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# A Wear Analysis of Composite Ball Materials using Tribometer

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**ABSTRACT**
The bearing is a main element in case of rotating machines for aircraft engines applications. The major failure of ball bearing is because of wear of balls. This paper focused on prediction of wear of balls under pure sliding contact conditions for Chrome steel, Alumina Oxide and Silicon Nitride materials. The wear calculation method is employed as per ASTM G99 standard. Pin on Disc Apparatus is used to perform trials. To reduce number of experimentations, DOE technique is used with L9 orthogonal array. Accordingly tests are conducted. Engine oil is used for maintaining the lubricating conditions. Finally Comparison is done for various materials.
***Keywords –*** Ball Bearing, Pin on Disc apparatus, Wear, DOE.

## I. INTRODUCTION

Wear is related to interactions between surfaces and specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. The selection of bearing steel surfaces for use with silicon nitride rolling elements within hybrid bearings is critical to the performance and life of such components, which have potential applications in advanced high speed aircraft. The wear and friction performance of these combinations is a major factor currently being considered for the next generation hybrid bearings [1]. The majority failure of ball bearing is because of wear in ball and races. Ball and roller bearings are widely used in a variety of industrial machinery to allow relative motion and support load in rotating shafts. In conventional ball bearings, with metal raceways and balls, subsurface-originated spalling and surface-originated pitting have been recognized as the dominant modes of failure due to rolling contact fatigue (RCF)[5]. Aircraft engine manufacturers have been aggressively pursuing advanced materials to meet main-shaft bearing requirements of advanced engines for military, commercial and space propulsion. These requirements include bearings with extended life, superior corrosion resistance, surface durability and tribological performance. Hence it has been observed that the bearing failure takes place because of contacting surface wear.

From above summary it is observed that for high speed aircraft, the ball bearing material should be such that it can have negligible wear. Therefore ceramic materials such as Silicon Nitride, Alumina Oxide can be considered for satisfying the requirements.

## II. WEAR TEST PROCEDURE

This test is conducted as per G99 Standard of ASTM. Chrome Steel discs were polished with metallographic abrasive papers (C-400) and (C-600) respectively. Chrome Steel disc rotating at a selected speed slide against a ball according to velocity track diameter of ball on disc was varied accordingly. This pre-rubbing process ensured a full contact of the ball and disc surfaces. The surface roughness *R*a of disc specimens was 0.09–0.11μm. All the specimens were manually cleaned in petrol and then thoroughly dried.

Figure 1 Pin on Disc Apparatus

The friction and wear tests are performed at room temperature ($28^0$ C) in atmosphere. Applied loads ranged from 10 N to 120N and rotation speeds of discs ranged from 7m/s to 14m/s, time ranged from 30 to 90 minute, and the sliding distance was varied accordingly. The Servo engine oil (20W40) oil was used at flow rate of 50 ml/min on the rubbing surfaces using oil lubrication system during the wet test. It was ensure that lubrication will be continuously between Pin and counterface during the wet test.

As per Taguchi approach the test are conducted. Depends upon the number of parameters and the no of levels, the proper L9 orthogonal array is selected. The experiments were conducted as per the standard orthogonal array.

Table 1 Orthogonal Array

| L9 Test | Velocity (m/s) | Load (N) | Time (min.) |
|---|---|---|---|
| 1 | 7 | 10 | 30 |
| 2 | 7 | 60 | 60 |
| 3 | 7 | 120 | 90 |
| 4 | 10 | 10 | 60 |
| 5 | 10 | 60 | 90 |
| 6 | 10 | 120 | 30 |
| 7 | 14 | 10 | 90 |
| 8 | 14 | 60 | 30 |
| 9 | 14 | 120 | 60 |

## III. RESULTS & DISCUSSIONS

After successful conduction of trials, the following results are observed.

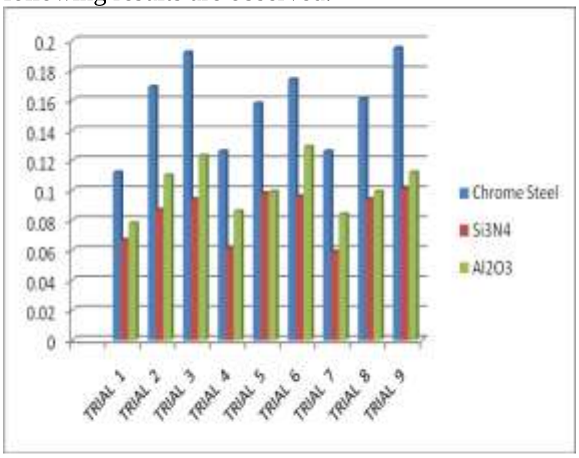


Figure 2 Wear results for various trials in grams

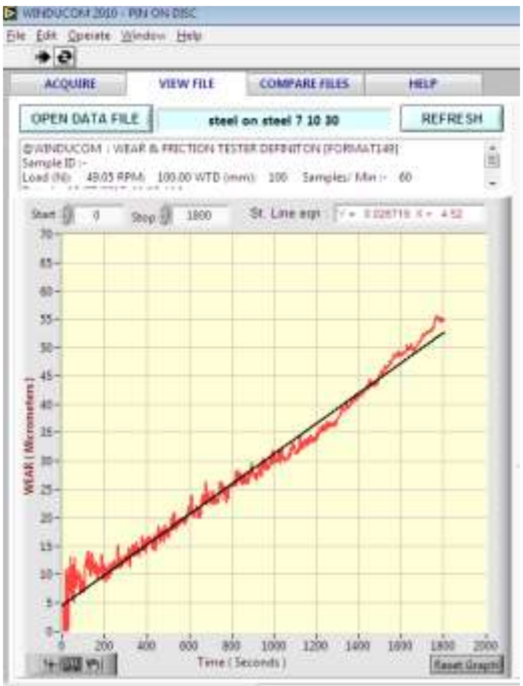


Figure 3 Wear V/s Time for Trial 2 with Chrome steel

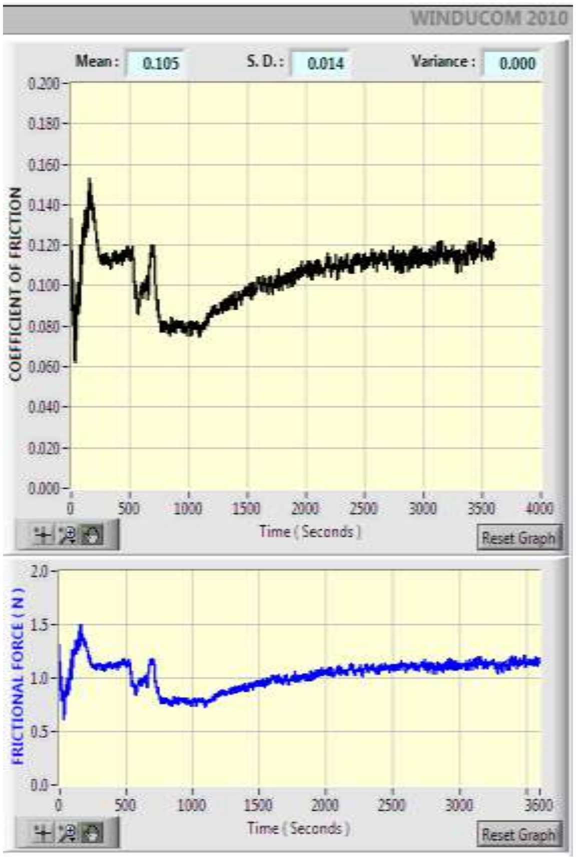


Figure 4 Coefficient of Friction & Frictional force for Trial 2 with Chrome Steel Material


Figure 5 Wear V/s Time for Trial 2 with Alumina

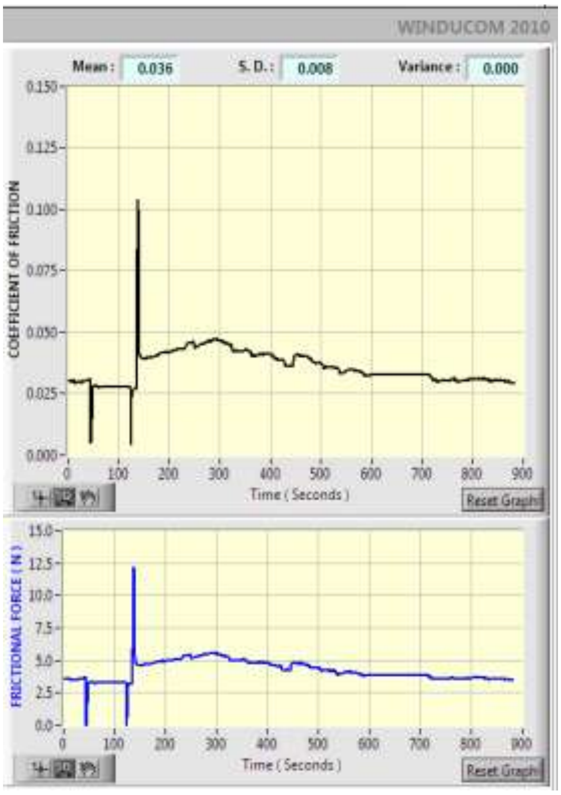


Figure 6 Coefficient of Friction & Frictional force for Trial 2 with Alumina


Figure 7 Wear V/s Time for Trial 2 with Silicon Nitride


Figure 8 Coefficient of Friction & Frictional force for Trial 2 with Silicon Nitride

## IV. CONCLUSIONS

From the various trials of wear analysis, following results are obtained

1. Silicon Nitride/M 50 shows the best wear resistance under load of 120 N.
2. Coefficient of friction for chrome steel is observed at a range of 0.1-0.16, whereas the Coefficient of friction for Silicon Nitride and Aluminium oxide is varies from 0.08-0.03.
3. Silicon Nitride and Alumina material balls have less wear compared to Chrome Steel.
4. It is proved that for aircraft engines, the Silicon Nitride Hybrid ball bearing is the best bearing.
5. At elevated temperatures the effect of wear can be study for various composite materials.
6. As we considered experimentation of material for purely sliding contact condition hence by modeling actual working condition setup the results can be up to the marks.
7. The test can be conducted by varying Temperature and Humidity on the friction and wear characteristics.

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