INVESTIGATION ON TRIBOLOGICAL PROPERTIES OF HEAT TREATABLE ALUMINIUM- BASED ALLOYS

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ABSTRACT

BACKGROUND

In this section, an investigation on tribological properties of Al-Sn-Cu-Si alloy were investigated under dry sliding condition. The aluminium alloy containing different composition was prepared using gravity die casting and their friction and wear properties was investigated at against EN65 steel at different hours (8, 16 and 24) for the ageing temperature of 170°C. Once alloy was prepared and tested under the same conditions to analyse the effect of addition of Sn-Si on the friction and wear behaviours. Before that, the microstructure of the alloy was investigated using optical microscopy and the hardness of this alloy was investigated using Rockwell Hardness testing machine. The hardness of the alloys increased with increasing silicon content, an alloy Al-Sn-Cu-Si, which exhibited the highest hardness was subjected to ageing heat treatment. The friction coefficients and wear rates were found to decrease with increasing temperature and amount of Sn and Si. Three distinct alloys were prepared by using electrical furnace and the samples of the Al-Sn-Cu-Si alloy was investigated in both as cast and heat-treated conditions were found to be superior to pure aluminium as far as their tribological properties are concerned and also the three distinct alloy results were compared.

KEYWORDS

Aluminium Alloy, Pin-on-Disk, Heat Treatment, Ageing.

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BACKGROUND

Aluminium alloys are considered for a variety of aerospace and structural applications due to their desirable specific mechanical properties. This type of alloy development is underway to optimise combinations of strength, toughness, hardness and wear resistance. A number of Al-based quaternary alloys Al-Cu-Zn-3.2Si have been developed as a result of extensive research.[1] These alloys in general were found to be superior to the pure aluminium their wear resistance is concerned. Amongst them, the highest strength and wear resistance were obtained from the aluminium alloys.[1,2,3] The hardness and both tensile and compressive strengths of the Al-25Zn-3Cu-based alloys increased with increasing silicon content, but the trend reversed for the ones with more than 3% Si.[1] The highest Brinell hardness values are obtained in the heat treatment at 515ºC for 6 hours, followed by ageing at 170ºC for 12 hours.[4,5,6] The values reach a maximum of 139 HBW (the hardness of the as-cast material is 90 HBW).[3] These hardness values could be increased by optimising the ageing times.[3] Therefore, the aim of this study was to investigate the dry sliding wear behaviour of heat treated Al-Sn-3Cu-(3.2-7) Si alloys in a systematic manner after determining their microstructural[7,8,9] and mechanical properties[10,11] and compare the results with pure aluminium under the same test conditions.

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Experimental Setup

Chemical Composition and Specimen Preparation

Three quaternary Al-Sn-Cu-(3.2-7) Si were prepared from commercially pure aluminium (99.7%), high purity Sn (99.9%), electrolytic copper (99.99%) and silicon. Alloys were melted in an electric furnace and poured at a temperature of 680°C into a steel mould at room temperature. The chemical compositions of the alloys were determined by atomic absorption analysis. Samples for structural examinations were prepared using standard metallographic techniques.

Chemical Composition				
Materials	Sn	Cu	Si	Al
Specimen I	4.5	1.1	3.5	Remaining
Specimen II	4.5	1.1	5	Remaining
Specimen III	4.5	1.1	7	Remaining

Table 1. Chemical Composition

Hardness Test

The average Rockwell hardness of pure aluminium components was 35 RHN. This value is smaller than the Rockwell hardness obtained by gravity die casting. The Rockwell hardness result was calculated for three different composites before and after heat treatment process. The results were tabulated and compared with pure aluminium. The Rockwell hardness number is maximum while comparing with the before heat treated alloys and the after heat treated alloys shown in table 1.

Heat Treatment Process

In order to increase the hardness of the alloys, the heat treatment process has performed. The treatment was performed by ageing at 170°C for 8 hrs., 16 hrs. and 24 hrs., respectively. The specimen has heated up to 170°C and the same temperature maintained for 8 hrs., 16 hrs. and 24 hrs.

for three specimens, respectively.[4,5,6] The heat treatment process furnace has shown in Figure.

Figure 1. Specimens in Heat Treatment Furnace

Figure 2. Heat treatment Furnace Overview

Pin-On-Disc Apparatus

The pin on disc is an apparatus used to determine tribological properties. These properties include frictional coefficient and wear properties include frictional coefficient and wear rate. The specimen is placed on a rotating disc spinning at a variable speed and load. The tangential force and the frictional coefficient are measured and the volume of material removed can be measured. The wear and friction are determined by keeping the pin in contact with the circular disc, which revolves during which the sensors (LVDT, frictional force sensor) senses the values and are recorded in the computer by using Winducom software.

A dispersion process casting setup has been fabricated for manufacturing the Al-Sn-alloy. It consists of three basic arrangements as shown in Figure. The melting arrangement has been used for melting and holding the liquid metal at a desired temperature (850ºC). The required quantity (3 kg) of aluminium has been placed in the graphite crucible and kept inside the furnace. The alloy is heated in the electrical resistance furnace and the temperature is set at 850ºC using the temperature controller. The melting of aluminium takes place at 660ºC. After melting the pure aluminium, tin, silicon, copper and iron are added to the molten aluminium. The temperature of the mixture is increased up to 850ºC and it is maintained for 3 hours. Then, the Al alloy molten alloy is poured into the die to obtain the required shape (circular rod 10 mm dia. and 30 mm length). Then, the specimen is machined in centre lathe to obtain the exact dimensions that are required. The schematic representation of the dispersion casting setup is shown in Figure.

Figure 3. Over All View of the Pin-On-Disc Machine

Figure 4. Pin and Disc Arrangement

RESULT AND DISCUSSION

Microstructure

Figure 5. Al-Si3.2%

Figure 6. Al-Si5%

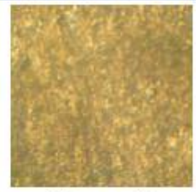

Figure 7. Al-Si7%

Hardness Test Result

Heat Treatment			
Al - 3.2% Si			
B.H.T	A.H.T		
	At 170° 8H	At 170° 16H	At 170° 8H
35	40	36	36
Al - 5% Si			
B.H.T	A.H.T		
	At 170° 8H	At 170° 16H	At 170° 8H
36	42	44	50
Al - 5% Si			
B.H.T	A.H.T		
	At 170° 8H	At 170° 16H	At 170° 8H
36	42	44	50

Table 2. Hardness Vs. Alloys in Various Compositions

Friction and Wear Test Results

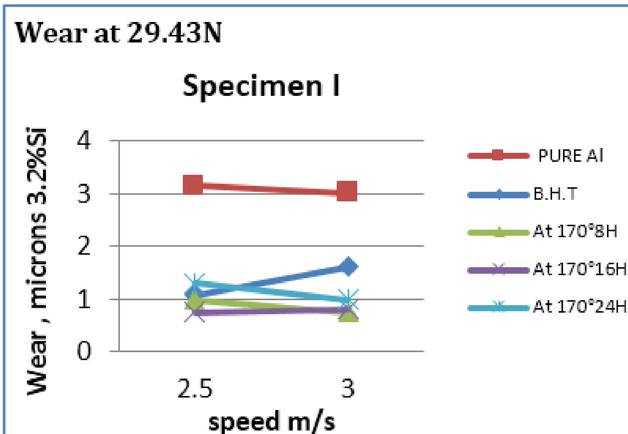

Figure 8. wear Vs Speed

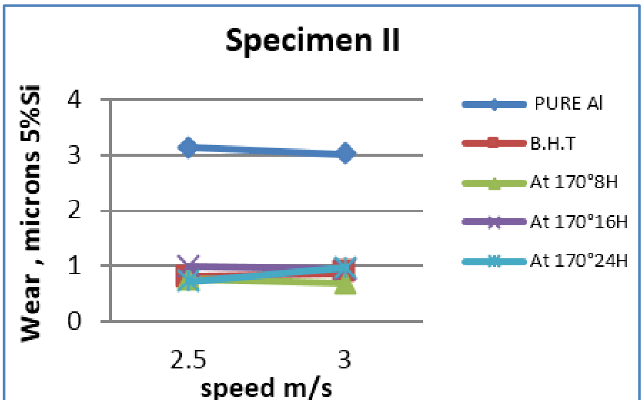

Figure 9. Wear Vs Speed

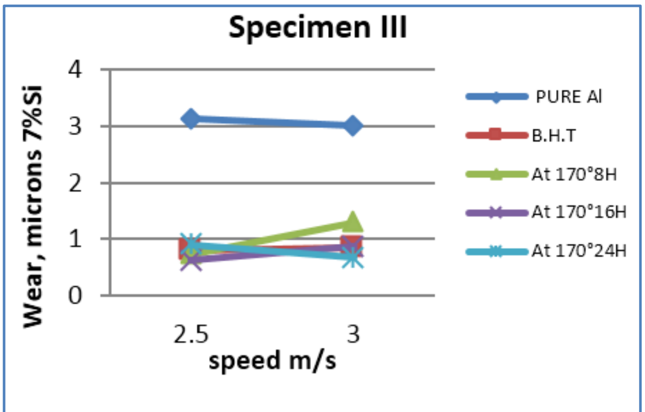

Figure 10. wear Vs Speed

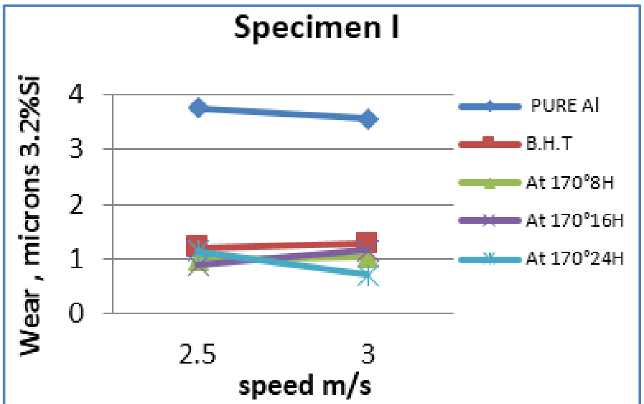

Figure 11

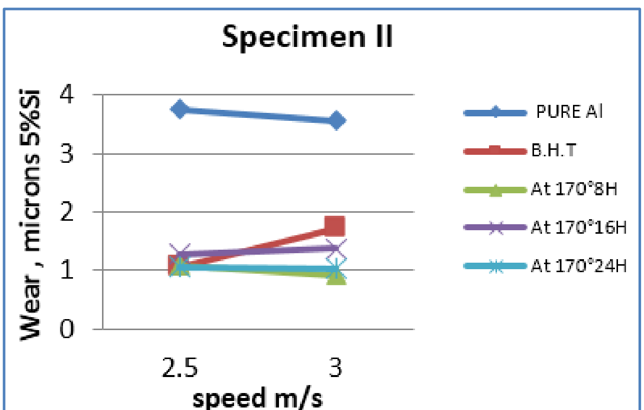

Figure 12. Wear Vs Speed

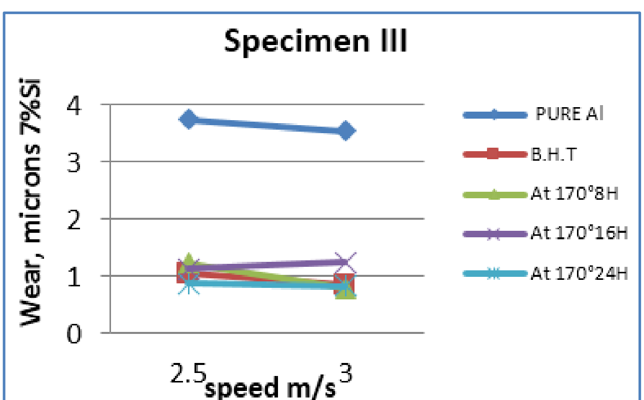

Figure 13. Wear Vs Speed

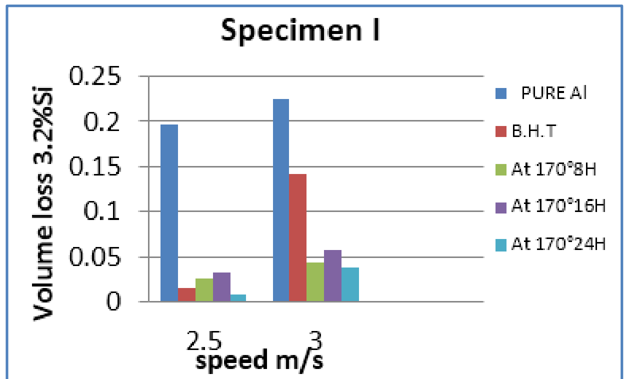

Figure 14. Volume loss Vs Speed

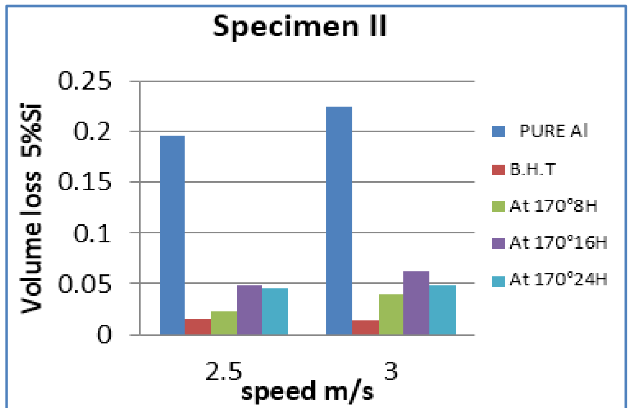

Figure 15. Volume loss Vs Speed

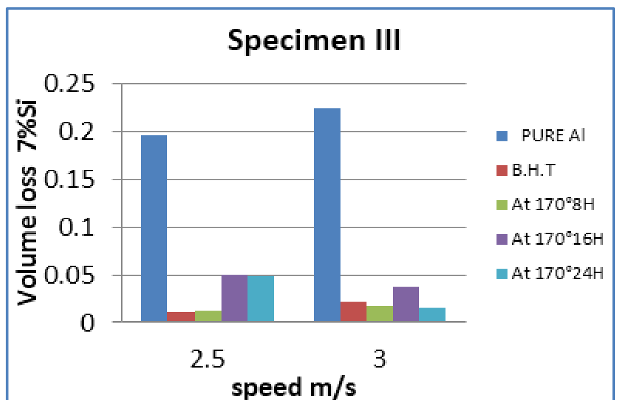

Figure 16. Volume loss Vs Speed

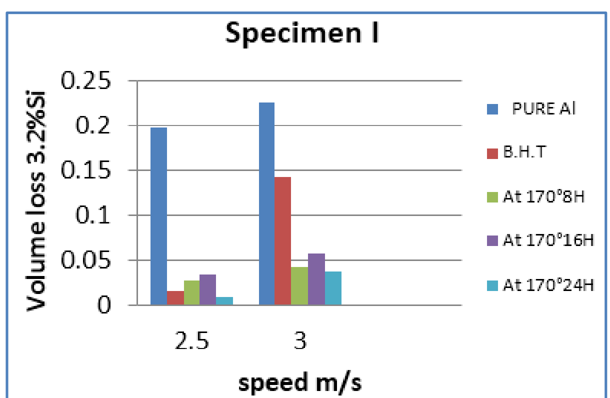

Figure 17. Volume loss Vs Speed

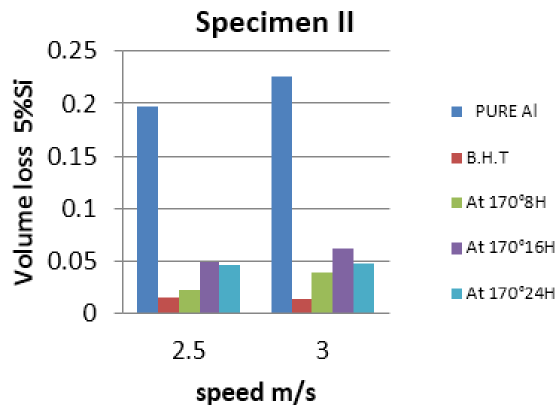

Figure 18. Volume losses Vs Speed

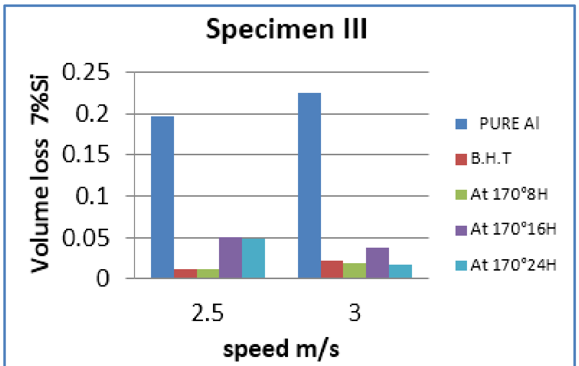

Figure 19. Volume losses Vs Speed

Co Efficient of Friction (At Load 29.43N)

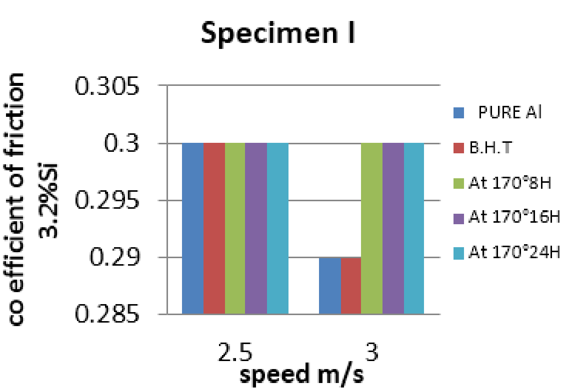

Figure 20. Co Efficient of Friction Vs Speed

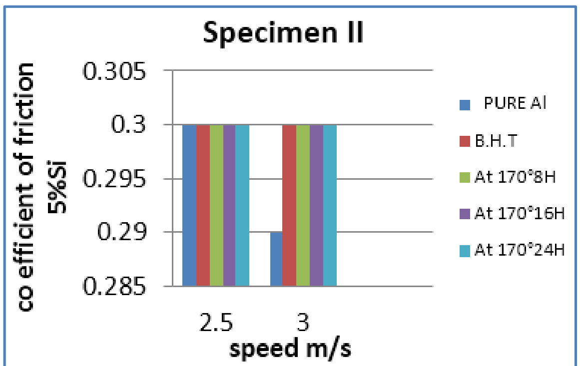

Figure 21. Co Efficient of Friction Vs Speed

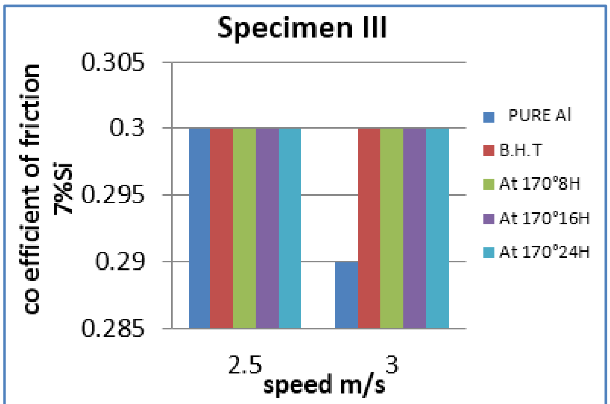

Figure 22. Co Efficient of Friction Vs Speed

Co Efficient of Friction (At Load 49.05N)

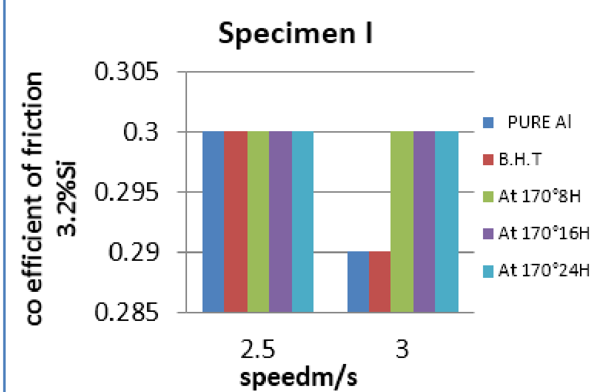

Figure 23. Co Efficient of Friction Vs Speed

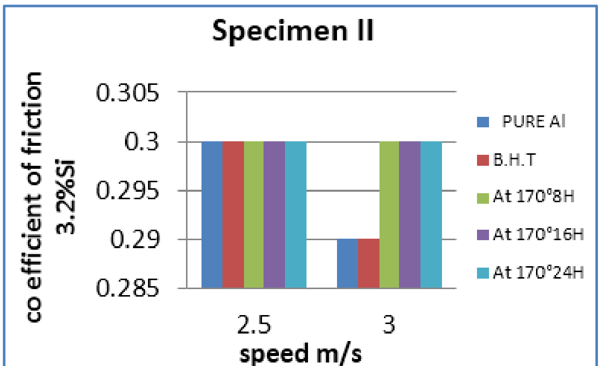

Figure 24. Co Efficient of Friction Vs Speed

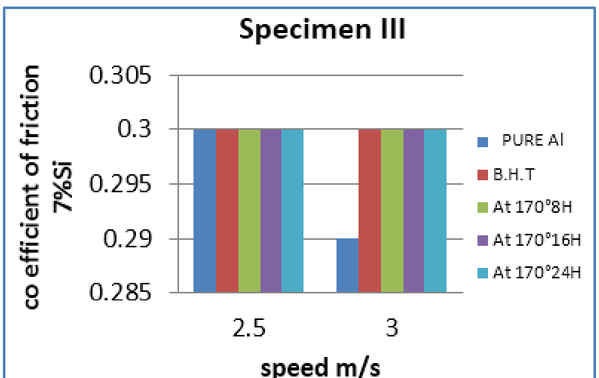

Figure 25. Co Efficient of Friction Vs Speed

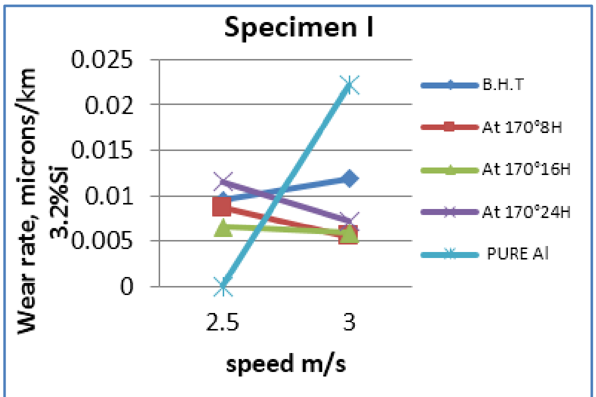

Figure 26. Wear Rate Vs Speed

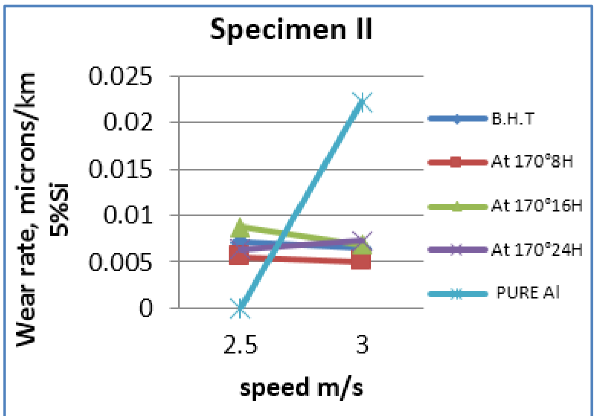

Figure 27. Wear rate Vs Speed

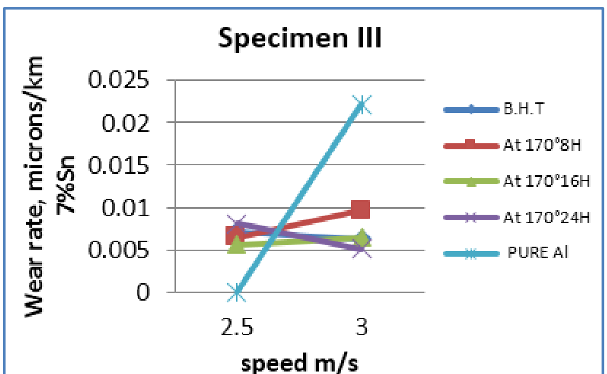

Figure 28. Wear Rate Vs Speed

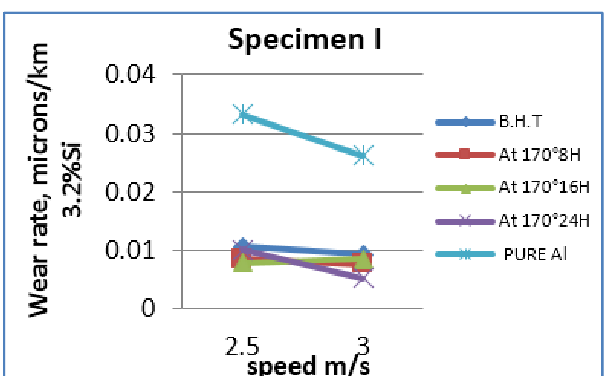

Figure 29. Wear Rate Vs Speed

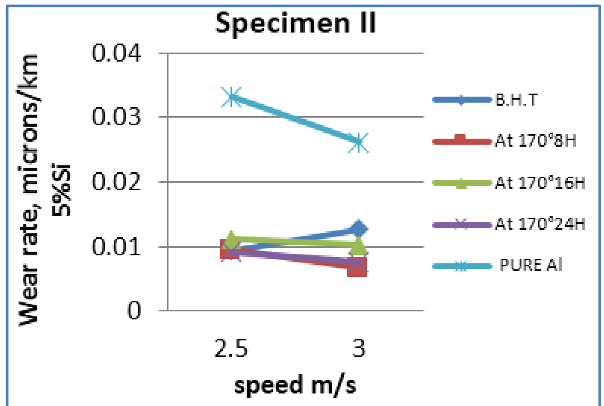

Figure 30. Wear Rate Vs Speed

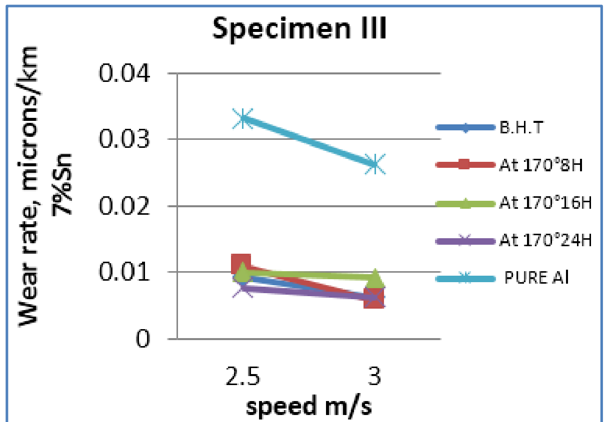

Figure 31. Wear Rate Vs Speed

CONCLUSION

The aluminium-tin based alloy material maybe effectively used in the industry due to better mechanical and tribological properties like good resistance and better surface properties. In this experiment, friction coefficient and wear test for aluminium-tin based bearing materials with two different loads were tested using pin-on-disc apparatus-

1. Hardness values increased with addition of alloying element and because of heat treatment.
2. The wear characteristics of bearing materials are compared in their working range of 200 μm to 400 μm with different normal loads.
3. Friction coefficient of aluminium-based alloy bearings is less than that of pure aluminium bearing.
4. Aluminium-based alloy bearings materials exhibit less wear compared to pure aluminium bearing.

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