Effect of Al_2O_3 Reinforcement to the AA5052 Matrix Using Stir Casting Route

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Abstract:- The hardness property and the wear behavior of AA5052 aluminum alloy with the reinforcement Al_2O_3 particles added in various proportions as 5wt% and 10wt% to fabricate the composite by employing the stir-casting process. The wear resistance property of the fabricated composite was studied under an optical microscope and the hardness property was measured by the Vickers hardness tester. The wear property and the hardness property tend to be optimized with the increase in the Al_2O_3 reinforcement percentage.

Keywords:- *AA5052, Wear behavior, Vickers hardness, Composite.*

I. INTRODUCTION

Aluminum itself is weak and soft having few applications. When a small amount of alloying elements added to it then it becomes hard and strong by retaining its lightweight in its alloyed state. Due to its extensive property, it is used where lightweight and resistance to corrosion are the main purpose as in aircraft, missiles, and automobile parts lightweight is an advantage [2]. AA5052 aluminum alloy comes under the 5xxx series where magnesium is the major alloying element having high fatigue strength, used at the field having excessive vibration. AA5052 aluminum alloy has applications in boats, marine components, fuel, and oil tubing due to its excellent corrosion resistance [3]. Every element presents in the AA5052 aluminum alloy having their own characteristics makes the alloy favorable for the high-end application. In AA5052 aluminum alloy magnesium retards formability and Zinc helps to improve castability and strength. Iron increases the recrystallization temperature whereas silicon improves fluidity, copper reduces the pitting effect, chromium enhances strength and manganese helps to increase corrosion resistance [4,5].

Element present	Si	Fe	Cu	Mn	Mg	Zn	Cr	Al
Wt%	0.25	0.40	0.1	0.1	2.2-2.8	0.1	0.15-0.35	Rem

Table 1:- Chemical composition of AA5052 alloy according to ASTM [1]

Al-mg alloys are the most suitable alloy for the automobile industries due to their high strength to weight ratio, excellent corrosion resistance, weldability, and formability. The microstructural constituent of AA5052 alloy is the primary α-Al phase and magnesium in the solid solution. Refinement of grains tends to form an equiaxed grain structure, which enhances the mechanical property as well as the quality and efficiency of casting [6, 7]. The presence of magnesium in the aluminum alloy increases the wettability of aluminum melt with the nucleating sites by decreasing the surface tension [8]. The mechanical property of aluminum alloy can be enhanced by adding reinforcement for refinement. Most preferred ceramic reinforcements are TiB_2, SiC, Al_2O_3 to the aluminum-based matrix phase, which ensures the marginal rise in strength to weight ratio, modulus and wear property [9-13]. In this work, an effort has been made to investigate the mechanical property like hardness and wear behavior enhancement of AA5052 alloy by adding Al_2O_3 reinforcement in a proportion of 5wt% and 10wt% by means of stir casting route.

II. EXPERIMENTAL PROCEDURE

A. Synthesis of AA5052 alloy and Al2O3 reinforced composite

The AA5052 alloy was synthesized by deploying the stir casting process. Commercially pure aluminum (99%), magnesium (99.9%) and alumina powder (50-60 micron) were taken as the starting material for casting the alloy and composite. First of all, pure aluminum was taken in a graphite crucible and melted in a pit type melting furnace at around 750ºC-800 ºC. When the aluminum melt is prepared then magnesium turnings are added covered with aluminum foil with continuous stirring by the stirrer-rod. At the same time, the Al_2O_3 were taken and preheated for the moisture removal at 200ºC. When both aluminum melt and the magnesium mixed properly then the stirring speed was set up to slightly more speed than before and the Al_2O_3 particles were added to the vortex, which created due to the continuous stirring of the melt for proper distribution of the reinforcement particles to the matrix. Before casting, the druss were removed from the bath to have sound casting. The desired alloy and composite samples were casted by the help of cast iron mould which was preheated at 450ºC to avoid chilling effect [15].

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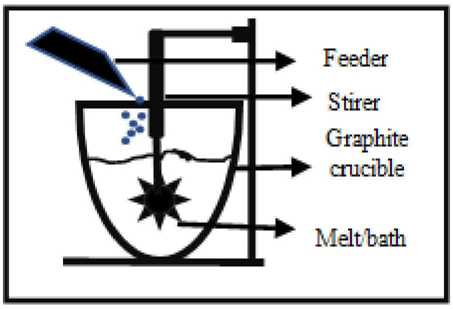

Fig 1:- Schematic diagram of stir casting setup

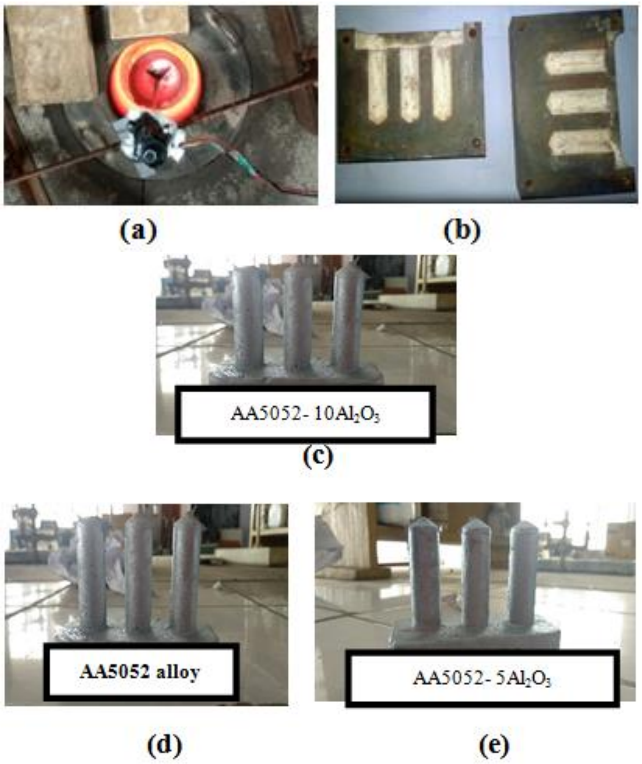

Fig 2:- (a) stir casting setup during experiment (b) cast iron mould (c) AA5052 casted alloy (d) AA5052- $5Al_2O_3$ casted composite (e) AA5052-$10Al_2O_3$ casted composite.

B. Microstructural Studies

The microstructural investigations of AA5052 alloy and AA5052 with Al_2O_3 reinforced composite were conducted by cutting samples from the casted ingot, polishing metallographically and etching with Keller's reagent (1% HF, 1.5% HCl, 2.5% HNO_3 and remaining water). The samples were investigated under CARL ZEISS computerized optical microscope.

C. Hardness

The hardness of the specimen was measured by the Microvicker's hardness tester where a square-based diamond pyramid is used as indenter. 1kg of load is applied for 15seconds. Five reading for each sample were taken and the average value of hardness was taken as the hardness of the sample

D. Study of Waer Property

Dry sliding wear test of AA5052 alloy and the AA5052 alloy reinforced with Al_2O_3 were studied using pin-on-disk wear testing set up. The samples with (10mm dia and 30mm height) were prepared, to use it as the pin on the pin-on-disk set up to study the wear property. The sample was cleaned with acetone and weight taken into noted before and after each test with the help of an electronic weighing balance (accuracy of ±0.01mg).

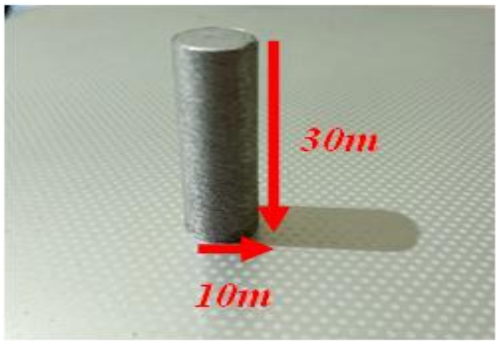

Fig 3:- Specimen (pin) for wear test on pin-on-disk setup

III. RESULTS AND DISCUSSION

A. Microstructural Characterization

The optical micrograph in figure 3.1 (a) shows the micrograph of AA5052 alloy and figure. 3.1 (b) and (c) show the uniform distribution of Al_2O_3 particle all over the microstructure of AA5052 alloy reinforced with Al_2O_3 in 5wt% and 10wt% respectively with the grain refinement.

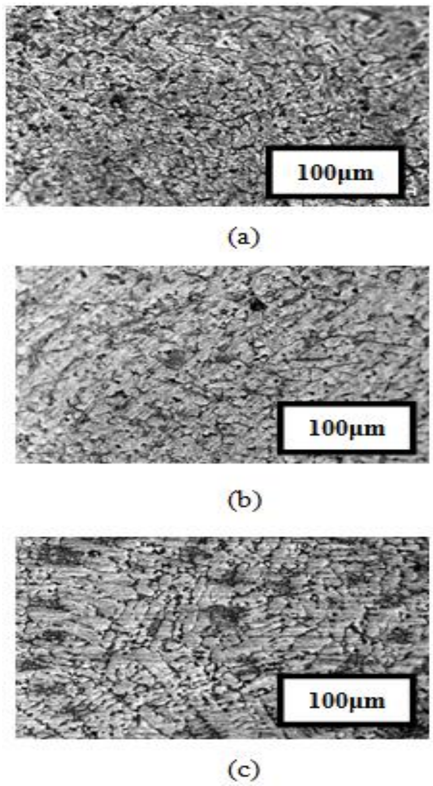

Fig 4:- Micograph of (a) AA5052 alloy (b) AA5052 alloy with 5wt% Al_2O_3 reinforcement (c) AA5052 alloy with 10wt% Al_2O_3 reinforcement.

B. Hardness

The hardness test in AA5052 alloy, AA5052-5%Al_2O_3 composite, AA5052-10%Al_2O_3 composite samples were carried out using a Vicker's micro-hardness tester. The hardness of AA5052 alloy was found to be 109.21VHN, in the case of 5wt% Al_2O_3 reinforced composite the hardness was 116.16VHN and the 10wt% Al_2O_3 reinforced composite had a hardness of 126.10VHN. Thus the presence of harder and stiffer Al_2O_3 particles when reinforced to the alloy matrix leads to an increase in the tendency to resist plastic deformation, which indirectly resists the indentation.

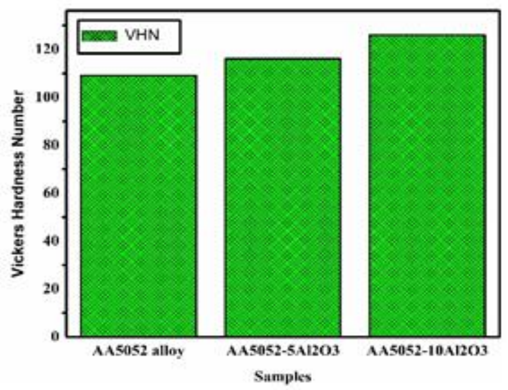

Fig 5:- The graph showing variation of hardness with respect to reinforcement percentage

C. Dry Sliding Wears Property Analysis

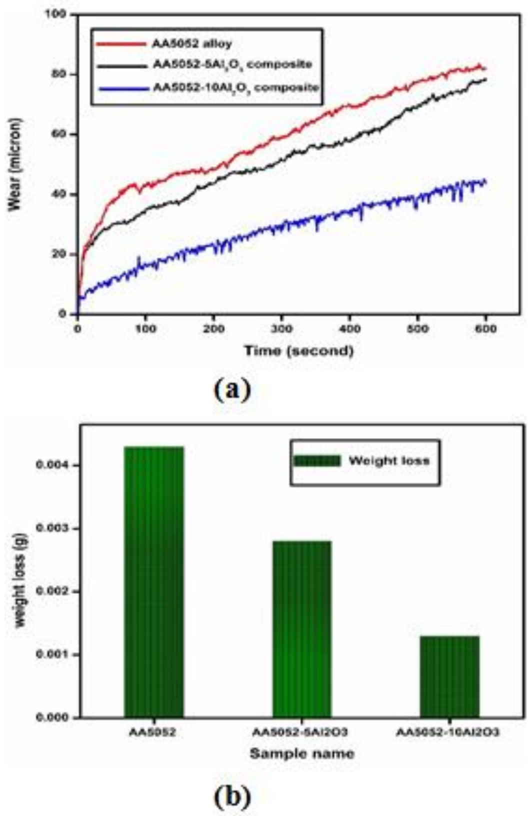

Fig 6:- (a) Wear vs. time curve for a given condition (b) comparison of weight loss cause of wear test

Here the wear behavior of the samples was tested using a pin-on-disk setup. The samples are subjected to 477rpm at 20N load for 10 minutes (600 seconds) and the graph was plotted against wear vs. time in figure 3.3 (a). The weight loss during the wear test was calculated and reported in figure 3.3(b). It can be observed that the weight loss was decreased with the increase in the percentage of Al_2O_3 reinforcement. The hard Al_2O_3 ceramic particles minimize the wear rate and loss of the material. In the case of AA5052 alloy direct material comes to the contact of the wear surface while in case of AA5052-5Al_2O_3 and AA5052-10Al_2O_3 composites the reinforcement particles come in contact to the wear surface causing minimization in the wear rate, as the reinforcement particles are itself hard and difficult to wear [16].

IV. CONCLUSION

- The AA5052 alloy, AA5052-5Al2O3, and AA5052-10Al2O3 composites are successfully cast by deploying the stir casting process.
- The microstructure analysis shows the uniform distribution of reinforcement Al2O3 particles.
- The hardness increases with the increase in the amount of Al2O3 particle reinforcement.
- The wear rate and loss of weight decreased with the increase in the Al2O3 particle reinforcement percentage.

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