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FINITE ELEMENT ANALYSIS OF GAS FOIL BEARINGS

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Abstract - *Micro turbomachinery demands gas comportments to be light compact and should operate at varying temperature conditions. Low heat generation disunion and lack of lubricant rotation system makes it compact dependable andeco-friendly. still low stiffness and damping portions, high cost and lack of sufficient knowledge and prophetic tools kindly restricts GFBs use in mass produced operation. Current marketable and engineering operation demands further and more aggressive designs with high face speed and unit loads as well as thinner fluid film. Again rotor-dynamics analysis uses stiffness and damping portions to represent fluid film geste or in other words these portions play the crucial part in determining dynamic characteristics of a rotor shaft. Stiffness portions depend substantially on two factors first the static deviation of antipode due to shaft cargo and second the hydrodynamic effect produced due to the fluid film. Then's an approach to calculate the stiffness measure produced due to static deviation of GFBs due to static cargo using finite element analysis and the stiffness measure has been calculated. Reynold's equation is to be answered using FDM to gain pressure profile during hydrodynamic action of fluid film and using these pressure values in the bearing model dynamic element of stiffness can be produced. Adding both factors will produce the overall stiffness measure of a gas antipode bearing.*

Key Words: ***FEA, gas foil bearing, stiffness coefficients.***

1. INTRODUCTION

A bearing is a mechanical device that separates two opposing shells fully by a subcaste of fluid lubricant. Plain journal bearing is used commercially in nearly all bias that has a rotating part. Compressors, pumps turbines, motors creators are many exemplifications need to be mentioned. Journal bearing is a structure where two cylinders rotate concentrically relative to each other. One being the shaft, rotating at a particular angular speed, and other the bearing. The main ideal is to support the rotating structures and give sufficient lubrication to avoid disunion that causes wear and tear and gash to machine corridor. The fluid film at high pressure provides the hydrodynamic film lubrication and determines the cargo capacity of the bearing. curiosity is a bearing parameter which is defined as the relegation between shaft and bearing center.

2. MODELLING PARAMETERS OF BEARING

Table-1: Parameters and dimensions of 3 gas foil bearings to be modelled and analyzed

Serial no.	Parameter	GFB1	GFB2	GFB3
1	Journal diameter	28.5mm	25mm	30mm
2	Journal length	28.5mm	25mm	30mm
3	Film clearance	.020mm	.020mm	.020mm
4	Foil thickness (top & bump)	127μm	150μm	300μm
5	Number of bumps	40	36	40
6	Bump height	580μm	580μm	580μm
7	Bump pitch	1.2mm	1.3mm	1.15mm
8	Bump diameter	1mm	1mm	1mm
9	Bump foil Young's modulus	200Gpa	200Gpa	200Gpa
10	Bump foil Poisson's ratio	0.31	0.31	0.31

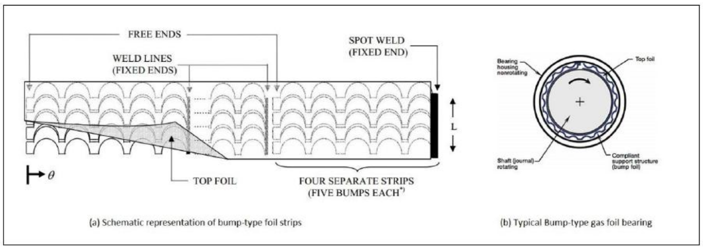

Figure- 3: Schematic view of extended bump strips and a typical bump foil bearing

3. FINITE ELEMENT ANALYSIS USING ANSYS

3.1 GENERATION OF MESH

Generating mesh is the most important and critical work in engineering simulation in Ansys software. Large no of cells may take longer time to produce solutions without increasing accuracy whereas very few number of cells might produce inaccurate results.

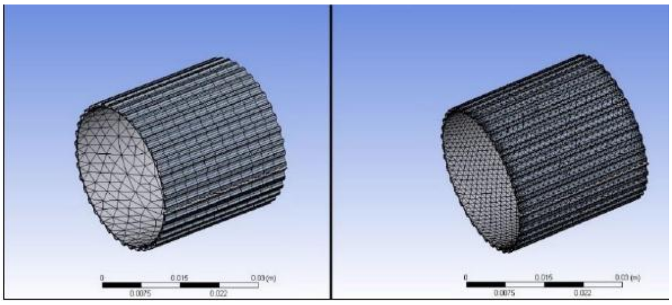

Figure-2: Optimization of auto-generated mesh.

3.2 APPLYING BOUNDARY CONDITIONS AND LOAD

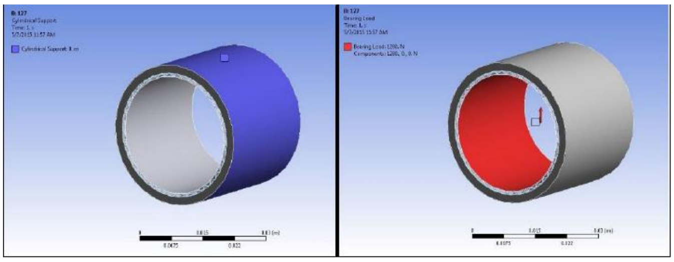

Figure-3: Applying boundary conditions and bearing load to GFB1 for pressure corresponding to 1N/mm2.

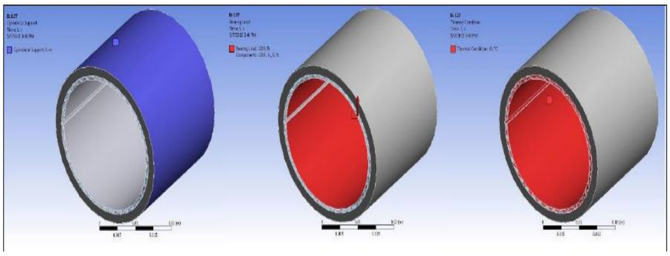

Figure-4: Applying boundary conditions, thermal conditions and bearing load to GFB1 for pressure corresponding to 1N/mm2 and temperature 10oC.

4. RESULT AND DISCUSSION

4.1 CALCULATION OF STIFFNESS

Ansys simulation of all 3 gasfoil bearings for a varying pressure range (0.1-1 N/mm2) is carried out and total deformation, directional deformation and von-Mises stress are obtained. Results for GFB 1 at 1280N are shown here.

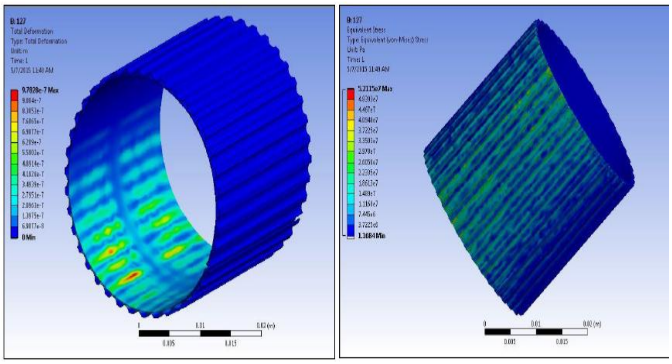

Figure 5: Variation of total deformation.
Figure 6: Variation of equivalent stress

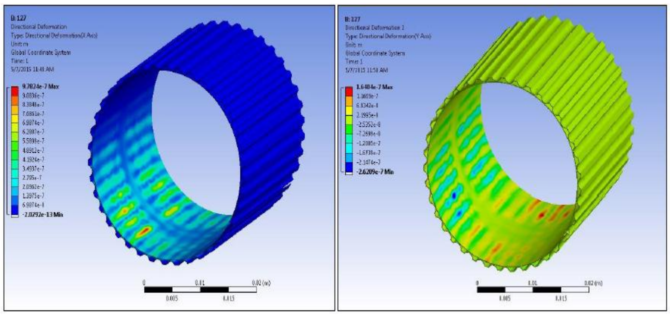

Figure 7: Directional deformation (X-axis).
Figure 8: Directional deformation (Y-axis).

Table 2: Bearing load and directional deformation (along X-axis) for a varying pressure range.

no.	F1(GFB1) in N	F2(GFB2) in N	F3(GFB3) in N	X1(GFB1) in mm	X2(GFB2) in mm	X3(GFB3) in mm
1	128	98.17	141	4.36×10-8	2.31×10-8	1.04×10-8
2	255	196.35	283	8.69×10-8	4.61×10-8	2.09×10-8
3	383	294.52	424	1.31×10-7	6.92×10-8	3.12×10-8
4	510	392.7	565	1.74×10-7	9.22×10-8	4.16×10-8
5	638	490.87	707	2.18×10-7	1.15×10-7	5.21×10-8
6	766	589.05	848	2.61×10-7	1.38×10-7	6.25×10-8
7	893	687.22	990	3.04×10-7	1.61×10-7	7.30×10-8
8	1020	785.4	1130	3.48×10-7	1.84×10-7	8.33×10-8
9	1150	883.57	1270	3.92×10-7	2.08×10-7	9.36×10-8
10	1280	981.75	1410	9.78×10-7	2.31×10-7	1.04×10-7

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4.2 PLOTS FOR BEARING LOAD VS DEFLECTION:

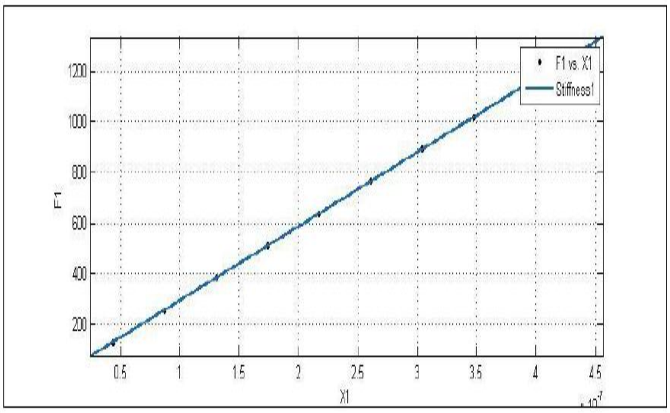

Figure -9: Bearing load (N) vs Deflection (mm) for GFB 1, (F1 vs X1).

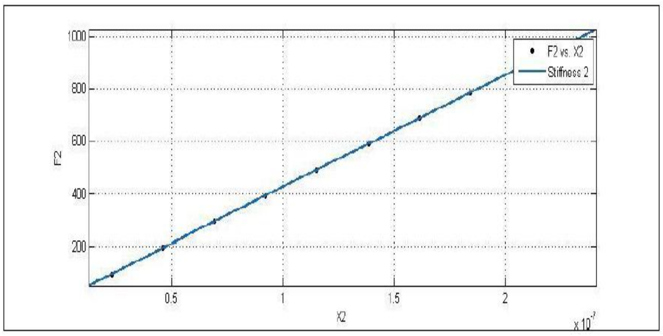

Figure -10: Bearing load (N) vs Deflection (mm) for GFB 2, (F2 vs X2)

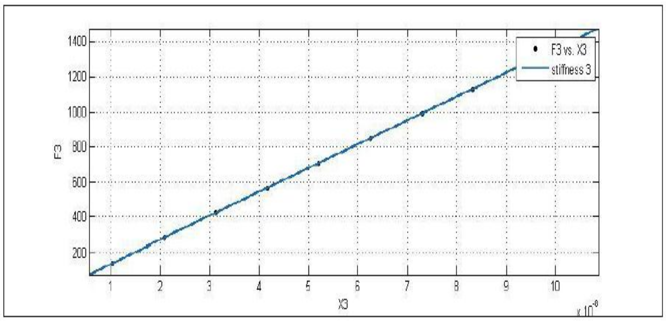

Figure -11: Bearing load (N) vs Deflection (mm) for GFB 3, (F3 vs X3)

4.3 VARIATION OF STIFFNESS WITH TEMPERATURE

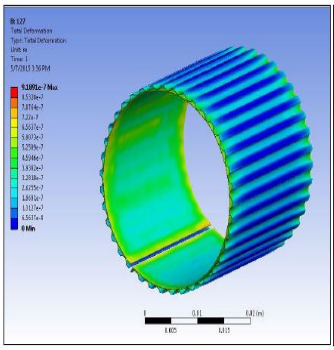
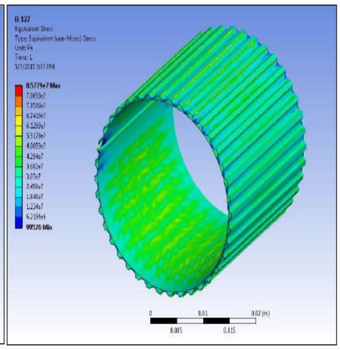

Figure 12: Variation of total deformation at 10°C.
Figure 13: Variation of equivalent stress at 10°C.

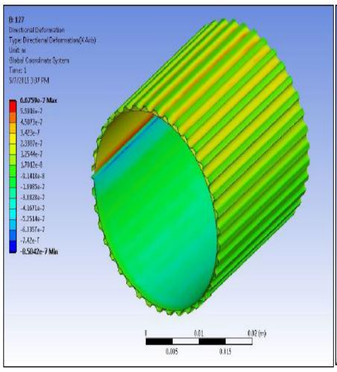
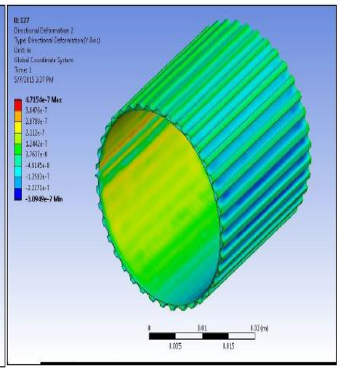

Figure 14: Directional deformation (X-axis) at 10oC.
Figure 15: Directional deformation (Y-axis) at 10oC.

Table-3: Temperature and directional deformation (along X-axis).

No	Temperature	Deformation in GFB1 at 1280N	Deformation in GFB2 at 981.75 N	Deformation in GFB3 at 1410N
1	10	6.68×10-7	8.88×10-7	7.21×10-7
2	20	4.25×10-7	4.63×10-7	1.51×10-7
3	30	5.76×10-7	2.31×10-7	6.59×10-7
4	40	1.29×10-6	6.39×10-7	1.48×10-6
5	50	2.00×10-6	1.28×10-6	2.30×10-6
6	60	2.72×10-6	1.92×10-6	3.12×10-6
7	70	3.43×10-6	2.55×10-6	3.95×10-6
8	80	4.14×10-6	3.19×10-6	4.77×10-6
9	90	4.86×10-6	3.83×10-6	5.59×10-6
10	100	5.57×10-6	4.47×10-6	6.41×10-6

4.4 PLOTS FOR TEMPERATURE VS STIFFNESS:

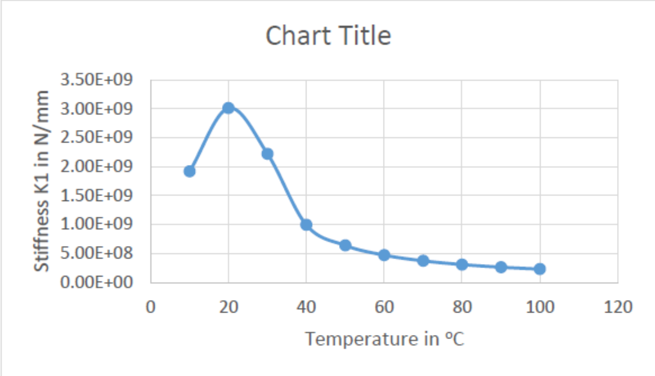

Figure 16: Stiffness (N/mm) vs Temperature (oC) for GFB 1.

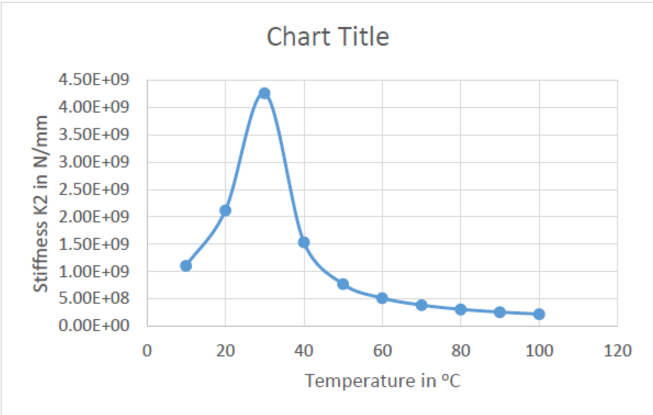

Figure-17: Stiffness (N/mm) vs Temperature (oC) for GFB 2.

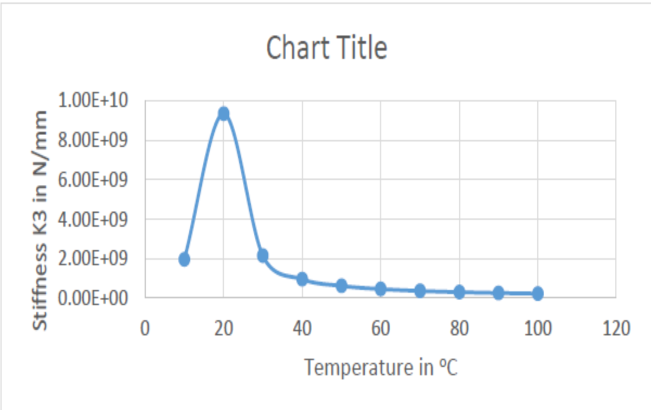

Figure-18: Stiffness (N/mm) vs Temperature (oC) for GFB 3.

5. CONCLUSIONS

Bearing load is applied to three different models of gas foil bearings. Deflections for different load values obtained using finite element analysis. Graph is plotted between load and deflection and a straight line is obtained, the slope of each curve represents stiffness of each bearing.

Graph between stiffness and temperature is plotted and the variation is obtained. It is observed that the stiffness is maximum as the temperature of the bearing coincides with the ambient temperature and stiffness reduces as the temperature difference between the bearing and working environment increases.

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