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Analysis on Active Hydromagnetic Journal Bearing using Ansys

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Abstract: In this study Active hydromagnetic journal bearing is designed and analysed by using ANSYS tool. Active Hydromagnetic journal bearing is a combination of Hydrodynamic journal bearing & Active magnetic bearing. We know that hydrodynamic journal bearing used to low speed and high load carrying capacity & its drawback is at high-speed shaft surface is come in contact and there wear also happen. In this condition hydrodynamic bearing also damages from contaminants as dirt or ash, also in the rise in temperature. In the active magnetic bearing is used to high speed and low load carrying capacity. When increasing load carrying capacity of active hydromagnetic bearing, it also increases design of active hydromagnetic bearing. When combining Hydrodynamic journal bearing & Active magnetic bearing it reduces drawback of both bearing. It working on high speed and high load carrying capacity. When combining both bearing considering main parameter is clearance in hydrodynamic journal bearing & Air gap in active magnetic bearing.

I. INTRODUCTION

Rotating machinery is incredibly common and wide utilized in the trendy industrial world. Steam turbine, compressors, pumps and jet engines are the foremost renowned and unremarkably used rotating machinery. Within the application of rotating machines one in all the key issues to be resolved, is that the safety and stability regarding rotor dynamics. "The high-speed machine is utilized in machining, that may be promising advanced producing technology for minimise cost and increasing productivity. Motorised spindle wont to attaining larger accuracy, that demands rotating machinery to run at high speeds, because of high heat generation the bearing. In trendy engineering technology fluid mechanics and magnetic bearing innovated in several ancient support forms have several benefits like long life, high speed, precision, no friction and abrasions. Hydrodyanamic and magnetic bearings are utilized in many industrial applications like machine operation and fossil fuel handling. They are additionally utilized in the turbo molecular pumps, and energy storage systems of high speed flywheels."[10]. Active hydromagnetic journal bearing (AHJB) is new and innovative kind of bearing, that is employed to retain move shafts from low to high speed operations. It's a mix of hydrodynamic journal bearing (HJB) and active magnetic bearing (AMB). The active hydromagnetic journal bearing is used for the active stability control of the rotor bearing system as well as to increase the load carrying capacity of the bearings. In the following section, the properties and performance characteristics of the hydrodynamic parts are given. Subsequently the active magnetic bearing properties, characteristics additionally given. In term of its mathematics and, operation and its dynamic properties.

II. BEARING DESIGN

A. Hydrodynamic Journal Bearing Geometry

In rotor-bearing systems hydrodynamic journal bearings are widely used as with excellent properties.

1) Raimondi And Boyd Method

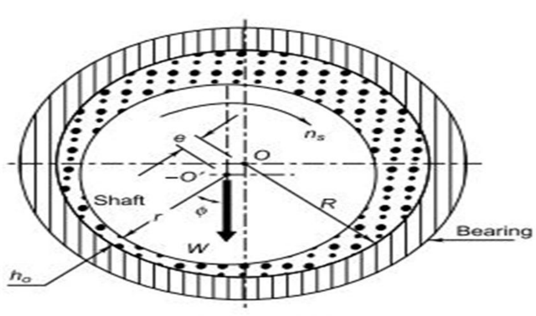

Fig No.1- hydrodynamic journal bearing

where,
c = radial clearance (mm)
R = radius of bearing (mm)
r = radius of journal (mm)
e = eccentricity
ho = minimum film thickness (mm)

B. Selection Of Parameters

1) length-to-diameter ratio

a) When (l/d) >1, the bearing is called 'long' bearing.

b) When (l/d)<1, the bearing is called 'short' bearing.

c) When (l/d) =1, the bearing is called 'square' bearing.

2) Unit Bearing Pressure: The unit bearing pressure is,load per unit of projected area of the bearing in running condition. The unit bearing pressure for starting conditions should not exceed 2 N/mm2.

3) Startup Load: It mainly consists of the dead weight of the shaft and its attachments. The start up load used to determine the minimum length of the bearing on the basis of starting conditions.

4) Radial Clearance: The practical value of radial clearance is 0.001 mm per mm of the journal radius.

Material	Radial clearance
Babbitts	(0.001) r to (0.00167) r
Copper–lead	(0.001) r to (0.01) r
Aluminium–alloy	(0.002) r to (0.0025) r

Chart No. 1 – Selection of radial clearance

5) Minimum oil Film Thickness: There is a lower limit for the minimum oil film thickness, below which metal to metal contact occurs and the hydrodynamic film breaks. This lower limit is given by, h0 = (0.0002)r

6) Maximum oil Film Temperature: The lubricating oil tends to oxidise where the operating temperature exceeds 120°.

C. Theory (Hydrodynamic Journal Bearing)

1) Sommerfeld No.(S)

The Sommerfeld number is given by,
Sommerfeld No.(S) = [μ*N(rps)]*(r/c)^2/P]

where,
S = Sommerfeld number (dimensionless)
μ = viscosity of the lubricant (Ns/mm2)
N = journal speed (rps)
p = unit bearing pressure, (N/mm2)

2) Load Carrying Capacity (W)

Load Carrying Capacity (W) = [μ*N(rps)*L*D]*(r/c)^2/S]

Where,
W = Load Carrying Capacity(Radial Load)
S = Sommerfeld number (dimensionless)
μ = viscosity of the lubricant (N-s/mm2)
N = journal speed (rps)
r = radius of journal (mm)
c = radial clearance (mm)
L = Length of bearing
D= Diameter of bearing

3) Coefficient of friction variable, frictional torque and frictional power

Coefficient of friction variable (CFV) = (r/c)*f

[CFV value taken from RAIMONDI AND BOYD charts]

Where,

f = coefficient of friction

The frictional torque is given by Mt= fWr N-mm.

Frictional power = (2πN) (fWr) N-mm/s

= (2πN) (fWr) (10^–3) W

= (2πN) (fWr) (10^–6) kW

= (2πN) (fWr) /10^6 kW

4) Flow of Lubricant

The flow variable (FV) is given by,

FV = Q/(r*c*N*L)

Where,

L=length of bearing

Q=flow of variable (mm^3/s)

Given in the RAIMONDI AND BOYD chart.

5) *Maximum Pressure of Oil:* The maximum pressure (Pmax) developed in the film is calculated from the ratio (P/Pmax), Given in the RAIMONDI AND BOYD chart.
6) *Temperature Rise:* The total heat generated in the bearing is carried away by the total oil flow in the bearing, the expression for temperature rise can be given by,

Taverage = Ti +(dt/2)

Where,

Ti = initial temperature

dt = 8.3*P*(CFV)/(FV)

D. Theory (Active Magnetic Journal Bearing)

Active magnetic bearing is composed of four horseshoe-shaped electromagnets.

This configuration is shown in fig. the four magnets are arranged evenly around a circular shaft that can be levitated, which is made from a ferromagnetic material, such as iron. Each horse shoe shaped ferromagnet can produce a force that attracts the journal to it, and thus, all four electromagnets must act in concert, to produce a force of arbitrary magnitude and direction on the rotor.

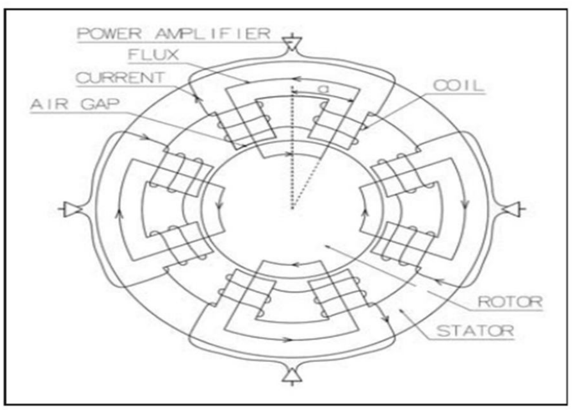

Fig N0. 2- Active magnetic journal bearing

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E. Active Magnetic Journal Bearing

1) *Selection of Flux Density:* For electroplated FeCuNbCrSiB film flux density of 1.6T – 1.7T. for design of model took average of value is,

Where,

B = flux density(Tesla)

Why:

a) The thickness of the as-deposited electroplate FeCuNbCrSiB film is 4 µm.
b) due to eddy current effect the skin effect become stronger in thicker magnetic thin film at high frequencies .

Estimate the flux density in air gap Bg and also assuming 10% leakage.

Bg = 0.9

2) *For The Known Load Capacity Calculate The Force Per Pole*

For the design we take a three active pole,

Pole pitch = α = (360/p)

=(360/8)

= 45°

Hence,

F = F1 + 2(F1*cos 45°)
= 2.41*F1

Using the expression for force in terms of flux in the gap is,

F1 = (Bg^2 * A) / (2μ0)

Where,

Bg = magnetic flux density in air gap
μ0 = magnetic permeability of the vacuum
A = cross-sectional area of the stator pole

To find required cross-sectional area of the stator pole expression is interchange,

A = (2*μ0*F1) / (Bg^2)

3) *Determine no. of Winding Per Pole*

F1 = (μ0*Nw^2*I^2*A) / (8*g)

Where,

μ0 = magnetic permeability of the vacuum
Nw = No. of winding per pole
I = current (5A)
g = Air gap (1 mm)

4) *Calculations of Width of Pole, Length of pole, back iorn(Radial Width)*

Width of pole (Wp) = A/Lb
Length of the pole (Lp) = (1 – 1.5) Wp
Used 1.25 it average between 1 to 1.5.
Calculate back iron (radial width)

Wbi = 0.5 Wp

5) Calculate outer Diameter of Stator

Dst = Di + 2(Wpi + 1.15hw) …….{research paper_ radial active magnetic bearing design optimization }

Where,

Dst = stator outer diameter

Di (internal diameter) = journal diameter + air gap

Lp (pole length)

Lp = hw + 0.15 hw

6) Wire Diameter (dw)

((N*dw) / Lp) ≥ 1 …….(research paper optimization of 8 pole active magnetic bearing)

Where,

N = number of turns

dw = wire diameter

Lp = length of pole

Total coil thickness (t)

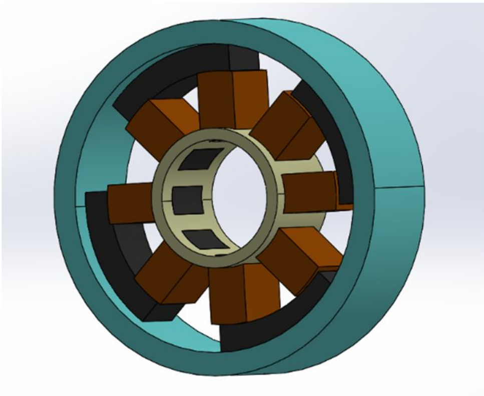
t = (2 * dw) + Wp

where,

dw = wire diameter

Wp = wodth of pole

Design of Active Hydromagnetic Journal Bearing



III. RESULT

Sr.No	Revolution	Total deformation	Equivalent stress	Equivalent elastic strain	Maximum principal stress	Maximum principal elastic strain
	rpm	m (10^-7)	Pa (10^6)	10^-5	Pa (10^6)	10^-5
1	500	3.0321	1.8517	1.3506	1.2100	1.3104
2	1000	3.0391	1.8539	1.3536	1.2128	1.3134
3	1500	3.0507	1.8577	1.3587	1.2173	1.3185
4	2000	3.06699	1.8629	1.3658	1.2237	1.3255

IV. CONCLUSION

From the static structural analysis results,

A. Total deformation for 500, 1000, 1500, 2000 rpm revolution is permissible so designed active hydromagnetic bearing is safe.
B. Equivalent stress for 500, 1000, 1500, 2000 rpm revolution is permissible so designed active hydromagnetic bearing is safe.
C. Equivalent elastic strain for 500, 1000, 1500, 2000 rpm revolution is permissible so designed active hydromagnetic bearing is safe.
D. Maximum principal stress for 500, 1000, 1500, 2000 rpm revolution is permissible so designed active hydromagnetic bearing is safe.
E. Maximum principal elastic strain for 500, 1000, 1500, 2000 rpm revolution is permissible so designed active hydromagnetic bearing is safe.

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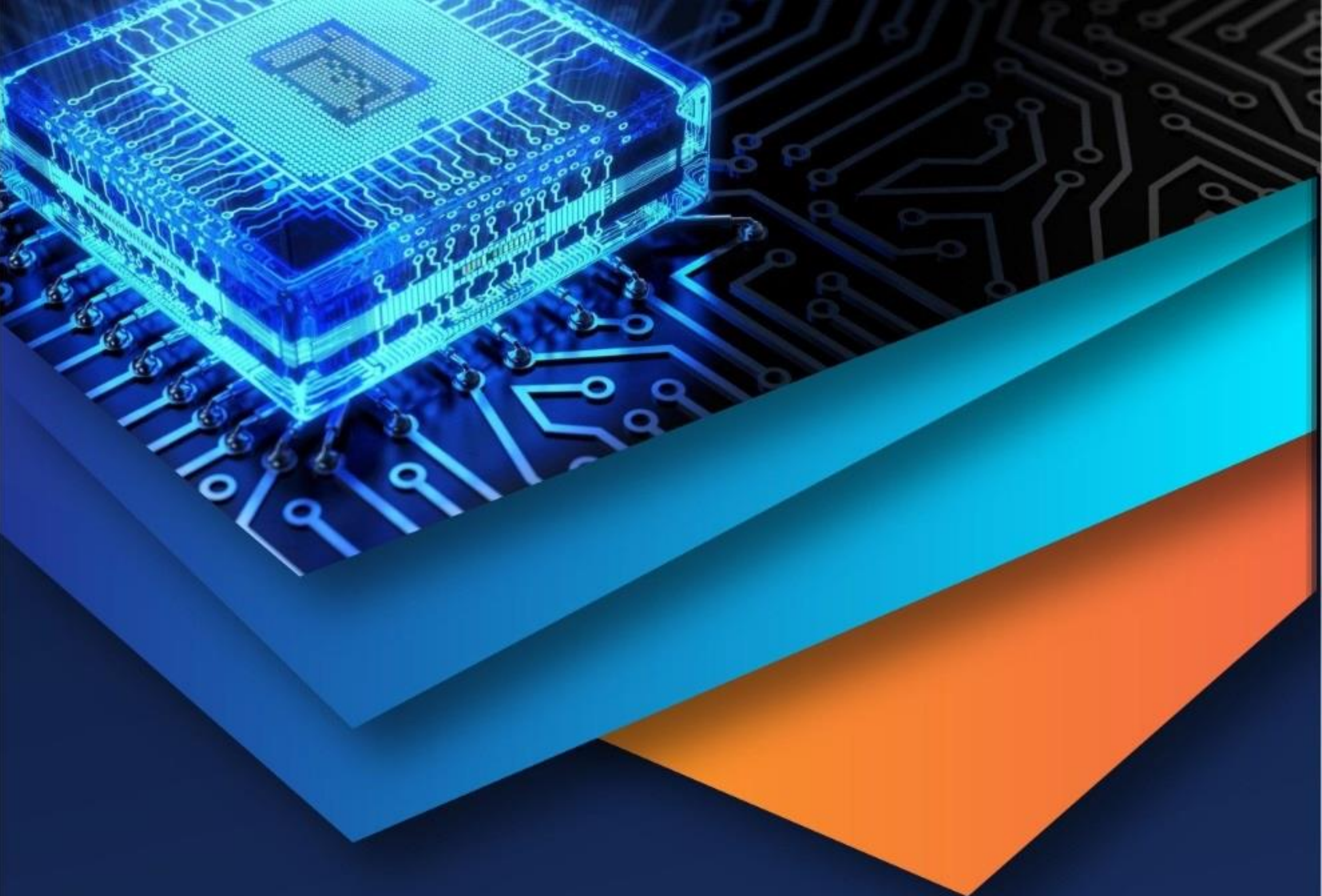

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