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Study of Dynamic Characteristics of Multi Lobe Journal Bearing Using FE Based Method

Mr. Imran Ali M R[a], Mr. Raghu Yogaraj[b], & Mr. Rangaswamy H[c]

[a]*M.Tech Student, Machine Design, S.I.E.T, Tumkur, India*
[b]*Research Scholar, Dept. of Mechanical Engineering, B.M.S.C.E, Bangalore, India*
[c]*Senior Lecturer, Machine Design, S.I.E.T, Tumkur, India*

ABSTRACT

Presently the industries are using journal bearing with one profile i.e. general type (circular), 2 lobes or 3 lobes at a time. But based on the situation we need a bearing that can provide a multipurpose journal bearing mechanism. Hence the present research work is carried on the study of journal bearing that can serve a multipurpose journal bearing mechanism in one bearing system. To achieve this, flexible shim and lubrication oil with good viscosity is used. The shim and lubrication should be adequate in such a way that when the external load is applied through the holes the shim can possess multipurpose journal bearing mechanism. Henceforth, providing general type, 2 lobes or 3 lobes based on the working loads. The research work basically focuses on developing a multipurpose journal bearing by changing the inner profile of the journal bearing by means of external load i.e. the journal bearing should possess 2 lobes and 3 lobes profile when working loads are increased abruptly. Multi-lobe journal bearing can refer to any number of lobes with the designer taking advantage of the ability to control the geometry of the shim. This usually means applying external load on the flexible shim so that the shim can possess 2 lobes and 3 lobes profile. In this thesis we will check the stability of the journal bearing for the given working loads for general (ordinary type), 2lobes and 3 lobes profile. This paper discusses the geometry and FEA analysis results which have been obtained all the three type of bearing profiles. The three main bearing profiles types discussed in this work are general (ordinary type), 2lobes and 3 lobes journal bearings. The critical speed summary table indicating some of the critical speeds for the first 9 modes of all the three types of journal bearings.

Keywords- *Stiffness, Critical Speed, Shim, Stability.*

1. INTRODUCTION

The bearing is a machine element that constraints the relative motion between two or more parts to desired type of motion and typically allows and controls rotation around any fixed axis. There are many types of bearings with varying shape, material and lubrication. A journal bearing is a simple bearing in which a shaft, or "journal", rotates in the bearing with a layer of oil or grease separating the two parts through fluid dynamic effects. The plain Journal Bearing is simplest form of journal bearing shown in fig 1 in which a shaft or journal rotates in the bearing with a layer of lubricant (oil) separating the two parts through fluid dynamic effects. . Pressure dam journal bearing is similar to Plain Journal Bearing except shallow relief cut in the center of the bearing over the top half of the bearing. The Two-Lobe Journal Bearing is a two-pad-fixed geometry beating which is preloaded in the vertical direction. Three Lobe bearing is the similar in concept to the Lemon bore Journal Bearing. It has three curved segments that are referred to as lobes. N P Mehta [2] investigated the stability analysis of 2-Lobe hydrodynamic journal bearing with couple stress lubricant. Stanislaw Strzelecki [3] investigated the Power Loss of Multi-Lobe Journal Bearing. Stanislaw Strzelecki [4] investigated the effect of lobe profile on the load capacity of 2-lobe journal bearing. Dinesh Dhande, Dr D W Pande, Vikas Chatarkar [6] made analysis of pressure for 3-lobe hydrodynamic journal bearing. G Bhushan [7] investigated the effect of load orientation on the stability of a three-lobe bearing supporting rigid and flexible rotors. Mahesh Aher, Sanjay Belkar, R. R. Kharde [9] investigated the pressure distribution analysis of plain journal bearing with lobe journal bearing. M Varun Kumar, B Ashiwini Kumar [14] made model analysis of axially symmetric linear rotating structures.

2. RESULTS AND DISCUSSIONS

2.1 Stiffness calculation for Journal bearing (General Type)

Force acting on the journal, F= 500N

Radial displacement, y = 0.5mm

Stiffness in Y direction, $K_y = \frac{F}{y} = \frac{500}{0.5}$;

$$K_y = 1000 \frac{N}{mm}$$

Here, stiffness will be same in Y and Z direction due to the uniform radial displacement. Hence, $K_y = K_z = 1000 \frac{N}{mm}$

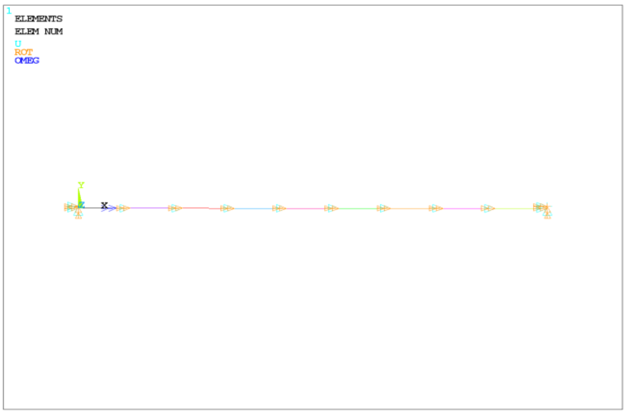

Fig 2.1: FE Model with Boundary Conditions

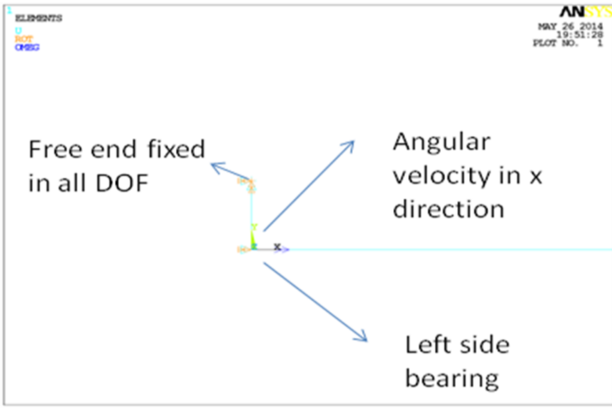

Fig 2.2: Boundary Conditions (detailing)

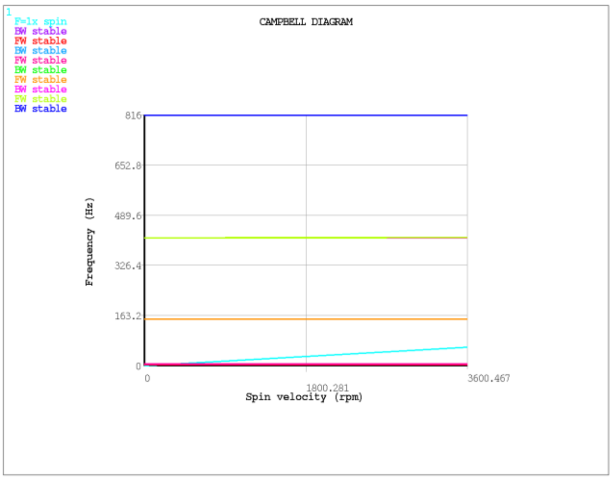

Fig 2.3: Campbell Diagram at Whirl Slope 1x

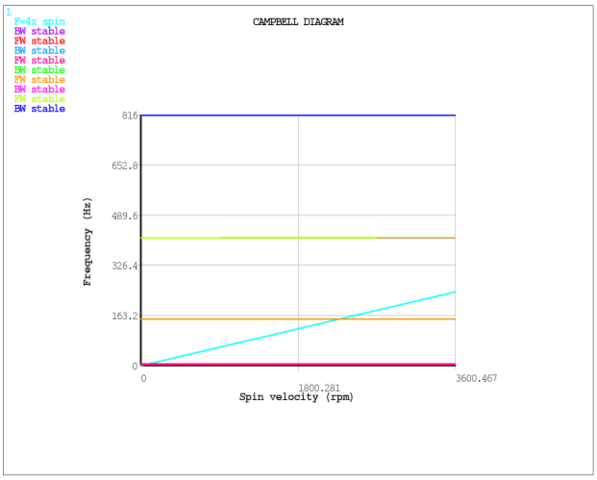

Fig 2.4: Campbell Diagram at Whirl Slope with 4x

Sl No:	WHIRL SPEEDS WITH SLOPE = 4.0		
	Parameter	Critical Speed	Whirl Type
1	CRIC1	41.27	-1
2	CRIC1	41.27	1
3	CRIC1	71.47	-1
4	CRIC1	71.50	1
5	CRIC1	2265.96	-1
6	CRIC1	2269.77	1
7	CRIC1	None	-1
8	CRIC1	None	1
9	CRIC1	None	-1

Table 2.1: Critical speed with whirl type at whirl slope 1x

Sl No:	WHIRL SPEEDS WITH SLOPE = 1.0		
	Parameter	Critical Speed	Whirl Type
1	CRIC1	165.07	-1
2	CRIC1	165.07	1
3	CRIC1	285.71	-1
4	CRIC1	286.18	1
5	CRIC1	None	-1
6	CRIC1	None	1
7	CRIC1	None	-1
8	CRIC1	None	1
9	CRIC1	None	-1

Table 2.2: Critical speed with whirl type at whirl slope 4x

From the above table 2.1 it is clear that the induced critical speed in the journal bearing is only first 4 modes and the speed is also very less and from the above table 2.2 it is clear that the number of critical speed for the whirl slope with 4x has more and the critical speed is also high.

2.2 Stiffness calculation for Journal bearing (2 Lobe Type)

Force acting on the journal, F= 500N

Displacement in Y direction, y = 0.3mm;

Stiffness in Y direction, $K_y = \frac{F}{y} = \frac{500}{0.3}$;

$K_y = 1666.667 \frac{N}{mm}$

Displacement in Z direction, z = 0.6mm;

Stiffness in Z direction, $K_z = \frac{F}{z} = \frac{500}{0.6}$; $K_z = 833.33 \frac{N}{mm}$

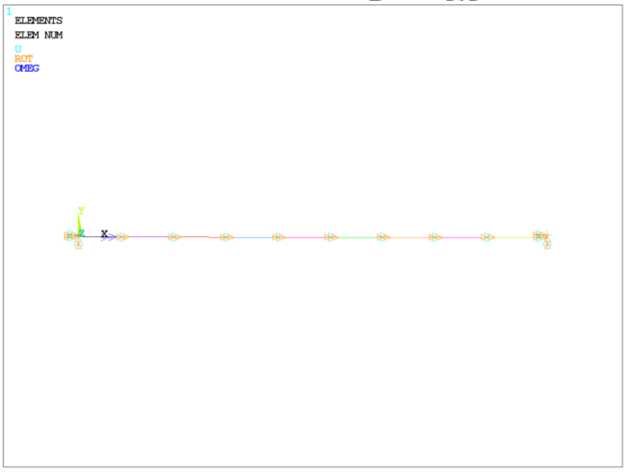

Fig 2.5: FE Model with Boundary Conditions

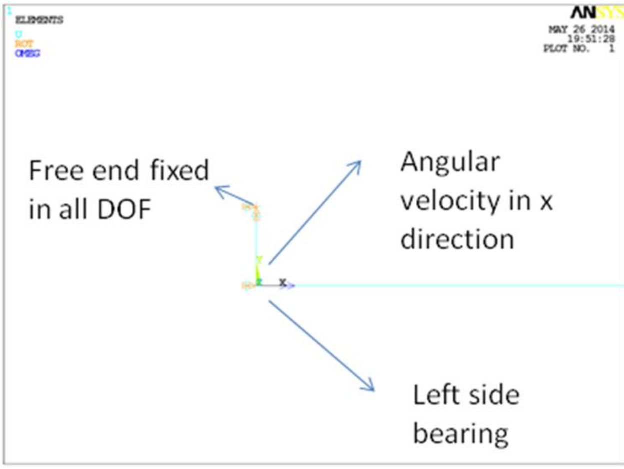

Fig 2.6: Boundary Conditions (detailing)

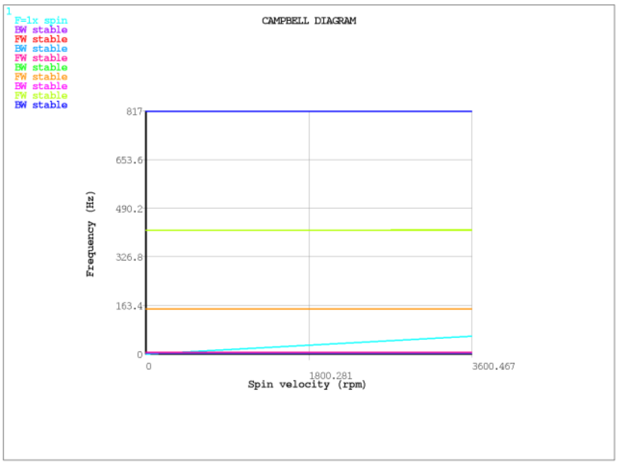

Fig 2.7: Campbell Diagram at whirl slope 1x

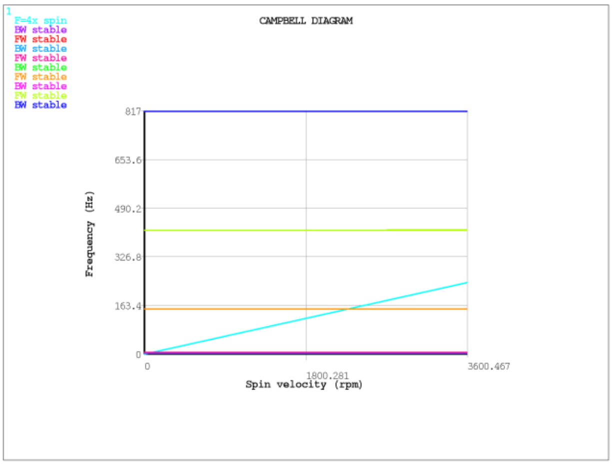

Fig 2.8: Campbell Diagram at whirl slope 4x

Sl No:	WHIRL SPEEDS WITH SLOPE = 1.0		
	Parameter	Critical Speed	Whirl Type
1	CRIC1	144.93	-1
2	CRIC1	213.21	1
3	CRIC1	251.01	-1
4	CRIC1	369.48	1
5	CRIC1	None	-1
6	CRIC1	None	1
7	CRIC1	None	-1
8	CRIC1	None	1
9	CRIC1	None	-1

Table 2.3: Critical speed with whirl type at whirl slope 1x

Sl No:	WHIRL SPEEDS WITH SLOPE = 4.0		
	Parameter	Critical Speed	Whirl Type
1	CRIC1	36.23	-1
2	CRIC1	53.30	1
3	CRIC1	62.75	-1
4	CRIC1	92.37	1
5	CRIC1	2268.20	-1
6	CRIC1	2272.25	1
7	CRIC1	None	-1
8	CRIC1	None	1
9	CRIC1	None	-1

Table 2.4: Critical speed with whirl type at whirl slope 4x

From the above table 2.3 it is clear that the induced critical speed in the journal bearing is only first 4 modes and the speed is also very less. From the above table 2.4 it is clear that the number of critical speed for the whirl slope with 4x has more and the critical speed is also high.

2.3 Stiffness calculation for Journal bearing (3 Lobe Type)

Force acting on the journal, F= 500N

Displacement in Y direction, y = 0.3mm.

Stiffness in Y direction, $K_y = \frac{F}{y} = \frac{500}{0.3}$; $K_y = 1666.667 \frac{N}{mm}$

Displacement in Z direction, z = 0.3mm.

Stiffness in Z direction, $K_z = \frac{F}{z} = \frac{500}{0.3}$; $K_z = 1666.667 \frac{N}{mm}$

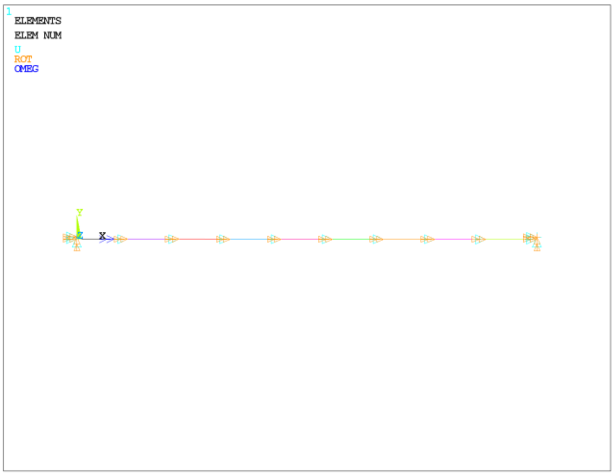

Fig 2.9: FE Model with Boundary Conditions

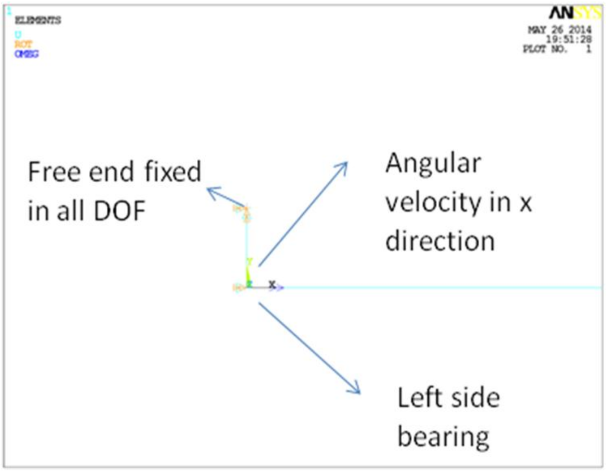

Fig 2.10: Boundary Conditions (detailing)

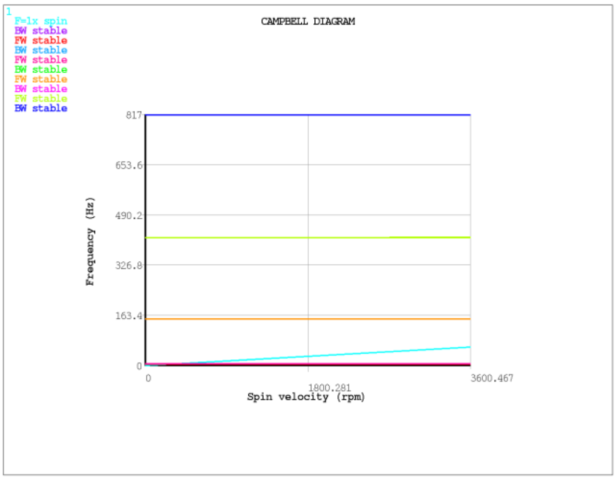

Fig 2.11: Campbell Diagram at whirl slope 1x

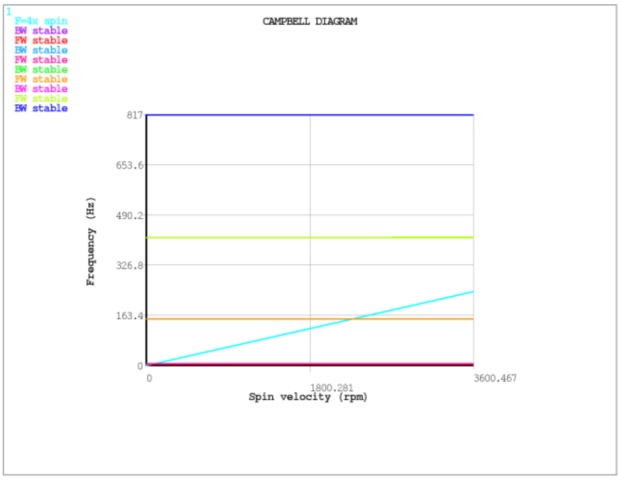

Fig 2.12: Campbell Diagram at whirl slope 4x

Sl No:	WHIRL SPEEDS WITH SLOPE = 1.0		
	Parameter	Critical Speed	Whirl Type
1	CRIC1	213.21	-1
2	CRIC1	213.21	1
3	CRIC1	369.18	-1
4	CRIC1	369.18	1
5	CRIC1	None	-1
6	CRIC1	None	1
7	CRIC1	None	-1
8	CRIC1	None	1
9	CRIC1	None	-1

Table 2.5: Critical speed with whirl type at whirl slope 1x

Sl No:	WHIRL SPEEDS WITH SLOPE = 4.0		
	Parameter	Critical Speed	Whirl Type
1	CRIC1	53.30	-1
2	CRIC1	53.30	1
3	CRIC1	92.35	-1
4	CRIC1	92.35	1
5	CRIC1	2269.00	-1
6	CRIC1	2272.80	1
7	CRIC1	None	-1
8	CRIC1	None	1
9	CRIC1	None	-1

Table 2.6: Critical speed with whirl type at whirl slope 4x

From the above table 2.5 and 2.6 it is clear that only first six modes have critical speed and these are very less than the expected. The above table also shows that there is repetitive mode in forward and backward whirl. Hence there is a less chance of space for eccentricity and the system may be stable for the given working conditions.

3. CONCLUSION

Thus the main objective of this thesis work is to build the model and to perform the stability analysis of Journal Bearing for three profiles i.e. general, 2 lobes and 3 lobes.

From the above FE analysis following conclusion can be made:

- From the Campbell diagram it is seen that the newly designed system is stable, which indicates the new journal bearing provides adequate stiffness for all the conditions.
- From 1x and 4x Campbell diagram, all the curves are straight which indicates the system has good stiffness. Hence for the same stiffness the new journal bearing can take much higher loads.
- From 1x Campbell diagram it is clearly seen that, Out of all the 9 modes only first four speeds are critical and they are much lesser.
- From 4x Campbell diagram it is clearly seen that, Out of all the 9 modes only first six speeds are critical and these will not create any instability of the bearing.
- From 4x Campbell diagram, it is also observed that the system possess alternative forward and backward which may reduce the eccentricity.
- The new journal bearing can work with less or without the eccentricity compared with conventional journal bearing.

REFERENCES

[1] Ray D. Kelm, '*Journal Bearing analysis*'.

[2] N P Mehta, S S Rattan and Rajiv Verma, '*Stability analysis of two lobe hydrodynamic journal bearing with couple stress lubricant*', VOL. 5, NO. 1, January 2010.

[3] Stainslaw Strzelcki, Institute of Machine Design, Technical University of Lodz, '*Power loss of multi lobe journal bearing*', 12-14, 1999.

[4] StainslawStrzelcki, Institute of Machine Design, Technical University of Lodz, '*Effect of lobe profile on the load capacity of 2-lobe journal bearing*', 1/15, 90-924 Łódź, Poland, Vol. 44 Supp.

[5] Vijay Kumar Dwivedi, S. Chand, K. N. Pandey, '*Effect of geometry of lobes and l/d ratio on the static performance of 2-lobe hybrid journal bearing*', IJPRET, 2013; Volume 1(8): 64-71.

[6] Dinesh Dhande, Dr D W Pande, VikasChatarkar, '*Analysis of Pressure for 3lobe Hydrodynamic Journal Bearing*', Volume X Issue Y- Month 2013.

[7] G. Bhushan, '*Effect of Load Orientation on the Stability of a Three-Lobe Bearing Supporting Rigid and Flexible Rotors*', Vol:5 2011-09-26.

[8] Brain Pettinato and Ronald D Flack, '*Test results for a highly preloaded Three-lobe journal bearing – Effect of load orientation on static and dynamic characteristics*', University of Virinia.

[9] Mahesh Aher, Sanjay Belkar, R. R. Kharde, '*Pressure Distribution Analysis of Plain Journal Bearing with Lobe Journal Bearing*', Vol. 2 Issue 1, January- 2013.

[10] N P Mehta, S S Rattan and Rajiv Verma, '*Stability analysis of three lobe hydrodynamic journal bearing: couple stress flued effects*', Vol. 2(10), 2010, 5736-5745.

[11] Fredrick T. Schuller, '*experiments on the stability of water-lubricated three-lobe Hydrodynamic journal bearings at zero load*', National Aeronautics and Space Administration, Washington D C, April 1971.

[12] Chaitanya K Desai and Dilip C Patel, '*Experimental analysis of pressure distribution of hydrodynamic journal bearing: a parametric study*', 28- 30 December 2005, Dhaka, Bangladesh.

[13] UgurYucel, '*Calculation of Dynamic Coefficients for Fluid Film Journal Bearing*', Pamukkale University, Faculty of Science and Art, Department of Mathematics, 20017/DenizliGelişTarihi: 20.08.2004

[14] M Varun Kumar, B Ashiwini Kumar, 'Model Analysis of Axially Symmetric Linear Rotating Structures', IJEAT, ISSN: 2249-8958, Vol-2, Issue-4, April 20.