Production and Characterization of Al 6061- TiB_2 Metal Matrix Composites

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Abstract

Metal-matrix composites(MMC) are applied in aerospace, motor vehicle industries, mechanical tools manufacturing industries due to light in weight, flexibility, stiffness and hardness. This paper focused on production of metal-matrix Al TiB_2 composites using the stir-casting method and prepared total five samples of varying percentage compositions of TiB_2 –0%, 3%, 6%, 9%, and 12% with aluminium.The obtained cast composites of Al6061- TiB_2 were carefully machined to prepare the test specimens for tensile, and hardness tests as per ASTM standards. The incorporation of TiB_2 improved the microhardness and ultimate tensile strength (UTS) of the AMCs

Index Terms: *Al 6061 alloy, Al- TiB_2 Metal matrix Composite (MMC), Aluminium Matrix Composite (AMC) Stir Casting Method.*

1. INTRODUCTION

Al 6061 is widely used in numerous engineering applications including transport and construction where superior mechanical properties such as tensile strength, hardness etc.[1] are essentially required. A typical chemical composition of Al 6061 is presented in Table 1. It superior corrosion resistance makes it a suitable candidate material for marine structural applications. The demand for lighter weight, cost effective and high performance materials for 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 , B_4C,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 , TiB_2 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. Discontinuously reinforced metal matrix composites have received much attention because of their improved specific strength, good wear resistance and modified thermal properties[4].There is a variety of manufacturing processes available for discontinuous metal matrix composites; stir casting is generally accepted as a particularly promising route, currently practiced commercially. In general stir casting of MMCs involves producing a melt of the selected matrix material followed by introducing reinforcement material into the melt, obtaining a suitable dispersion through stirring. Its advantages lie in its simplicity, flexibility and applicability to large quantity production.

Table 1. Chemical Composition (Al 6061)

Elements	Si	Cu	Mg	Fe	Mn	Al
Percentage	0.63	0.32	1.08	1.72	0.52	rem

2. EXPERIMENTEL PROCEDURE

2.1Production of Metal Matrix Composite

Aluminium Alloy was melted in a graphite crucible by heating it in a muffle furnace at 600°C-650°Cfor one hour. The titanium di boride particles were preheated at 900°C for one hour to make their surfaces oxidized.The furnace temperature was first raised above the liquids temperature of aluminium near about 750°C to melt aluminium alloy and was then cooled down just below the liquidus to keep the slurry in Semi solid state. Automatic stirring was carried out with the help of radial drilling machine for about 10 minutes at stirring rate of

400RPM.At this stage the preheated titanium di boride were added manually to the vortex.In the final mixing processes the furnace temperature was controlled with in 700±10°C. The optimum stirring speed of 450 rpm was determined and selected prior to this experiment.

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Fig. 1. Stir casting facility**.**

This is to avoid excessive gas content that resulted from over agitating of melts, which led to unacceptable porosity content in the casting product[5] The impeller and stirring rod was coated with liquid alumina so as to avoid any metals contamination to the molten metal. After stirring process the mixture was pour in the other mould to get desired shape. Five such castings were produced with different weight percentages (0, 3, 6, 9 and 12%) of , TiB_2 . Fig. 2 shows a typical AA6061– , TiB_2 casting samples.

Fig 2: Casting samples with different compositions

2.2 Preparation of Tensile Test Specimen

The tensile test specimen has been machined in CNC milling machine as per ASTM E8M-04 standard having a gauge length of 40 mm, a gauge width of 6 mm and a thickness of 10 mm.The dimensions of the specimen are shown in Fig 3.

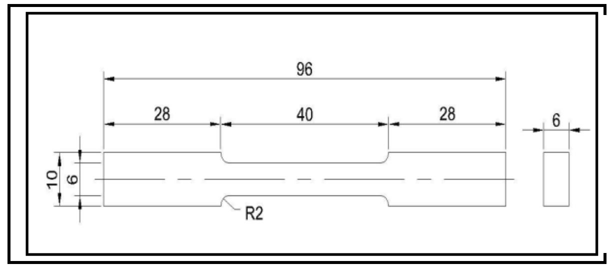


Fig 3: Dimensions of Tensile Test Specimen

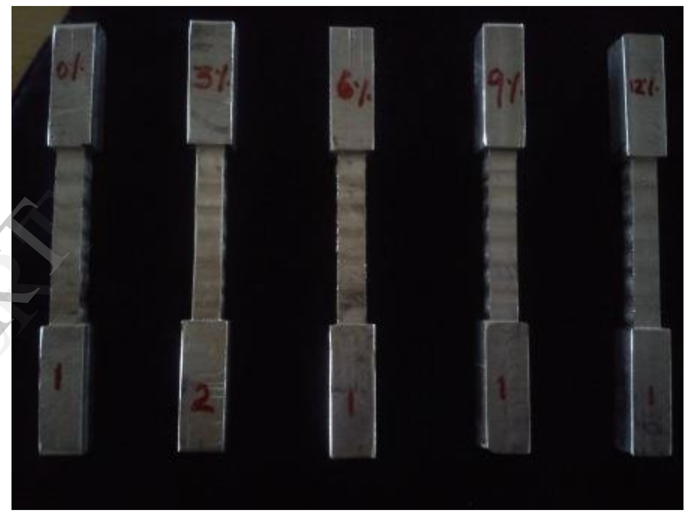


Fig 4: Tensile Test Specimens

2.3 Preparation of Micro Hardness Test Specimen

The Hardness specimen was prepared in the dimensions of 20 x 20 x10mm (l x b x t) as shown in fig 5. The surface was polished with the help of emery paper. Hardness test was conducted by using digital micro-hardness tester (Model Shimadzu HMV-2000),the micro hardness of Al alloy and composites samples were determined in the as-polished condition. The micro hardness measurement were made using a pyramidal diamond having face angle 136º, 100g indenting load and dwelling time 15 seconds.

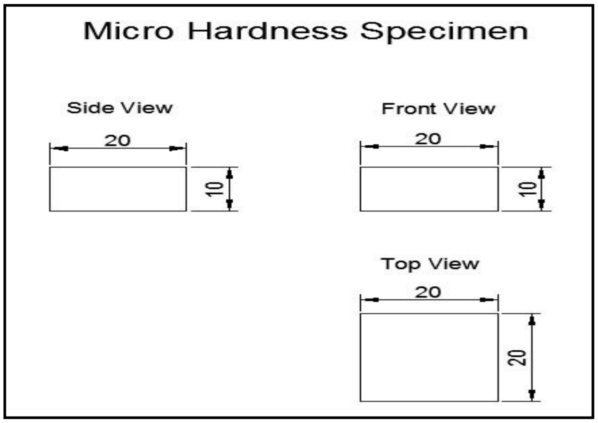


Fig 5: Dimensions of Micro Hardness Test Specimen

Fig 6: Hardness Test Specimens

3.RESULT AND DISCUSSION

3.1 Tensile Test

The ultimate tensile strength (UTS) was estimated using a computerized universal testing machine inRoots industris Pvt.Ltd,Coimbatore.

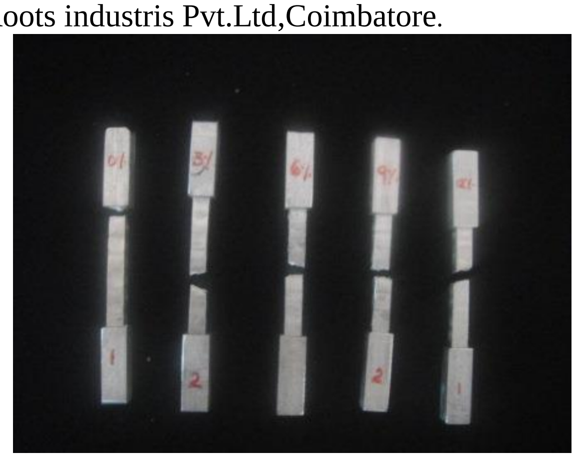


Fig 7: Tensile Specimens after test

Table 2: Tensile Test Results

S.NO	SAMPLE NAME	TENSILE STRENGTH (MPa)	% Elongation
1	AA+0% TiB_2	178	8.1%
2	AA+3% TiB_2	198	7.6%
3	AA+6% TiB_2	207	5.1%
4	AA+9% TiB_2	219	3.8%
5	AA+12%TiB_2	210	3%

The effect of weight percentage of TiB_2 particles on UTS as shown in Table 2.The Tensile strength of each composition increased with the TiB_2 content. Representive load-displacement curves for each composition are provided in chart 3.The addition of 9% TiB_2 results in a increase of 40MPa compared with pure aluminium.The Tensile strength increased significantly to 220MPa when the TiB_2 particles reached 9% of the composite. As shown in table, the elongation of the AMCs drops when TiB_2 particle weight percentage is increased. The grain refinement and reduction of ductile matrix content when the weight percentages of TiB2 particles are increased reduces the ductility of the AMCs.

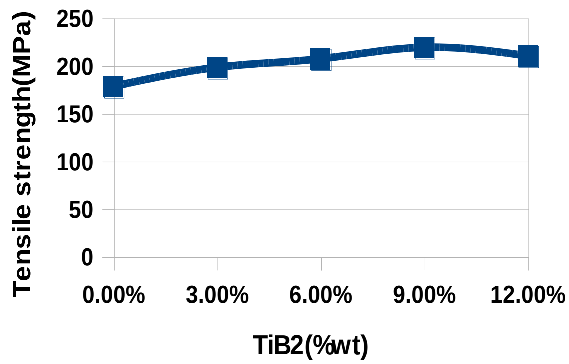


Chart 1: Effect of TiB2 content with tensile strength

Chart 3: Curves shows the tensile strength of Al -TiB_2 composites with different compositions

a) 0% TiB_2 **b)** 3% TiB_2 **c)** 6% TiB_2 **d)** 9%TiB_2 **e)** 12% TiB_2

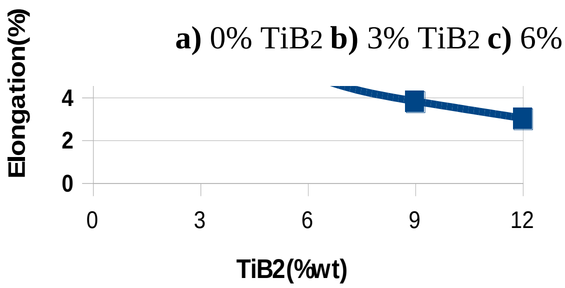
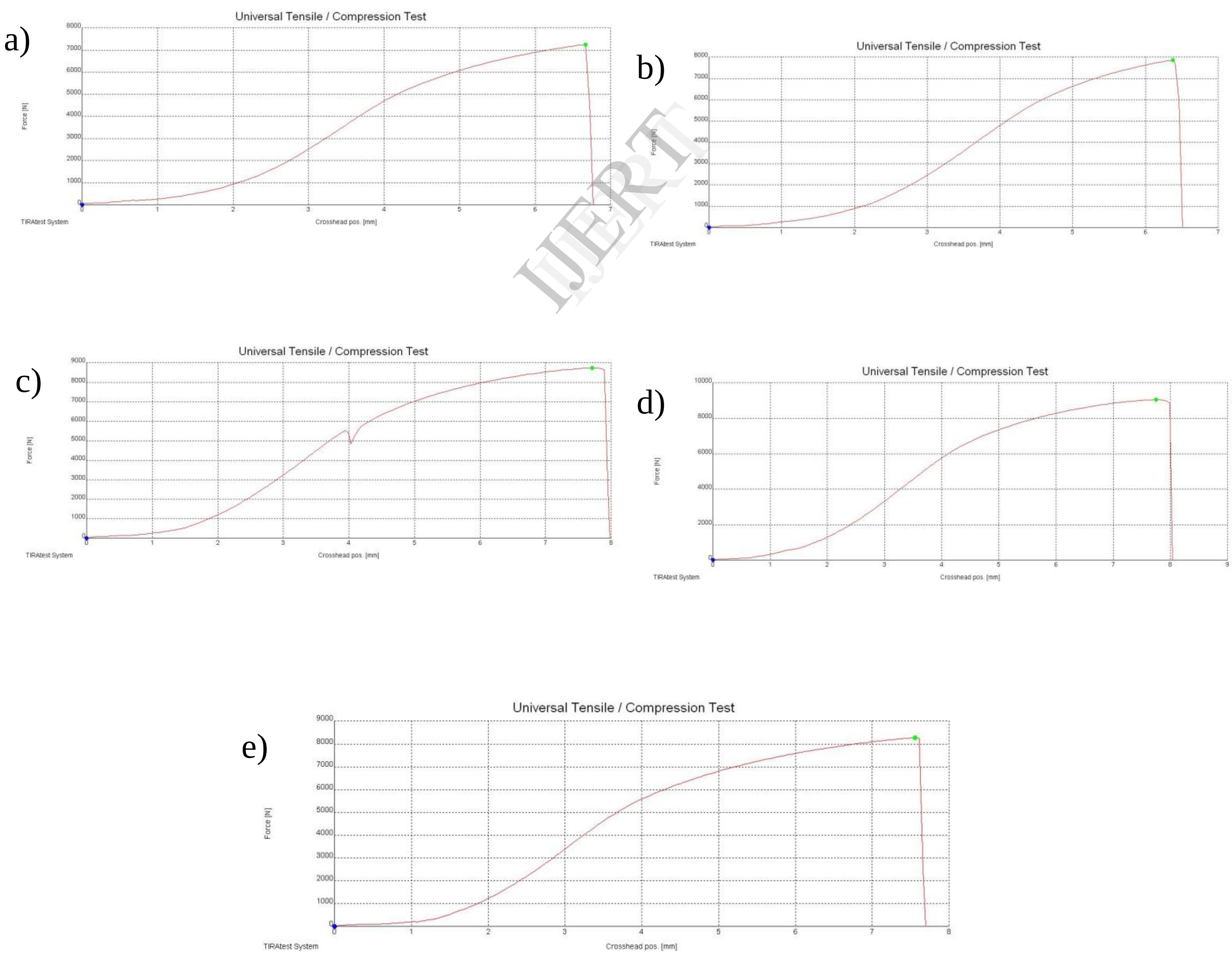


Chart 2: Effect of TiB_2 content with elongation



3.2 Hardness Test

The hardness values of Al alloy, Al/TiB_2 composites are shown in Table 2. A significant increase in hardness of the alloy matrix can be seen with addition of TiB_2 reinforced powder.A hardness reading showed a higher value of hardness indicating that the existence particulates in the matrix has improved the overall hardness of the composites. This is true due to aluminum is a soft material and the reinforced particle especially ceramics material being hard, contributes positively to the hardness of the composites. The presence of stiffer and harder, TiB_2 reinforcement leads to the increase in constraint to plastic deformation of the matrix during the hardness test [7]. Thus increase of hardness of composites could be attributed to the relatively high hardness of, TiB_2 itself.

Table 3: Hardness Test Results

Sample Name	Hardness value(VHN)			Mean Hardness
	Trial 1	Trial 2	Trial 3	
AA+0% TiB2	39.2	42	40	40.4
AA+3% TiB_2	57	55.5	60	57.5
AA+6% TiB_2	67	65	64.7	65.56
AA+9% TiB_2	77	75.5	78	76.83
AA+12% TiB_2	88	89	92	89.66

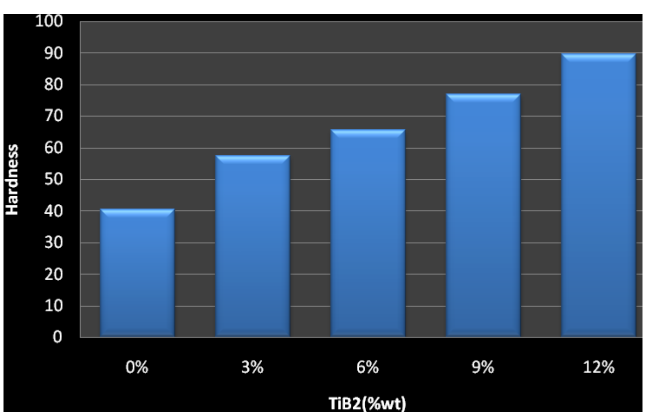


Chart 4: Comparison the hardness with wt.% variation of TiB_2

4.CONCLUSION

A stir casting process which was set at 750ºC was successfully utilized for casting Al-6061 matrix composites reinforced with TiB2 particles. Aluminium composite so developed exhibit uniform distribution of the particle in the matrix and good interface bonding between the ceramic phase and the metallic matrix. The mechanical properties of the AMCs improved when the content of TiB_2 particles was increased. The Tensile strength increased significantly to 220MPa when the TiB_2 particles reached 9% of the composite.The hardness value of 12% TiB_2 increased by 50% higher than the base alloy(0%TiB_2)

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