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Experimental Investigation On Tin Based Babbitt Composite Material

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Abstract - B83 Babbit is a widely used material in Russian engineering for manufacturing journal bearings through casting, hard facing, and metallization processes. This alloy is known for its low friction coefficient and desirable properties such as rapid conformability, good thermal conductivity, high impact viscosity, and compatibility with oil. However, the low fatigue strength under alternating loads and moderate wear resistance of Babbitt can reduce the operational lifespan of the bearing. To address these limitations, ceramic particles are incorporated into the matrix alloy to enhance the load-bearing capacity and wear resistance of composite materials. In this research, the stir casting method is employed to fabricate a Babbitt metal matrix composite by reinforcing it with silicon carbide at varying concentrations of 2%, 4%, and 6%.

1. INTRODUCTION

The B83 Babbit alloy, a popular material in Russian engineering, is commonly used for manufacturing sleeve bearings through casting, hard facing, and metallization processes. This alloy offers several advantageous properties, including a low friction coefficient, rapid conformability, good thermal conductivity, high impact viscosity, and compatibility with both petroleum and synthetic oils. However, the fatigue strength under alternating loads is relatively low, and the wear resistance of Babbit is moderate, resulting in reduced operational lifespan for components made from this material. Currently, Babbit alloys, specifically Sn-Sb-Cu alloys, are extensively employed in various industries, including the sugar industry, shipbuilding, and automotive industry, as the material for sliding bearings that operate in oil.

1.1. Introduction to Wear

Wear is the gradual loss or removal of material from one or both surfaces in contact due to relative motion between them. It is a significant factor that significantly reduces the effective lifespan of machines and their components. Wear occurs when two surfaces experience relative motion. It involves the progressive removal of material from one surface in relation to the other. The process of wear is complex and involves the gradual deterioration of the surfaces, resulting in changes in shape, weight loss, and the generation of debris.

2. SUMMARY OF LITERATURE SURVEY

The incorporation of nanoparticles in metal matrix composites can enhance the wear resistance, damping properties, and mechanical strength of the base material.

Babbitt bearings exhibit excellent conformability, meaning they can adapt to small misalignments or shaft deflections.

The properties of metal matrix composite materials are influenced by various processing parameters in the stir casting process, such as stirring temperature, stirring speed, stirring time, preheating time, as well as the selection of matrix and reinforcements.

3. PROBLEM STATEMENT

The bearing used in boiler feed pumps operates under high-speed conditions. However, when subjected to excessively heavy loads and high rotational velocities of the shaft, the bearing is prone to damage, especially if an adequate oil film thickness is not present between the shaft and the bearing.

• Excessive wear leading to bearing failure is a significant cause of failures in boiler feed pumps. In industries like the sugar industry, pump failure can disrupt subsequent operations and result in substantial financial losses.

• This issue can be addressed by reinforcing metal matrix composites with silicon carbide particles, which can enhance the base material's wear resistance, damping properties, and mechanical strength.

Figure No. 3.1 Bearing Failure in boiler feed pump

3.1 Objectives

The primary objectives of this project are as follows:

To perform wear tests on B83 Babbit and B83 Babbit-SiC composite materials with varying compositions, loads, and sliding speeds.

To investigate the tribological properties of Babbitt and its composite materials with different compositions, aiming to identify the most suitable composite material for use in boiler feed pump bearings based on wear characteristics.

Composition of composite material

Table No. 3.1 Babbit Composite Materials Composition

Sr. No	Materials	% of Silicon Carbide
1	Material- 1	0
2	Material- 2	2
3	Material-3	4
4	Material-4	6

For sample preparation the following chemical composition is taken.

a) Sample 1 – Babbit metal + 2% SiC Powder

b) Sample 2 – Babbit metal + 4% SiC Powder

c) Sample 3 – Babbit metal + 6% SiC Powder

Metal powder and silicon carbide powder are accurately measured using an electronic weighing machine. To serve as a metallic binder, phenolic formaldehyde resin powder is employed. Tin, antimony, copper, and SiC powder are then combined in a planetary ball mill and mixed for a standard duration of 30 minutes to achieve uniform blending of the powders. The resulting mixture is compacted using a compression strength testing machine with a load of 450 KN.

3.2. Wear Test

The fabricated samples were utilized for conducting tribological tests to measure wear and friction. The pin-on-disc apparatus was employed to evaluate the tribological properties of the composite materials. This apparatus allows for the determination of important properties such as the friction coefficient and wear rate.

3.2.1 Pin on Disc Apparatus (TR20PHM400)

Figure No. 3.2 - Pin on Disc Apparatus

3.2.2 Experimental Procedure

Prior to conducting the wear test using the pin-on-disc apparatus, certain calculations were performed. The sliding velocity (Vs) was determined using the equation $V = \pi * D *$

N / 60. The shaft diameter and speed were obtained from the pump specification data and set as 50 mm and 2900 rpm, respectively.

Table No. 3.2 - Operating parameters

Sliding velocity(mm/sec)	7592.18
Normal Loads(N)	49.05 to 88.29
Test Duration (Sec)	900
RPM	1035-1812
Track Diameter(mm)	80-140

3.3 Observation Table

Table No. 3.3 Observation table of wear test

Sr. No	Material	% of SiC	Normal Load(N)	RPM	Track Dia. (mm)	Sliding distance(m)	Wear (µm)	Temp. (°C)
1	Babbit	0	49.05	1035	140	6828.25	29	32
2		0	68.67	1035	140	6828.25	36	33
3		0	88.29	1035	140	6828.25	39	33
4	Babbit+2% SiC	2	49.05	1115	130	6830.60	8	26
5		2	68.67	1115	130	6830.60	13	27
6		2	88.29	1115	130	6830.60	14	29
7	Babbit+4% SiC	4	49.05	1318	110	6832.02	16	30
8		4	68.67	1318	110	6832.02	18	32
9		4	88.29	1318	110	6832.02	22	32
10	Babbit+6% SiC	6	49.05	1611	90	6832.49	22	31
11		6	68.67	1611	90	6832.49	24	31
12		6	88.29	1611	90	6832.49	28	33

4. RESULTS & DISCUSSIONS

4.1 Wear Test Results

4.1.1 Wear vs. Time

The obtained wear test data was analyzed by comparing the graphs while considering the influencing parameters, including the normal load, percentage of silicon carbide in babbit, and sliding speed for all four material compositions.

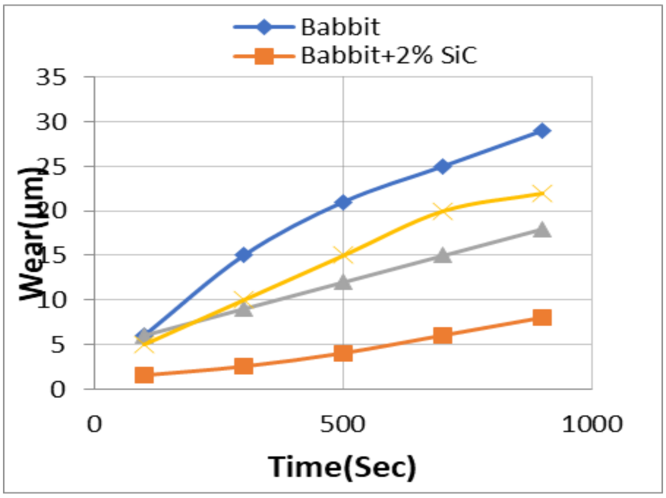

Figure No. 4.1 Wear vs. Time at 49.05N Load

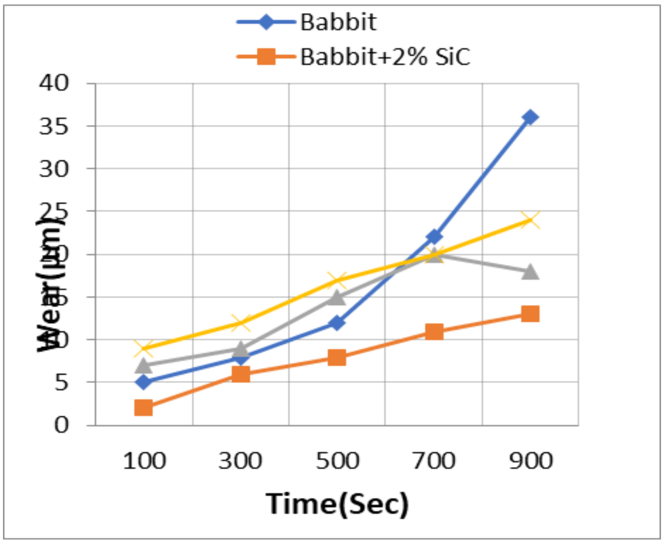

Figure No. 4.2 Wear vs. Time at 68.67N Load

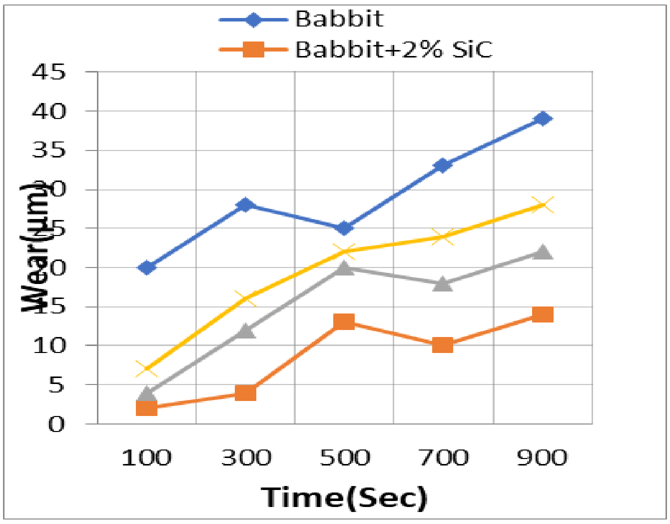

Figure No. 4.3 Wear vs. Time at 88.29N Load

The babbit material exhibited the highest wear under all loading conditions. Among the different compositions, the addition of 4% silicon carbide (SiC) in babbit showed the least wear for all loading conditions, with a minimum wear of 8 micrometers observed at a normal load of 49.05 N. Babbit with 4% SiC had higher wear compared to Babbit with 2% SiC, but lower wear compared to Babbit with 6% SiC and pure Babbit for all normal loads. The wear generally increased linearly with time, except at a load of 88.29 N, where the wear plot showed a peak and subsequent drop in wear. From the wear vs. time plot, it can be observed that the material composition of Babbit with 2% SiC exhibited the least wear compared to all other compositions. The wear rate increased with an increase in the percentage of silicon carbide in the material composition.

4.1.2 Pin Temperature vs. Time

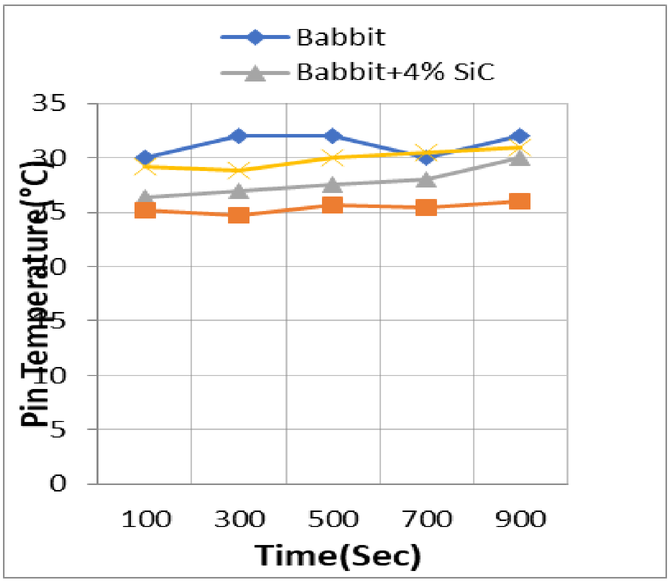

Figure No. 4.4 Pin Temperature vs. Time at 49.05 Load

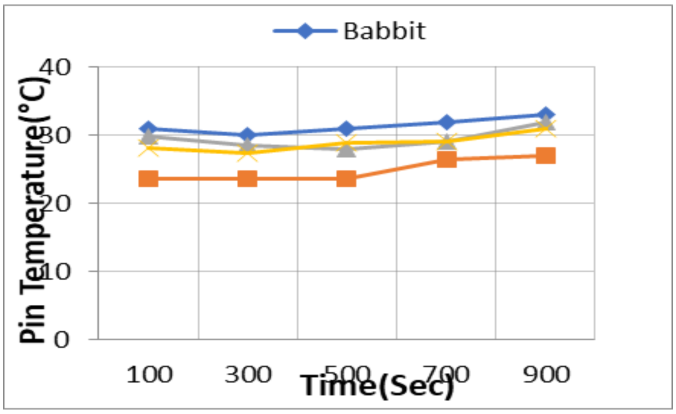

Figure No. 4.5 Pin Temperature vs. Time at 68.67 Load

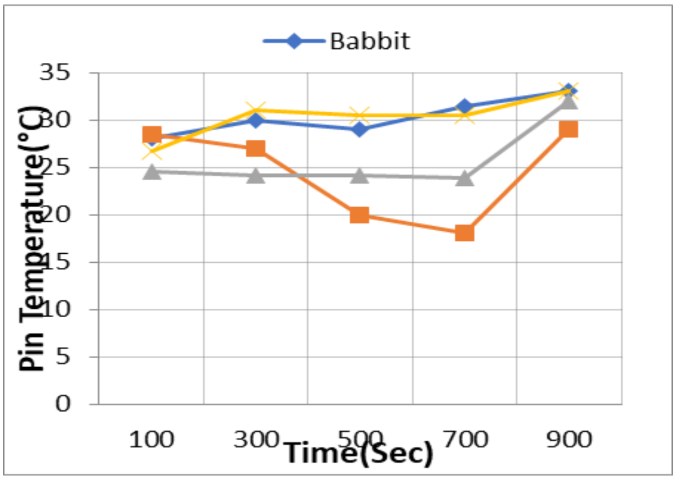

Figure No. 4.6 Pin Temperature vs. Time at 88.29 Load

The temperature of the pin was plotted against time for all normal load conditions. Figures 4.5 to 4.6 display these graphs at different loads. It was observed that as the wear rate increased, the temperature also increased. Babbit exhibited the highest temperature due to the highest wear observed in this material. On the other hand, the pin temperature was minimum in Babbit with 2% SiC compared to all other materials. The lowest pin temperature was observed in Babbit with 2% SiC at a load of 49.05 N.

4.1.3 Wear vs. Normal Load

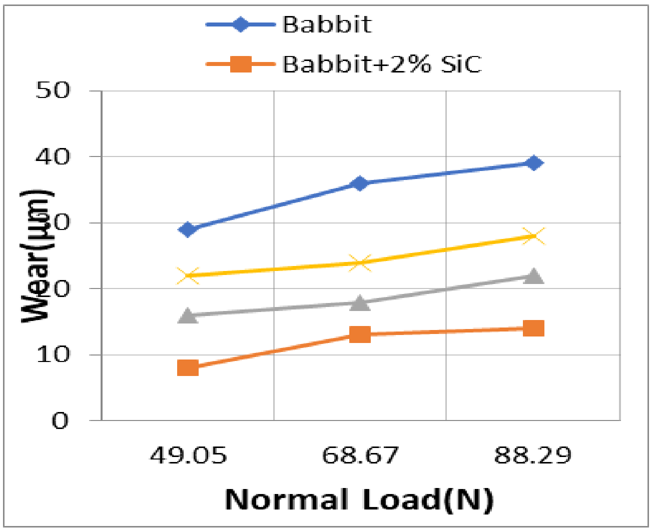

Figure No. 4.7 Wear vs. Normal Load

The wear versus normal load plot is presented in Figure 5.9. It is evident that the wear increases with an increase in the normal load. Babbit material exhibits the highest wear at all normal loads. Conversely, the minimum wear is observed in the Babbit+2% SiC composite material.

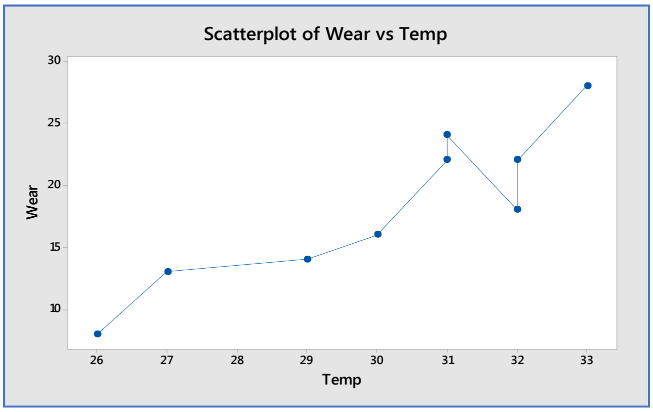

Figure No. 4.8 Wear vs. Pin Temperature

The plot depicting the relationship between wear and pin temperature is presented in Figure 5.10. It can be observed that as the wear of the material increases, the pin temperature also increases. The lowest temperature recorded is 26 °C, while the highest temperature observed is 33 °C.

5. CONCLUSIONS

The wear test was conducted on Babbitt and its composite materials at various normal loads and sliding speeds. It was observed that wear increases with an increase in normal loads and pin temperature.

• Based on the wear test results, it can be concluded that the Babbitt+2% silicon carbide composite material exhibits the lowest wear compared to the existing Babbitt, Babbitt+4% SiC, and Babbitt+6% SiC composite materials.

• The statistical analysis indicates that the percentage of silicon carbide in the composite material is the most influential factor affecting wear.

• The response optimization for wear revealed that the optimum level for minimum wear is achieved with 2% silicon carbide composites, a normal load of 49.05, and a rotational speed of 1115 RPM.

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