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Wear Behavior of As – Cast and Heat Treated Al 7075- SiC Composites

Dr.P. Shanmughasundaram
Professor and Head, Department of Automobile Engineering
Karpagam Academy of Higher Education, Coimbatore-641021, India.

Abstract- In the present investigation, AA 7075 – SiC composites were fabricated using the stir casting method. The wear loss of the composite in the as-cast and heat treated conditions was studied by using pin on disc test by varying load and sliding velocity. It was observed that the precipitated heat treated (T6 aged for 6 hrs) AA 7075 –SiC composites showed higher wear resistance than the precipitated heat treated (T6 aged for 2 hrs) and as –cast composite specimens irrespective of applied load and velocity conditions. Wear loss tends to increase with load and sliding velocity.
Keywords: stir casting, composite, heat treatment, wear, load, sliding velocity

I. INTRODUCTION

Metal–Matrix Composites which have high strength-to-weight ratio compared to many other alloys, are widely used in various tribological applications particularly in aerospace and automotive components [1]. Rao et al [2] studied the effect of heat treatment on the sliding wear behaviour of aluminium alloy hard particle composite under varying applied load and sliding speed. They reported that the hardness is improved due to heat treatment. Maximum hardness is noted when the materials are aged for 6 h. Md Abdul Maleque and Md Rezaul Karim [3] investigated the wear behavior of as-cast (AC) and heat treated (HT) silicon carbide reinforced aluminum alloy-based metal matrix composites. The results showed that HT composite exhibited better wear resistance properties compared to AC composite. Heat treatment could be an effective method of optimizing the wear resistance properties of the developed Al-MMC material. Myriounis et al [4] investigated the heat treatment and interface effects on the mechanical behavior of SiC-particle reinforced aluminium matrix composites. They observed that the T6 heat-treated composite with 20 % volume fraction of SiC particles had higher strength compared to the 31 % SiC composite. This is expected since the strength of the composite in the T6 condition comes from the formation of the Mg_2Si precipitates. Erdem Karakulak et al [5] investigated the effect of heat treatment conditions on microstructure and wear behaviour of Al4Cu2Ni2Mg alloy. They reported that with increasing the aging duration the wear loss decreases and solution treatment for 8 h ageing is chosen as optimal heat treatment conditions for Al4Cu2Ni2Mg alloy. Bekheet et al [6] studied the effects of aging on the hardness and fatigue behavior of 2024 Al alloy/SiC composites. They concluded that improvement in the mechanical properties of Al alloys can be achieved by suitable solution treatment and aging operations. When a particular reinforcement is introduced into a heat-treatable aluminum alloy matrix, similar aging characteristics might be expected for both composite and unreinforced material. Dipti Kanta Das et al [7] reviewed the fabrication and heat treatment of ceramic reinforced aluminium matrix composites. Song et al [8] examined the abrasive wear resistance of aluminium-based composites when heat-treated to different ageing conditions. Caton et al [9] analyzed the influence of heat treatment and solidification time on the behavior of small-fatigue-cracks in a cast aluminum alloy. Ridvan Yamanoglu et al [10] observed that the reinforced material exhibits an enhanced ageing response compared to the unreinforced material in the same heat treatment conditions. The best combinations for the enhanced tribological properties for the composite material were selected as 6 h ageing at 225°C. Fatemeh Piyadeha et al [11] investigated the effect of heat treatment on the microstructure, hardness and compression properties of AA2124/MoSi2/25p composites .The results showed that the hardness of the specimens in solution and aged condition was higher than in the as-extruded condition. Shanmughasundaram [12] studied the influence of the heat treatment, load and sliding velocity on the wear loss of the Al alloy 7075 using a pin-on-disc wear testing rig. The results showed that T6 Al - alloy aged for 6 hrs exhibited better wear resistance compared to as - cast alloy and T6 alloy aged for 2 hrs. The results reveal that the normal load is the most influencing the wear resistance followed by the heat treatment and sliding velocity. Mahadevan et al [13] analyzed the effect of heat-treatment parameters on the hardness of AA6061-SiC_p composite based on the design of experiments (DOE) technique.

In the present investigation, AA7075–SiC composites were successfully synthesized using stir casting method. Dry sliding wear

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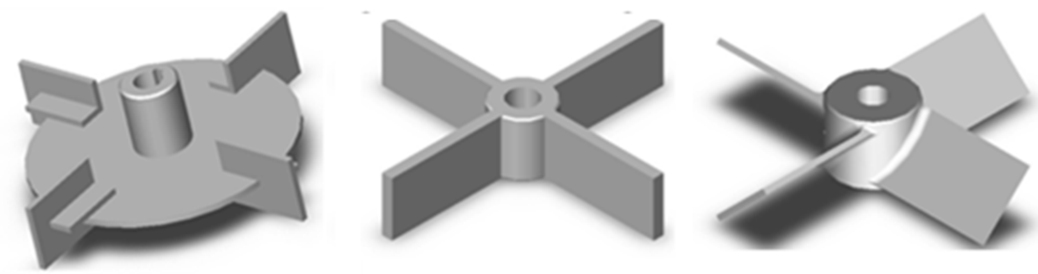
behavior of the as –cast and het treated composites was investigated by varying load and sliding velocity using pin on disc wear test rig.

II. METHODOLOGY

A. Fabrication Of Composites

AA 7075 was charged in to the graphite crucible and the melt temperature was raised to liquidus temperature of aluminium alloy. Preheated SiC (10wt. %) particles were added into the molten aluminium gradually and stirring was carried out at 300 rpm for 3 minutes. Then the melt temperature was dropped till the slurry attains the semi solid state. Stirring was done for 3 minutes in semi solid state in order to enhance the uniform distribution of the SiC particles throughout the melt.

Figure 1 Impeller models
(Courtesy: http://www.postmixing.com , Mr. Pete Csiszar and Ref.15)



Previous investigation [14] showed 4 bladed radial flow impeller with 0.7 I_{OD}/C_{ID} ratio as the optimum model in obtaining the maximum mechanical properties of composite. In the previous study, three types of 4 bladed impeller typical models [15] which are shown in Fig. 1 were designed (height and thickness of the blades are 6 cm and 1cm respectively) and fabricated with 0.7 I_{OD}/C_{ID} ratio (Impeller outer dia to Crucible inner dia) using stainless steel. It was found that the 4 bladed radial flow impeller as the optimum model in obtaining the maximum mechanical properties of composite. The radial flow contacts the side and moves in either an upward or downward direction to fill up the top and bottom of the impeller[14-15]. Hence in this study 4 bladed radial flow impeller with 0.7 I_{OD}/C_{ID} ratio was used to fabricate the composites. Finally, the melt temperature was again raised to liquidus temperature and composite slurry was poured in to the mould for solidification. The hexachloroethane tablets were used for degassing. Argon gas was blown to avoid oxidation.

B. Heat Treatment Of Composites

T6 (precipitation heat treatment) was done on AA7075 – SiC composites for two different aging durations, 2 hrs and 6 hrs. In the first stage (solution treatment), AA7075 – SiC composites was heated above the solvus temperature 470ºC and soaking the composites at this temperature for 1 hour in the furnace followed by cooling the composites by quenching in water. In the second stage (age hardening), solution treated AA7075 – SiC composites by heating to 120°C and holding them at this temperature for two different aging durations (2 hour and 6 hours) then followed by air cooling to room temperature [12] .

C. Dry Sliding Wear Test

A pin- on- disc test rig was employed to investigate the dry sliding wear behaviour of the composites as per ASTM G99 standard. The wear specimens (size of 10 mm diameter and height of 25 mm) were cut, machined and then polished with emery sheet. The wear tests were conducted for two different loads (20 and 40 N) and two different sliding velocities (1m/s and 2 m/s) for 10 minutes. Tests were conducted at a room temperature of 27°C and 65% relative humidity. The specimen is placed against the **counter** rotating **disc** which is made up of En-32 **steel** with hardness 65HRC.Linear variable differential transformer is employed to measure the wear in terms of microns during the test.

III. RESULTS AND DISCUSSION

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It can be observed from the Fig.2 that the precipitated heat treated (T6 aged for 6 hrs) AA 7075 –SiC composites showed higher wear resistance than the precipitated heat treated (T6 aged for 2 hrs) and as –cast composite specimens at 20 N and sliding velocity of 1 m/s.

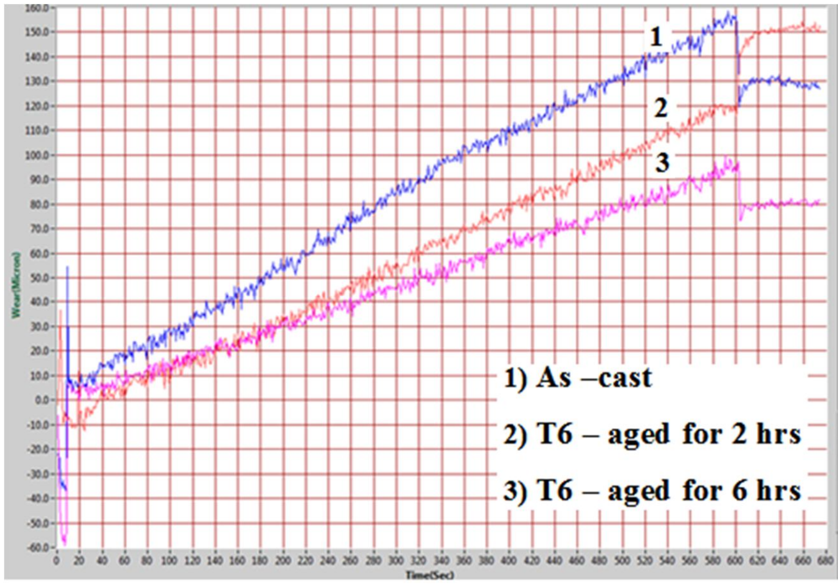

Figure. 2. Typical superimposed curves of wear of as – cast AA 7075 –SiC composite, AA 7075 –SiC composite T6 – aged for 2 hrs and 6 hrs at 20 N and sliding velocity of 1 m/s.

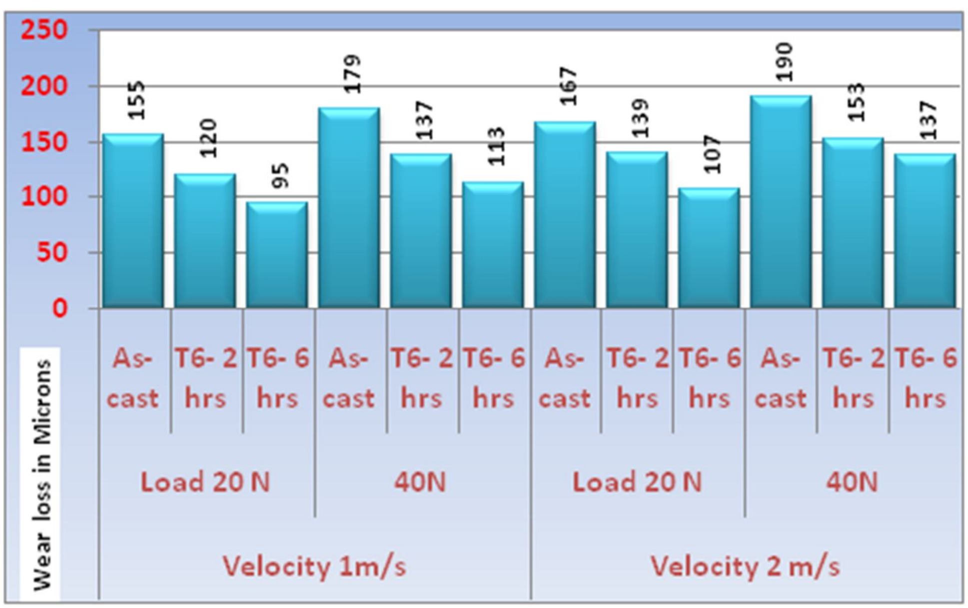

Figure 3 Effect of heat treatment, load and sliding velocity on wear of AA 7075 –SiC composite.

The effect of heat treatment, normal load and sliding velocity on the wear resistance of the as- cast and heat treated AA 7075- SiC composites is shown in Fig 3. It can be observed that when the normal load was increased from 20 N to 40 N at a sliding velocity of 2 m/s, wear of T6 (aged for 6 hrs) composites increased from 107 µm to 137 µm. Wear increased by 28 % when the load was increased from 20N to 40N. Figure 3 shows that the wear of composites increases with increase in sliding velocity. It can also be noted that the wear of T6 composite (aged for 6 hrs) increased considerably (21%) when increasing the sliding velocity from 1m/s to 2 m/s at a constant load of 40N. Moreover, the wear resistance of the heat treated composites increases with aging duration irrespective of load and sliding velocity conditions. This may due to the fact that the formation of more intermetallic precipitates during the heat treatment process. AA 7075 has major alloying elements such as zinc and magnesium which enhances the formation of intermetallic compounds during heat treatment.

IV. CONCLUSIONS

AA 7075-SiC composites were successfully fabricated using stir casting method. It was observed that the precipitated heat treated (T6 aged for 6 hrs) AA 7075 –SiC composites showed higher wear resistance than the precipitated heat treated (T6 aged for 2 hrs) and as-cast composite specimens. Moreover, the wear resistance of the heat treated composites increases with aging duration. Wear resistance of composites decreases with increase in load and sliding velocity.

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