Finite Element Analysis and Optimization of Flexure Bearing for Linear Motor Compressor

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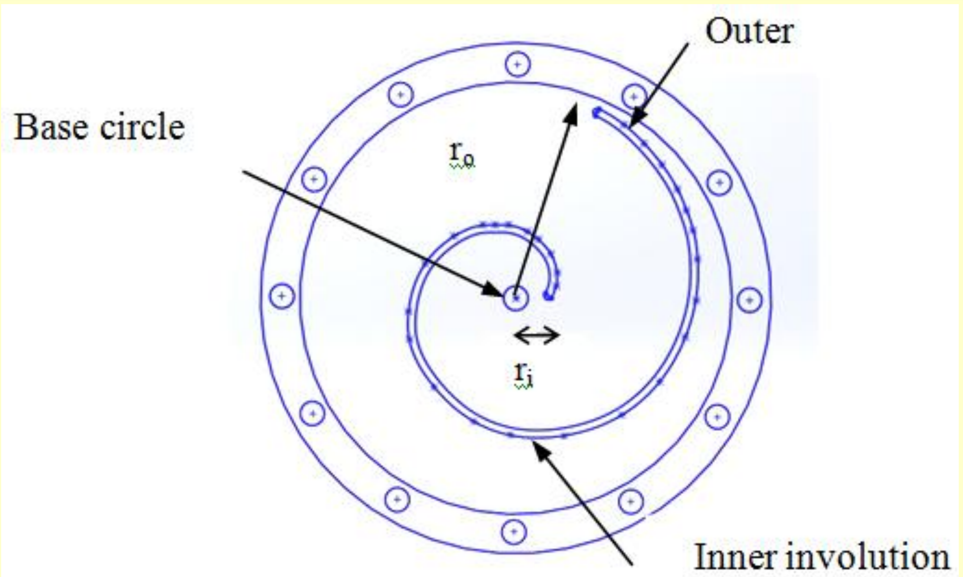
Background

Now a days linear motor compressors are commonly used in miniature cryocoolers instead of rotary compressors because rotary compressors apply large radial forces to piston, which provide no useful work, cause large amount of wear and usually require lubrication. Recent trends however favor flexure supported configuration for long life.

Objectives

- To design and geometrical optimization of spiral and linear flexure bearing using finite element analysis.
- To manufacture the flexures using different materials.
- To Develop static and dynamic loading setup and dual opposed piston compressor.
- To Validate the finite element analysis results experimentally.

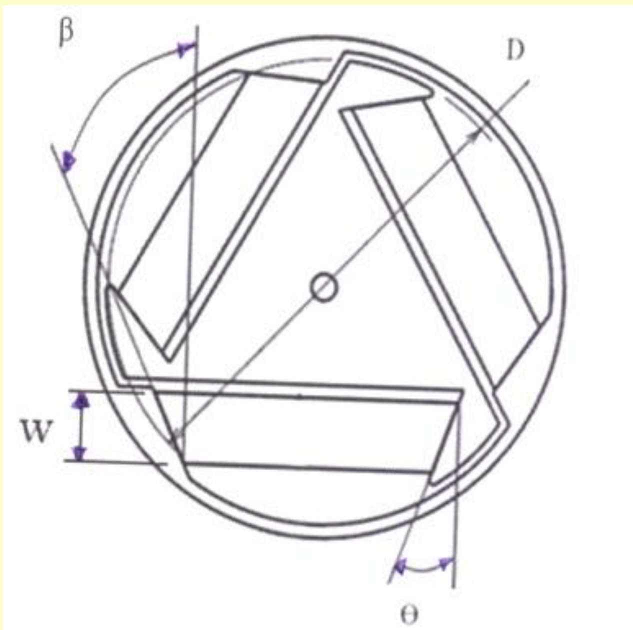
Finite Element Analysis of Flexure Bearing



FEA of Spiral Flexure Bearing

Sr. No.	Parameter	Variation	Levels
1	Effective diameter , D_s (mm)	40-80	5
2	Thickness, t (mm)	0.1-0.5	5
3	Swept angle, θ_s	360^0-600^0	5
4	Slot Width, s (mm)	0.2-1	5
5	Starting radius, r_i (mm)	5-9	5

Optimum Values: Ds = 60mm; t = 0.4mm; θ_s = 480°; s = 0.2mm; r_i = 9mm.



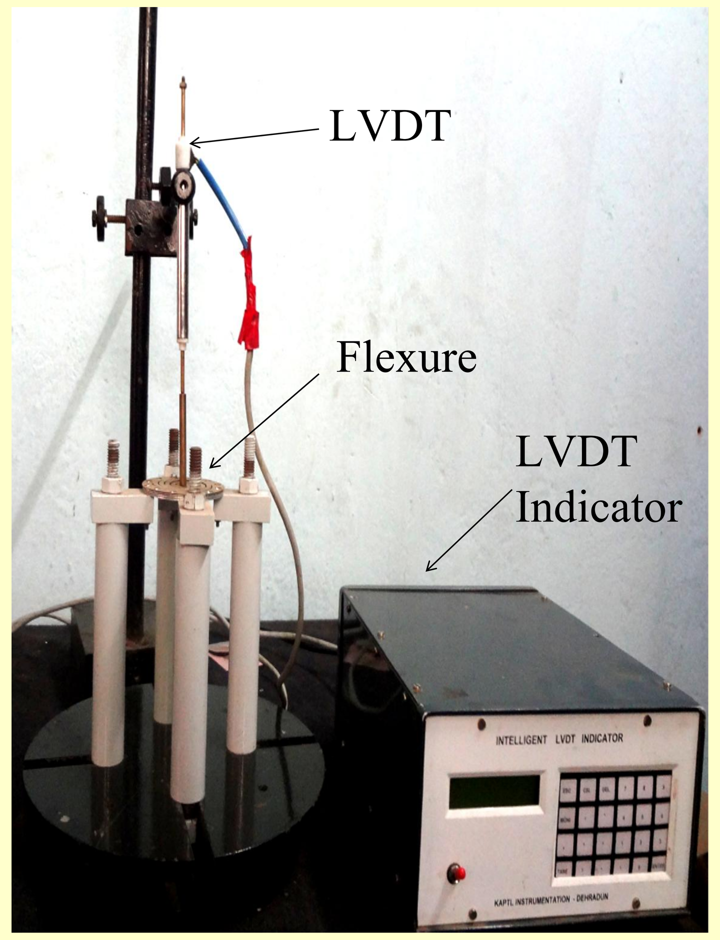
FEA of Linear Flexure Bearing

Sr. No.	Parameter	Variation	Levels
1	Effective diameter , Ds(mm)	50-80	4
2	Arm width, W (mm)	5-8	4
3	Arm angle, θ	15^0-22.5^0	4
4	Clamp angle, β	15^0-30^0	4
5	Thickness, t (mm)	0.1-0.4	4

Optimum Values: Ds = 70mm; W= 5mm; θ = 20°; β = 30°; t = 0.2mm.

Experimental Setups

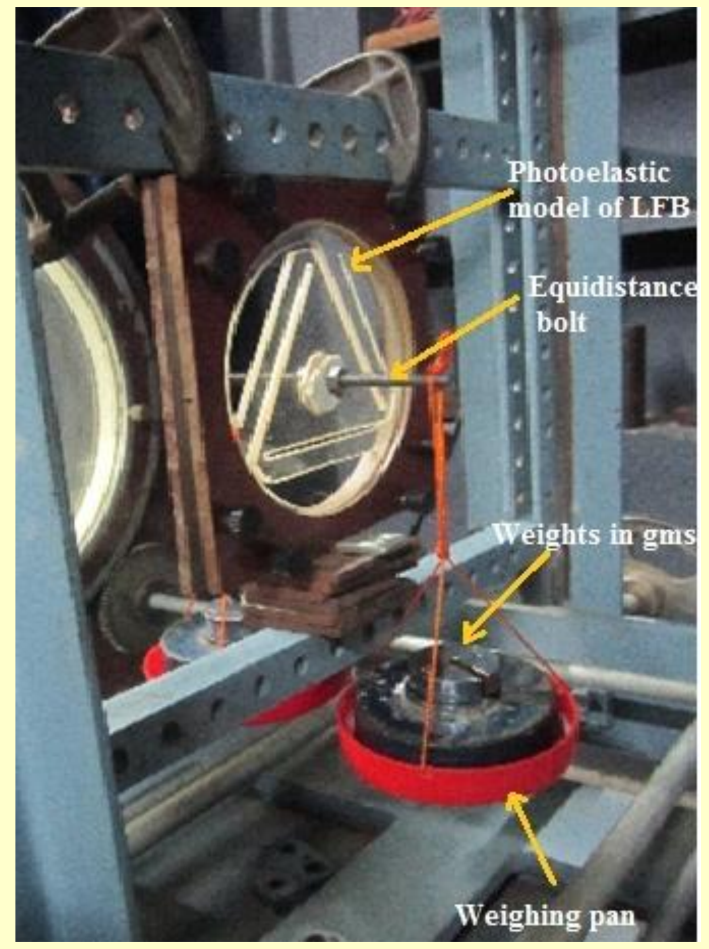
Static Loading



Dynamic Loading

Photoelasticity

Radial Loading



Axial Loading

Conclusion

➢The design methodology is developed to analyze the spiral and linear flexure bearings.

➢From the theoretical analysis of spiral and linear flexure bearing it is observed that in both cases the diameter, thickness and geometry are significant parameters.

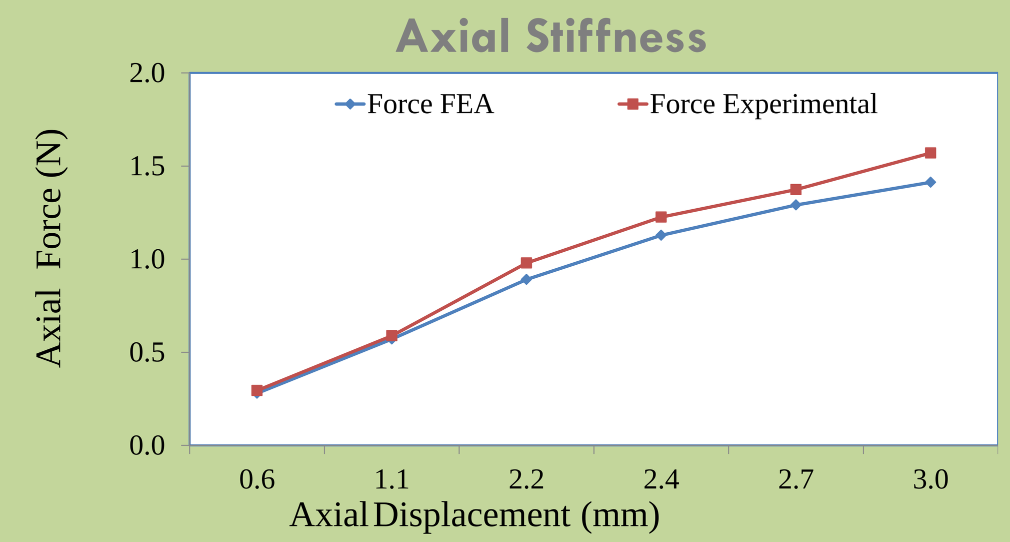
➢For same thickness and diameter Von Mises strain in linear flexure is three times greater and axial stiffness five times greater and radial stiffness ten times greater. Thus linear flexure bearing is suitable for compact size and long life application but for smaller axial strokes.

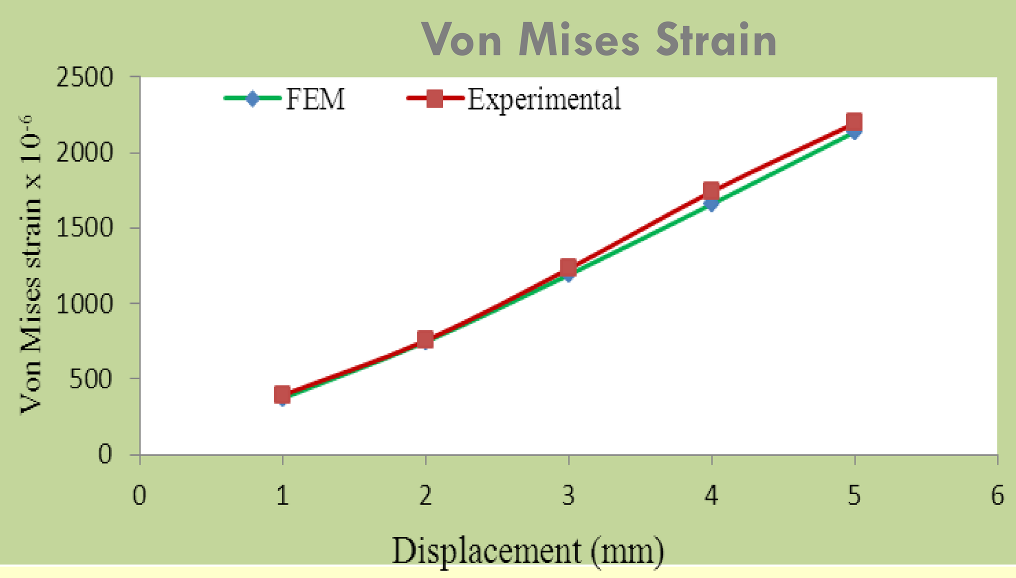
➢With the help of static and dynamic loading setups static strain, stress, axial stiffness and dynamic strain and stress measurement of flexure bearing can be carried out for a range of diameters.

➢The experimental stress analysis by Photoelastic method is used to measure the stresses in whole model of the flexure. The principal stresses at the point of interest were calculated using this method. The close agreement between theoretical and experimental results is found.

Results

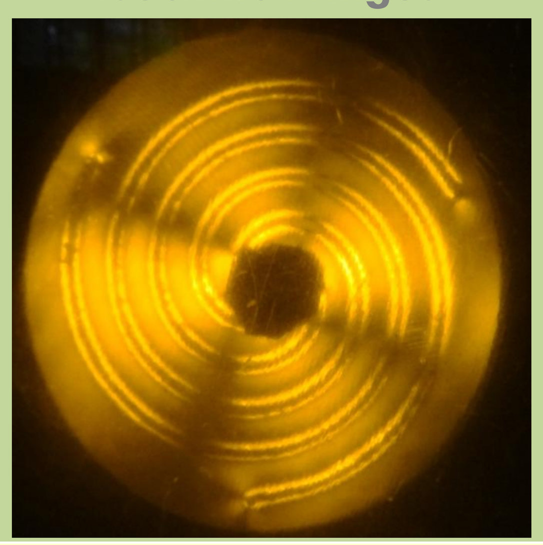
FEA



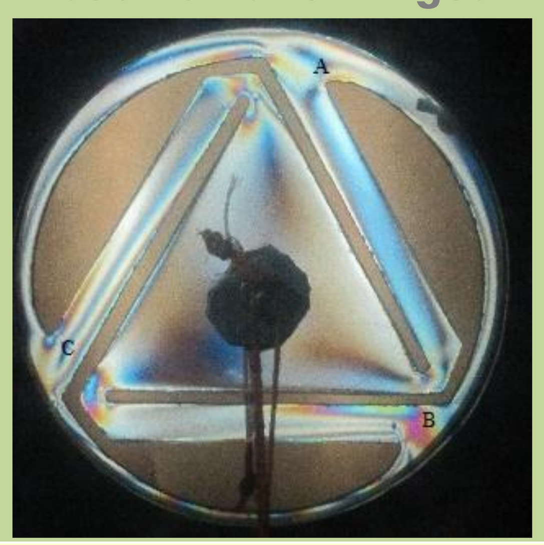


Photoelasticity

Isoclinic Fringes



Isochromatic Fringes



Development of Compressor