.5	1.5	1.5
Allow. Stress	136.6	143.3	222.2	147.3	733.3

Now from above table it can be conclude thatStainless steel 301, Stainless steel 304, Beryllium copper UNS C 17000 are not within allowable stress limit. So for further analysis only cold drawn copper and Beryllium copper UNS C 17200 (TH02) has been selected.

5. STIFFNESS ANALYSIS

The material having maximum Stiffness would be preferred. In other words it can be said that for same applied load deformation should be minimum.

Further analysis was carried out for the above two selected materials i.e. cold drawn copper and Beryllium copper UNS C 17200 (TH02) for 1N force at the Centre of the flexure.

1. Cold drawn copper

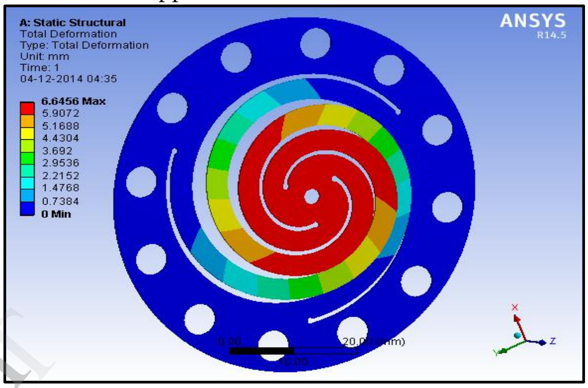

Fig.7 Ansys model for cold drawn copper

In the above figure the value of displacement and region of maximum displacement can be seen.

2. Beryllium copper UNS C 17200 (TH02)

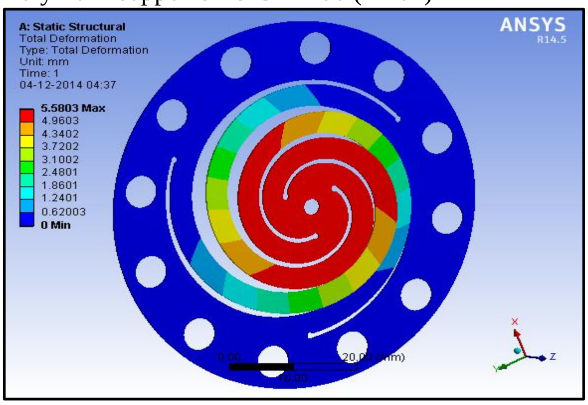

Fig.7 Ansys model for BC UNS C 17200 (TH02)

In the above figure the value of displacement by applying 1N force has shown.

5.3 Table of comparison of displacement for 1N force.

Material	3	5
Deformation (mm)	6.6456	5.5803
Stiffness (N/m)	150.47	179.20

Above table indicates the value of deformation and stiffness for 1N force of cold drawn copper (3) and Beryllium copper UNS C 17200 (TH02) (5)

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6. CONCLUSION

Now from table No.4.2, it can be concluded that Stainless steel 301, Stainless steel 304, Beryllium copper UNS C 17000 are not within allowable stress. Material which are within allowable stress are cold drawn copper and Beryllium copper UNS C 17200 (TH02)

The equivalent stress from the Ansys for cold drawn copper is 160.2Mpa which is less than permissible limit of that material that is 222.2MPa. And for Beryllium copper UNS C (TH02) is 190.8MPa which is less than its permissible value that is 733.3Mpa

From table No. 5.3, it has concluded that cold drawn copper shows stiffness value 150.47N/m and for Beryllium copper UNS C (TH02) shows stiffness 179.20 N/m which is greater than cold drawn copper.

So it is concluded thatBeryllium copper UNS C 17200 (TH02) is suitable for flexure bearing application.

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