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Performance Evolution of Self-Lubricating Composite Materials By Experimentation

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Abstract: *The purpose of this paper is to evaluate the performance of self-lubricating composite materials with vibration suppression. Composite materials are prepared by using stir casting method with the combination of Aluminium alloy + 15 weight percentage of fly ash + 4 weight percentage of Graphite and Boron Nitride. Two specimens have to be prepared for plain bearing applications. The test rig setup consists of mild steel shaft driven by AC induction motor and plain bearing setup loaded by spring balance arrangements. The load on the bearing and time are the parameters. The bearing vibrations and temperature of matting surface are measured using Labview software. The result shows that a variation of vibration amplitude and temperature for two different combinations of specimens. Tribological properties of four plain bearings are to be evaluated by experimentation.*

Keywords- *Composite Materials, Plain Bearing, Labview, Vibration, Temperature.*

I. Introduction

In the recent years there has been an emerging trend to use solid lubricants over a wide range of applications. The self-lubricating composites are suitable for application requires improved hardness, wear resistance and low coefficient of friction with lower density. These properties enhance the usage of self-lubricating composites in automotive and tribological applications. In the field of automobile and tribo industry [1], hybrid self-lubricating composites are extensively used for cylinder liner, piston, valve stem guide, and plain bearings. Self-lubricating composites have found wide application in many special machine parts; yet oil or grease cannot lubricate inaccessible parts and contamination is not acceptable. Composite materials are prepared by combination of Aluminium + 15 weight percentage of fly ash + 4 weight percentage of Graphite and Boron Nitride[2]. Two specimens have to be prepared for plain bearing applications.

Lot more methods are available to fabricate metal matrix composite. But wettability and the dispersion of reinforcement particles with the matrix alloy is the main problems. Many methods have been proposed to overcome this situation. Like, blending, consolidations, vapour deposition, stir casting, pressure infiltration technique, and spray deposition method. However, stir casting is the simplest and most economical method [3]. It has been suggested to develop composite materials have the capacity to achieve low friction and wear at the contact interface without any external supply of lubrication during the sliding [4]. . The test rig setup consists of mild steel shaft driven by AC induction motor and plain bearing setup loaded by spring balance arrangements.

II. Experimental Setup

2.1Materials

Aluminium alloy is a very useful material and over the years its range of application has widened immensely. It was selected as the base material as it possesses good formability, machinability, and corrosion resistance, with high mechanical strength after heat treatment compared to other grades of aluminium alloys. Aluminium alloy is a heat treatable wrought alloy. Its nominal chemical composition is shown in Table I. Fly ash is one of the residues generated in combustion, and comprises the fine particles that go up with the flue gases. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gas reaches the chimney of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata [5].The various materials of MoS_2, Graphite, Talc and Boron Nitride are added with flyash as a reinforcement.

TABLE 1: CHEMICAL COMPOSITION OF ALUMINIUM 2xxxseries ALLOY IN WEIGHT PERCENTAGE

Cu	Ni	Mg	Si	Fe	Ti	Al
3.87	1.90	1.47	0.51	0.16	0.02	Bal

2.2 Composite Preparation

The self lubricating Aluminium based composites with 15 wt. % of fly ash, 4 wt. % of Graphite and Boron Nitride were fabricated by metal stir casting (Fig. 1) method. Table 2 gives the compositions of the liquid metallurgy samples.

TABLE 2: TO CARRY OUT THE STUDY, TWO DIFFERENT COMBINATIONS ARE

Specimen-1	Aluminium alloy-15% fly ash-4% Graphite
Specimen-2	Aluminium alloy-15% fly ash-4% Boron Nitride

Fig. 4 Electrical Furnace

An electrical melting furnace with stirring assembly was used for the continuous dispersion of preheated reinforcement particles into liquid aluminium alloy. MoS_2, Graphite, Talc and Boron Nitride and fly ash was preheated at 400°C for one hour to increase the surface reaction. The heat treated particles were then added into the melt through the vortex, which was formed by continuous stirring. The speed of the stirrer has maintained at 300-400 rpm and continued about 10 minutes to get properly mixing and low porosity [6]. Non-wetting behavior of cause low interfacial bonding with matrix alloy. To overcome this effect 0.5 wt. % of magnesium also incorporated with Graphite and Boron Nitride into the matrix alloy.Two specimens have to be prepared for plain bearing applications.(Fig. 2 & 3).

Fig. 2 plain bearing specimen1

Fig. 3 plain bearing specimen 2

2.3 Test rig setup

The test rig setup consists of mild steel shaft driven by AC induction motor and plain bearing setup loaded by spring balance arrangements**.** The experiments were carried out in the plain bearing test rig setup shown in figure 4[7]. The experiments were carried out with two specimen of plain bearing application at constant speed of 1400 rpm.

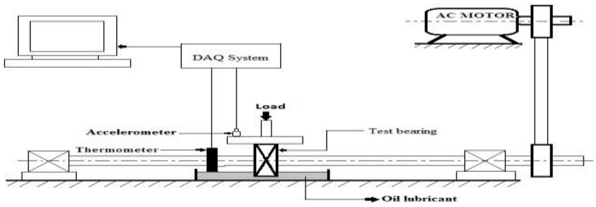


Fig. 4 Test rig setup

TABLE 3: SPECIFICATION

Name	Description
Motor	Single phase AC motor
Computer software	OS (Windows 7)
Bearing	Composite of Plain bearing specimen
Software	Labview & DAQ Kit

The vibration data collected in PC with the help of accelerometer [8] and NI-cDAQ-9172 device. Bearing vibrations were acquired with various loading condition.The NI cDAQ-9172 is an eight-slot USB chassis designed for use with C Series I/O modules shows in figure 5. The NI cDAQ-9172 chassis is capable of measuring a broad range of analog and digital I/O signals and sensors using a Hi-Speed USB 2.0 interface.

Fig.5 Data Acquisition card

2.4 Accelerometer Sensor

The vibration level of bearing was measured by using accelerometer and DAQ kit. Precision industrial ICP accelerometers are recommended for route-based vibration data collection and quantitative diagnostic measurements on industrial machinery. These sensors are directly compatible with most commercially available vibration data collectors and FFT analyzers that supply excitation power for ICP® sensors. These precision, shear-structured sensors offer tighter sensitivity tolerances than low-cost series units and are supported with full NIST traceable calibration data that encompasses an extensive frequency range. All units are laser welded and leak tested to ensure a true hermetic seal. Shock protection to 5000 g (49k m/s2) guards against damage due to accidental overloads. A host of available options including velocity output, temperature output, and hazardous area approvals adapt the units for virtually any machinery vibration monitoring requirement

2.5 About Lab view

LabVIEW is the acronym of Laboratory Virtual Instrumentation Enable Work bench, LabVIEW is product developed by National Instruments. LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution. In LabVIEW, you build a user interface with a set of tools and objects.

The user interface is known as the front panel. One can add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart.All this vibration data is stored into computer with help of Lab VIEW software and the block diagram.The block diagram is shown in fig 6.

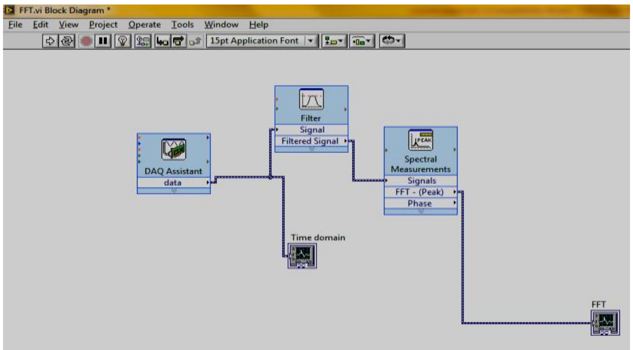


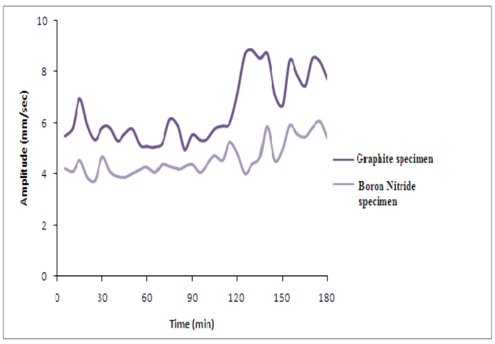
Fig.6 Block Diagram in Lab view

III. Results And Discussions

Figure 7 shows that the effect of vibration variation in plain bearing of graphite composite specimen supplied with base oil under the different load,the graph shows at 100 N of load conditions ,the another plain bearing of boron nitride specimen exhibits lower vibration level compared to other bearings. A notable difference in amplitude of vibration observed in fig 7.

3.1 Vibration Measurement

The plain bearing is test with constant speed range.The amplitude measurement and vibration level is calibrated in that bearing with the help of accelerometer sensor.



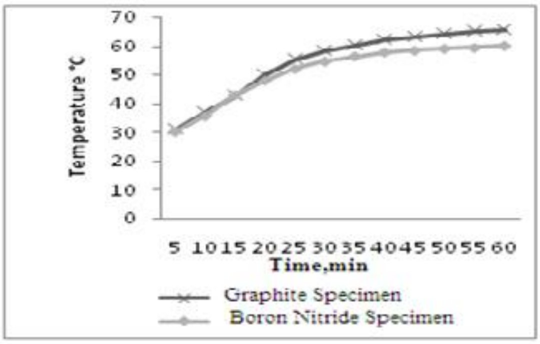


Fig.7 Amplitude of vibration Fig.8 plain bearing as function of Temperature

3.2Temperature Measurement

The temperature values are calibrated with the help of thermocouple. In this test graphite specimen of plain bearing and boron nitride of plain bearing using base oil.Fig.8 shows the effect of oil temperature on the two specimen of plain bearing. The specimen of plain bearing curves of base SAE 20-40oil rise rapidly with the increase of oil temperature.

IV. Conclusions

The present investigation, Aluminum alloy- Fly ash-graphite,boron nitride self-lubricating composite was produced by liquid metal stir casting technique,vibration and the tribological characteristics were studied. The following observations can be drawn:

1. Dispersion of low density fly ash particles significantly reduces the density of self- lubricating composite.
2. Accumulation of both fly ash and hBN particles into the matrix improves the wear resistance of aluminium composite.
3. The wear resistance of the hybrid composite containing 15 wt. % fly ash and 4 wt. % BN,graphite is marginally higher to that of the other hybrid composites.
4. Plain bearing of boron nitride specimen exhibits lower vibration level compared to graphite specimen.
5. Temperature rise on the two specimen of plain bearing performance is evaluated by thermocouple.

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