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Experimental Investigations on Material Characteristics of Al 6061- TiB2 MMC Processed by Stir Casting Route

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Abstract: Aluminium based metal matrix composites (MMCS) are advanced materials having the properties of high specific strength and modulus, greater resistance, high elevated temperature and low thermal expansion co efficient. These composites are widely used industries like aerospace, defence, automobile, biomaterials as well as sports etc. In present work aluminium alloy reinforced with TiB_2 MMCs materials are prepared by using stir casting technique have cost advantages over the composites made by other. Four different volume fractions (2%, 4%, 6% and 8%) of particulate TiB_2 are used in production of aluminium matrix composite at 750°C. An X-ray diffractometer is used to confirm the presence of TiB_2 as well as to estimate quantitatively the weight percentage of TiB_2 particles in the composite for the various reaction holding times. Microstructures of the composites are studied by Scanning Electron Microscopy (SEM). The wear and frictional properties of the metal matrix composites was studied by performing dry sliding wear test using a pin-on-disc wear tester. The addition of TiB_2 particles results in increased mechanical properties, such as tensile and hardness.

Key words: Metal matrix composites · Aluminium · TiB_2 and Stir casting

INTRODUCTION

The demands made on materials for better overall performance are so great and diverse that no one material can satisfy them. That naturally lead to a resurgence of the ancient concept of combining different materials in an integral composite material system that results in a performance unattainable by the individual constituent and offers the great advantage of a flexible design. It implies that, if it is given the most efficient design of an aerospace structure, an automobile, a boat, or a submarine, we can make a composite material that meets the need.

Metal matrix composite (MMCs) offer several advantages over other matrix composites. The principle advantage is that MMCs can be used as much higher temperature. The yield strength and modulus are higher for metals, which account for the higher transverse strength and modulus of metal matrix composites. Therefore, the metal matrix can be strengthened by various thermal and mechanical treatments [1]. Among modern composite materials, particle reinforced metal matrix composites (MMCs) are finding increased application due to their very favorable properties, including high mechanical Properties and good wear resistance [2-5].

Aluminium based metal matrix composites (MMC's) reinforced with ceramic particles have been the subject of numerous research workers. Owing to the low density, low melting point, high specific strength and thermal conductivity of aluminium alloys, a wide variety of ceramics such as SiC, Al_2O_3, TiC and graphite have been reinforced into it. Among these particles, TiB_2 has emerged as an outstanding reinforcement. This is due to the fact that TiB2 is stiff hard and more importantly it does not react with aluminium to form any reaction product at the interface between the reinforcement and the matrix [3]. Among liquid state methods, melt-stirring (vortex casting) technique is a common processing method, because of inexpensiveness and offering a wide range of materials and fabricating conditions [4].

TiB_2 is known as a suitable reinforcing phase for Al base composites because of its thermodynamic stability. It also presents a high modulus, excellent refractory properties and a high resistance to plastic deformation even at high temperature [5-7].

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Table 1: Percentage of TiB2 with Al6061

Sl.No	Weight % of TiB2	Al-6061 in grams	TiB2 in grams
1	2%	375.75	07.50
2	4%	376.43	15.05
3	6%	391.00	23.46
4	8%	402.40	32.19

Due to the unique combination properties of Al-TiB_2 composites such as low density and thermal expansion, high modulus, strength and wear resistance, good ductility and thermal conductivity; they have been used in many important Industries such as aerospace and military industries [8-11].

Metal matrix composites (MMCs) reinforced with ceramic or metallic particles are widely used Table 1 Percentage of TiB_2 with Al6061 application areas. Aluminium matrix composites (AMCs) have been reported to possess higher wear resistance and lower friction coefficient with an increasing volume fraction of reinforcement particles, compared to aluminium alloys without reinforcement. AMCs also combine the low density of the matrix with the high Hardness of the reinforcements [12].

Investigation of the effects of TiB_2 reinforcing particles on microstructure and mechanical properties of Al6061-TiB_2 composites is the subject of the present study.In this study the Al-MMC was formed by using stir casting method.

Experimental Setup and Procedures: The experimental arrangement has been assembled by the coupling gear-box motor and mild steel four blade stirrer used. The melting of the aluminium 1545.58 grams and TiB_2 78.2 grams was carried out in the graphite crucible into the coal-fired furnace. First the bar of aluminium were preheated for 3 to 4 hours at 450°C and TiB_2 powder also heated with 900°C and both the preheated mixtures were then mechanically mixed with each other below their melting points. This metal-matrix Al-TiB_2 was then poured into the graphite crucible and put in to the coal- fired furnace at 760°C temperature.

The furnace temperature was first increases above the composites completely melt the bar of aluminium and then cooled down just below the components temperature and keep it in a semi-solid state. At this stage the preheated TiB_2 were added with manually mixed with each other. It was very difficult to mix by machine or stirrer when metal-matrix composites were in semi molten state with manual mixing taking place. When the manual mixing was completed then automatic stirring carried out for ten minutes with normal 400 rpm of stirring rate. The temperature rate of the coal-fired furnace should be controlled at 760 ± 10°C in final mixing process. After complete the process the slurry had been taken into the sand mould within thirty seconds allowed it to solidify. Tests should be taken of solidified samples like hardness and Tensile tests. This experiment should repeatedly conducted by varying the compositions of the composite powder of TiB_2(2%, 4%, 6% and 8%), weight of aluminium bar in grams plus weight in grams of TiB_2 powder as shown in the following Table 1.

Figure 2.1 shows the manufactured samples of Al-TiB_2. These final samples are now ready for further testing processes of hardness test, tensile test, wear test and SEM with EDAX.

Fig. 2.1: Casted composites.

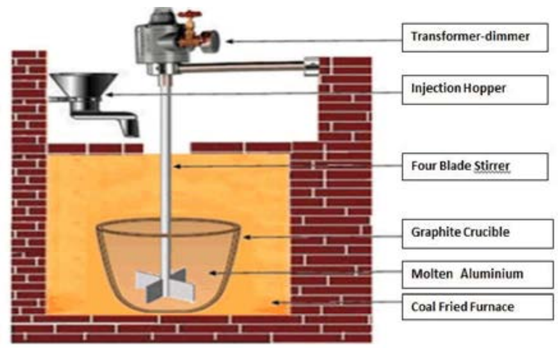

Fig. 2.2: Stir casting set up

Fig. 2.3 TiB_2 powder

Fig. 2.4: Al6061 bar

Fig. 2.5: Sand mould

Fig. 2.6: While pouring Molten

Fig. 2.7: Slag

Fig. 2.8: Graphite Crucible

Figure 2.2 shows the experimental set up of stir casting method. Figure 2.3 and Figure 2.4 Shows the collections of TiB_2 and Al6061. Figure 2.5 Shows the sand mould for making casted composite. Figure 2.6 shows while pouring molten metal into the sand. Figure 2.7 shows the wasted material while making casted composite. Figure 2.8 shows the graphite crucible for melting the Aluminium bar and TiB_2.

RESULTS AND DISCUSSION

Tensile Test: A tensile test also known as tension test is probably the most fundamental type of mechanical test we can perform on material. Tensile tests are simple, relatively inexpensive and fully standardized. By pulling on something, we shall very quickly determine how the material will react to forces being applied in tension. As the material is being pulled, we shall find its strength along with how much it will elongate. Tensile tests were carried out at room temperature using a tensile tester. The Tensile strength, % Elongation were calculated for each casting containing 4 samples and these Tensile strength and Elongation results are in Table 3.1. From table tensile strength was increased from 98.16N/mm^2 to 135.01N/mm^2 while 4%wt of TiB2 particle with AA6061 than 2%wt of TiB2 particle with AA6061. On the other hand % Elongation increased. It would be happened some kind of porous problem while manufacturing of Al-TiB2 composites.

Figure 3.1 shows the drawing of tensile specimen. This diagram was used to make tensile specimen from composite material for taking tensile test.Required dimensions are indicated in Figure 3.1. Figure 3.2 shows the tensile specimen. Figure 3.4 shows before tensile test. Figure 3.5 shows after tensile test.

SEM Observations: For the visual observation of the sample here the SEM with EDAX test is carried out. The various colour in the figure is represents the presence of various metal in the composites for example the red colour dots are the representation for the presence of Titanium particles in the sample.

Table 3.1: Tensile strength and Elongation Results

Sl.No	Compositions	Tensile strength N/mm2	% of Elongations
1	AA6061-2% wt.of TiB2	098.16	10
2	AA6061-4% wt.of TiB2	135.01	12.5
3	AA6061-6% wt.of TiB2	125.54	21.5
4	AA6061-8% wt.of TiB2	091.74	5.5

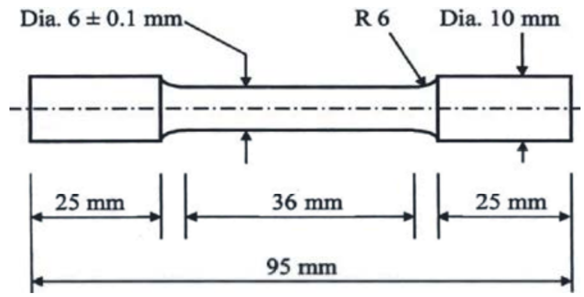

Fig. 3.1: Drawing of tensil specimen

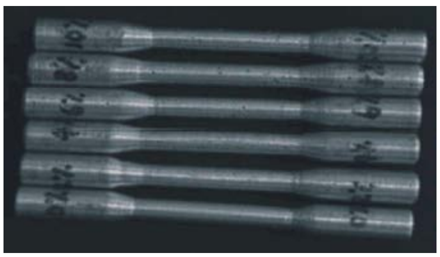

Fig. 3.2 Tensile specimen

Fig. 3.3 Before tensile test

Fig. 3.4 After tensile test

The SEM test were carried out using HITACHI – S 3000 Scanning Electron Microscope and Platinum sputtering before the test was carried out using Fine coat Ion sputter JFC 1100. The sputtering time was 2 minutes and 1.2KV, 7 milliamps DC supply was given for the emission of platinum ions. The photograph of sputtering process is shown in Figure 3.6.

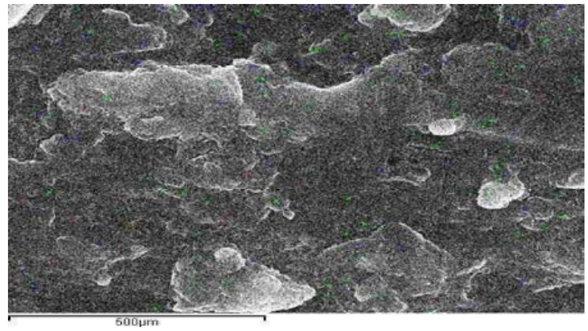

Fig. 3.5: SEM Microstructure (AA6061- 8% wt. of TiB_2)

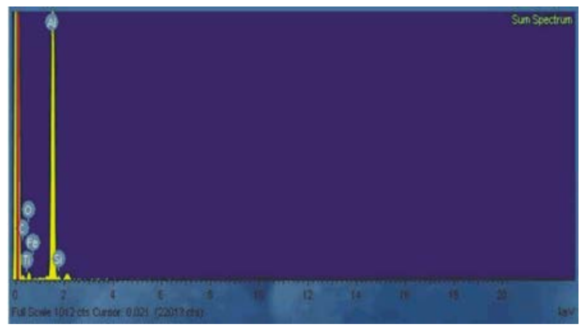

Fig. 3.6: EDAX Analysis of Composition (AA6061- 8% wt. of TiB_2)

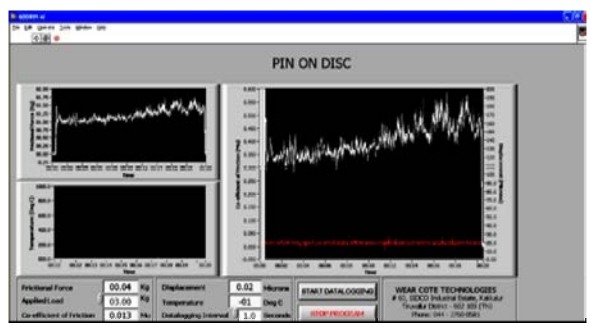

Fig. 3.7: Graphical results of Pin on Disc Test (Al6061- 4% wt. of TiB_2)

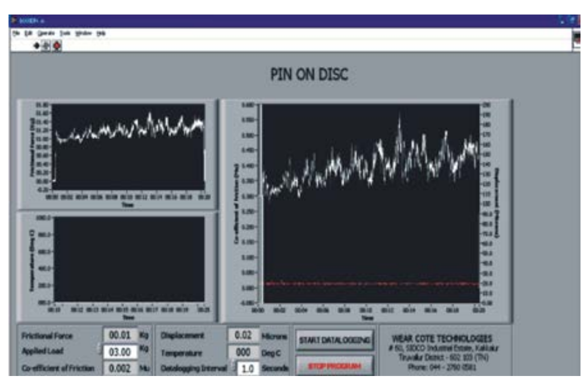

Fig. 3.8: Graphical results of Pin on Disc Test (AA6061- 8% wt. of TiB_2) Table 3.2 Wear Test report

Table 3.2: Wear Test report

Sl.No	Sliding speed m/s	Load (N)	Weight (grams)	Wear (μm)×10^{-6} m	[7C]OPH. μ=f/ftnem rein and
1	0.696	30	0.002	4.796	[80].013D.Pow110
2	0.55	30	0.001	3.03	[90].002M.KSci,opp

Wear Observations: Tests were conducted with the load range is 10 N at constant speed of 350 rpm and sliding distance of 500 mm. The initial weight of the specimen was calculated from single pan electronic weighing machine with the precision of 0.0001. The wear test observation shows the wear resistance of the composite is increased as the percentage of the TiB_2 increases.

CONCLUSION

- The addition of the TiB_2 particles into Al-6061 is a good route to improve the mechanical properties of materials.
- The resulting composite showed the increase in tensile strength when compared to the unreinforced alloy.
- SEM and XRD analysis of the composite confirms the presence of TiB_2 particle and its volume fraction.
- The increased volume fraction of the TiB_2 particles contributed to increase the strength of composites.
- The dry sliding at room temperature shows that there is a definite increase in the wear resistance of Al6061 alloy by the addition of TiB2 particles.

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