Manufacturing of Hybrid (Permanent Magnetic-Hydrodynamic) Bearing by Powder Metallurgy Process

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***Abstract* – A concept of hybrid (permanent magnet + hydrodynamic) bearing that provides non-contact support at all operating speeds has been hypothesized. NdFeB and Aluminium powders have been selected to manufacture the hybrid bearing. The manufacturing trails made at laboratory level have been reported in the present paper.**

***Index Terms* – Neodymium-Iron-Boron powder, Aluminium powder,**

I. INTRODUCTION

Today magnetic bearing and hydrodynamic journal bearing are well known to us. Magnetic bearing has advantages to provide non-contact support at various operating speeds, but its low load carrying capacity and negligible damping limits its applications. On the other hand hydrodynamic bearing posses high load carrying capacity, immense damping, and simplicity in structure. However, its inadequacy lies in its inability to film formations at lower speeds, i.e. particularly during starting and stopping conditions. This deficiency of hydrodynamic bearing makes it vulnerable to wear and reduce the life of the bearing.

In view of augmentation of both the bearings' performances authors have hypothesized a hybrid (permanent magnet + hydrodynamic) bearing in views of taking the advantages of both the bearings while compensating for each other's weakness. To implement this concept, authors have simulated the permanent magnet bearing configuration. The previous simulation results [1] show that a combination of 45° arc magnet above the 180° arc magnet provides the stable configuration for permanent magnet bearing. Based on simulation results, authors tried to fix both 180° and 45° in a non-magnetic aluminium ring as shown in Fig.1. This type of configuration helps to develop both magnetic bearing and hydrodynamic bearing in a single unit and simplify the design. But with such type of configuration a number of difficulties were faced. It is very difficult to fix the permanent magnets in the slot of aluminium ring and make a continuous smooth circular cylindrical surface suitable for hydrodynamic film formation. To minimize the assembly problems, authors

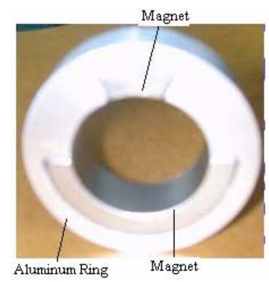

Fig.1Hybrid Bearing [1]

Fig.2: Teflon Coated Hybrid Bearing []

tried to coat the aluminium and NdFeB assembly using Teflon, as shown in Fig. 2.

As a result, problem of fixing the magnet in aluminium ring has been solved and inner surface of the ring become smooth and continuous. But the problem of getting the proper circular cylindrical surface persists. On the other hand, such an exercise increases the manufacturing steps.

To solve such problems and minimize the manufacturing efforts, authors have adopted the powder metallurgy process. Aluminium and NeFeB powders have been selected for the present experimental study.

II. LITERATURE REVIEW

Recently Q.Tan et al [3] have tried to concept of hybrid bearing by arranging the permanent magnetic bearing and hydrodynamic bearings side by side as shown in Fig. 3. In authors' views this arrangement unnecessarily takes the spaces and makes the system more complex.

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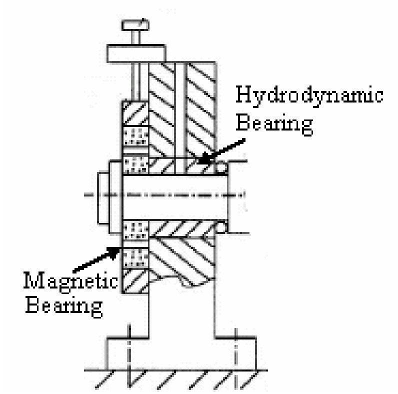

Fig-3 Bearing Arrangement [3]

III. Powder Metallurgy Process to Manufacture the Hybrid Bearing

A. Apparatus

The instrumentation used in the powder metallurgy process includes hydraulic press, magnetizer, die-cum-electromagnet.

The capacity of hydraulic press (Maker: Central Repair-and-Engineering works, Leningrad, Russia) shown in Fig.4 is 50 ton. The pump is equipped with two-plunger type oil pump driven by 3-phase 1 KW motor. The maximum pressure build up by the pump is 300 kg/cm^2. The speed of the piston is 62mm/min. The maximum stroke length is 150 mm.

The magneizer is made by Star Strace Pvt Ltd, Chennai, India. This is an impulse magnetizer and oparate according to the principal of capacitor discharge. The operating voltage is 240V A.C. 1 Phase. Output voltage 1200 volts (adjustable). Charging cycle time is 3-4 sec and output current is Pulse Train Tupe with 5 K.A peak. The maximum energy of this instrument is 3000 J.

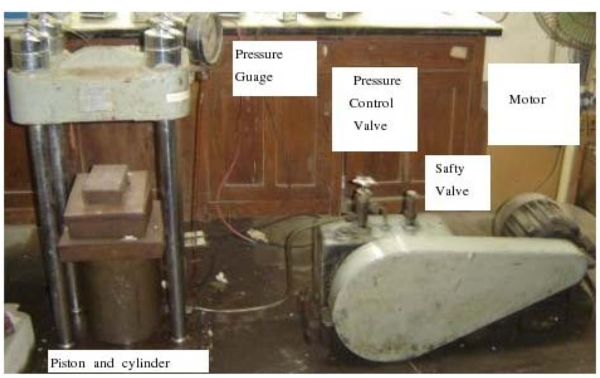

Fig.4 Hydraulic Press

Fig.5 Magnetizer

Fig.6 Die-cum-electromagnet and punc

To apply the magnetic field simultaneously in powder during compaction, the electromagnetic coil has been winded on surface of the die as shown in Fig.6. The guage of the coil is 28 and the number of turn of the coil is 1200.

B. Material

For manufacturing the hybrid type bearing, neodymium-iron-boron powder graded 13-9M and non-magnetic powder (aluminium alloy 7010) have been used. The magnetic powder having particle size ranging between 80 microns to 300 microns has been used to get the improved [4] magnetic and mechanical properties of the magnet. Loctitie 210213 Hysol and zinc stearate has been used as a binding and lubricant agent respectively.

C. Steps

The following steps have been used in manufacturing of hybrid bearing:

1. To start manufacturing process, 5 gm of NdFeB magnetic powder and 3 gm of aluminium alloy powder have been taken.
2. Binder taken by 2% weight of each powder was diluted in the acetone.

3. Diluted binder was properly mixed with the magnetic powder and aluminium powder separately.
4. The surfaces of the die and punch were daubed with zinc stearate.
5. Powders (NdFeB & Al7010) were arranged in the die as shown in Fig.6 to get configurations as shown in Fig.7. Then magnetic field was supplied to the powder in die connected to the magnetizer (3000 J) and simultaneously compressed in the hydraulic press.
6. The green compacts were cured at temperature 120 ºC for 30 minutes in inert gas atmosphere.
7. The cured green compacts had been magnetized again by magnetizer.

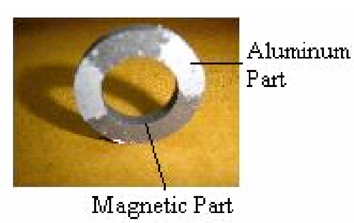

Fig.7 Hybrid Bearing Powder Metallurgy Process

CONCLUSIONS

Hybrid bearing manufacturing process by the powder metallurgy process is economic and easy to execute. It reduces the number of steps during manufacturing process. By this process it is possible to make bearing's inner surface circular and smooth which is suitable for hydrodynamic film formation.

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