COMPARATIVE STUDY OF PROPERTIES OF ALUMINIUM 2014 REINFORCED WITH 5% SiC AND TiB_2 PARTICULATES

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Abstract
In this present work, an effort has been made to fabricate and compare the properties of aluminium metal matrix composites. Aluminium 2014 Matrix Composite (AMC) is being used for the high-performance application such as automotive, Aerospace, Military and Electrical industries because of their improved physical and Mechanical properties. Two specimens were fabricated by adding 5 wt% of SiC and 5 wt% of TiB_2 with Aluminium Metal Matrix. The two specimens were fabricated using stir casting route. Morphology of the cast composites reinforced with 5 wt% of SiC and 5 wt% of TiB2 were studied in detail by scanning electron microscope (SEM) to analyze the particle distribution in Aluminium Metal phase. The Hardness test was carried out to find out the hardness of the cast composites using Brinell hardness testing machine. Mechanical testing was carried on the tensile samples prepared from the two cast composite specimens.

Keywords: Metal matrix composite, Microstructure, Stir Casting

Introduction

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess many advantages over monolithic materials, including higher specific strength, good wear resistance, higher thermal conductivity than ceramic materials, lower coefficient of thermal expansion compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Now a days the particulate reinforced aluminum matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminum matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys. The excellent mechanical properties of these materials and the relatively low production cost make them very attractive for a variety of applications in automotive and aerospace industries. Recent research work of the Al matrix composites such as those reinforced with SiC,TiB_2 are now commercially available in a variety of structural forms. A new effort has been taken to fabricate composite reinforced with single reinforcement SiC and $TiB_2$for a wt % of 5 using stir casting route. This work deeply compare and analyze Mechanical properties of both composite specimens, reinforced with SiC and TiB_2. Khairaldien's research shows a drop of strength at 15-20% weight percentage of silicon carbide due to the contact of SiC particle with the other and the increase in chance of more than two particle cluster together. Considering this, work % of reinforcement has been fixed (5% for SiC andTiB_2). This new effort clearly manifests the outstanding properties of SiC and TiB_2in aluminum metal matrix composite with respect to, hardness, tensile strength and wear.

Composites are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties that remain separate and distinct within the finished structure. Aluminum matrix composites (AMCs) are the competent material in the industrial world. Due to its excellent mechanical properties, it is widely used in aerospace, automobiles, marine etc. The aluminum matrix is getting strengthened when it is reinforced with the hard ceramic particles like SiC, TiB_2 etc. Aluminum alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. Literature study shows that among the reinforcement SiC is chemically compatible with aluminium metal matrix and forms an adequate bond with the metal matrix without forming inter metallic phase. Long ago main focus was offered for the improvement of metal matrix composite with SiC in various weight percentages and importance was given to study it's mechanical, tribological, and machinability properties etc. Presently due to the need of engineering materials with elevated strength, improved wear resistance and superior temperature performance various reinforcements compatible with aluminum metal matrix are under research.$Al_2O_3$is one of the widely used second reinforcement. But it has its own demerits like poor wetting behaviour with aluminum and more weight percentage leads to increase in porosity. Few works were carried out to introduce TiB_2an outstanding reinforcement among all reinforcements with aluminum metal

matrix. This is due to the fact that TiB_2reveals outstanding features such as high melting point(2790°C), high hardness and high elastic modulus and good thermal stability. TiB2 ceramic particle do not react with molten aluminum, thereby avoiding formation of brittle reaction products at the reinforcement matrix phases. Also aluminum reinforced with $TiB_2$is known for its high wear resistance property. T.V. Christy in his paper, "A comparative study on the Microstructure and Mechanical properties of Al 2014Alloy and the MMC Al 2014/TiB_2.The composite Al2014/$TiB_2$was successfully produced by in-situ reaction procedure. The manufactured Al-TiB_2 composite exhibited higher values of hardness, tensile strength and young's modulus than the base alloy. Investigation of previous work revealed that, the main fabrication technique used was in-situ salt reactions.

Experimental Procedure

The main metal matrix phase component is Aluminum2014 (T6Type). For the first reinforcement sample, Silicon Carbide (SiC) Particles of 320 grid size was selected. And then Titanium di Boride (TiB_2) particles is selected as the reinforcement for the second sample of average size 2microns.The reinforced weight percentage of SiC and TiB_2 with the main metal matrix component is 5%. Then the sample 1 is made to be preheated at the temperature of 720^0C for 1 hour. This is done in order to remove the moisture content present In the particles, and to increase the wettability by eliminating the other gases present in it. After the preheating is done SiC particles were added and mixed properly, in order to increase the wettability 2grms of Magnesium is added to it.Then sample 2 is made to be preheated at the temperature up to 150^0C.For the proper melting of matrix the temperature of the furnace was raised to 750^0C.Dynamic method stirring was carried out for 30 min at 300 rpm average stirring speed. In case of the 1st sample the molten mould is poured in to permanent mould. Similarly for the 2nd sample sand mould is prepared and the mould was made to poured In it. The Morphology of the samples reinforcement distribution, macro an micro structural characteristics of the materials was investigated by optical and scanning electron microscopy (Sem).Then hardness test was carried in Brinell Hardness. Three readings were taken from the samples, the reading are taken diagonally from the samples. To access the mechanical behavior of the reinforced material tensile test was done.

Results and Discussions

Tensile Test for Al2014 Reinforced with SiC and TiB_2

Tensile test was carried out for Sic and TiB_2Composite specimens and the values were tabulated. The development in the tensile property of the composites can be attributed to the size and distribution of particles and dislocation; Reinforcement particles as barriers to the movement of dislocations under the load, enhances higher tensile strength of composites. The average tensile value of Al/SiC MMC is 107MPa.The average tensile value of Al/TiB_2 MMC is 189MPa.The Al/TiB_2 composites exhibits higher strength then Al/SiC composites. The replacement of SiC with TiB_2 exhibit 77% increase in tensile strength of the composites. The Al/SiC MMC is expected to have agglomerates due to hand stirring adopted in this work being not effective. Also Al/SiC MMC is expected to contain SiC particles less than 5% (overall) in the casting due to settlement of SiC particles during prolonged hand stirring. Due to this reasons the Al/SiC MMC may have SiC content less than the quantity attempt to be mixed. Thus, Al/TiB_2 MMC may be having the expected 5% TiB_2 content for which it was attempt and Al/SiC MMC may be having less than 5% SiC content.

Al2014/ SiC -5%

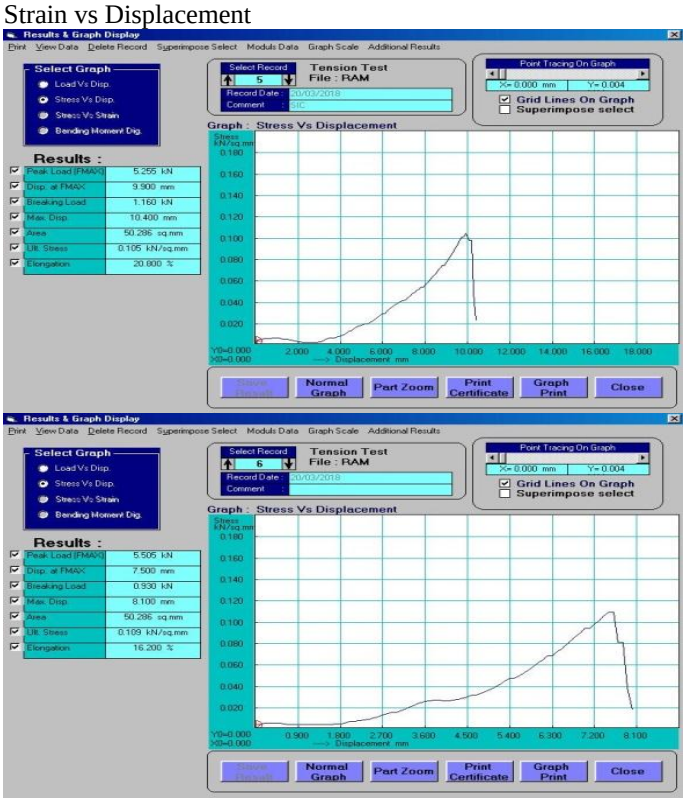
SL. NO	PEAK LOAD	ULTIMATE TENSILE STRESS	YIELD STESS	%OF ELONGATION
1	5.25	105	83	16
2	5.50	109	87	16

Al2014/TiB_2-5%

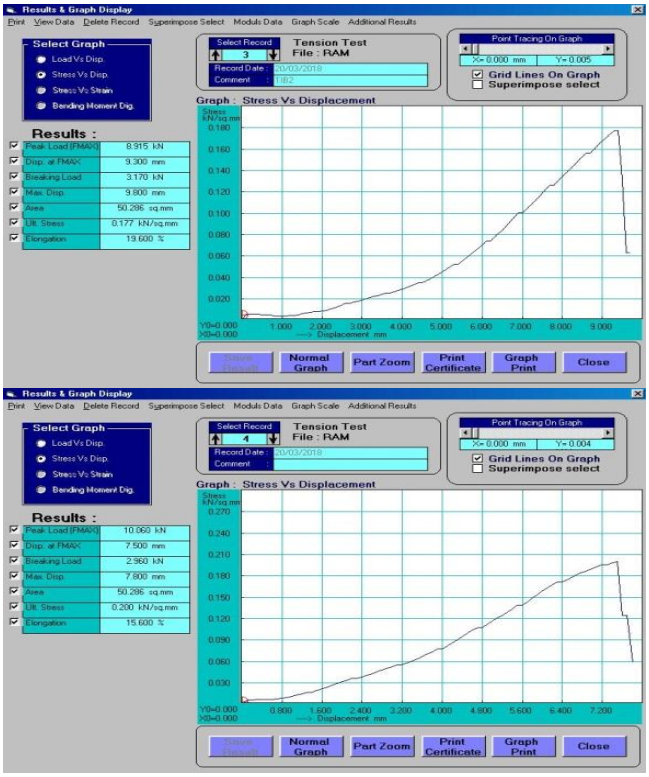
SL. NO	PEAK LOAD	ULTIMATE TENSILE STRESS	YIELD STRESS	%OF ELONGATION
1	8.915	177	160	15
2	10.06	200	176	14

Graph

For Al/SiC Reinforcement
Strain vs Displacement



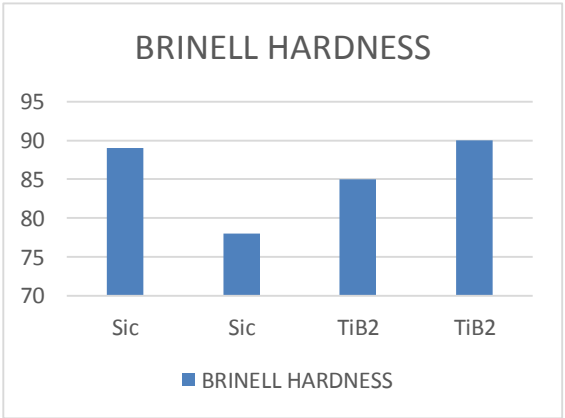
For Al/TiB_2 Reinforcement
Strain vs Displacement



Hardness Test for Al2014 Reinforced with SiC and TiB_2

The Hardness properties of the reinforced samples are tested using Brinell hardness testing machine. It was done to check the property of the materials to resist against surface deformation. The tabulation shows the test results of the samples.

SPECIMEN	LOAD(KgF)	BRINELL HARDNESS			AVERAGE
SiC	60	89	87	92	89
SiC	60	76	78	81	78
TiB2	60	85	82	88	85
TiB2	60	89	91	89	90



This graph represent that on comparison of both Al/SiC and Al/TiB_2 The average hardness value of the Al/TiB_2 is greater, since it produce low size of 2micron,which the hardness of the material is higher than the Al/SiC.

Sem Analysis

To analyse the sample deformed fracture surfaces sem analysis is done. Uniform distribution is not maintained in case of the sample 1(Al/SiC) clusture formation occurs in it.In the case of 2nd sample uniform distribution is maintained properly without the clusture formation.

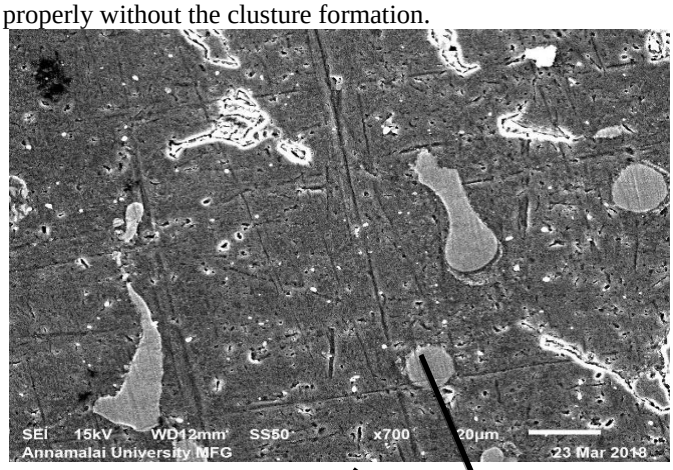
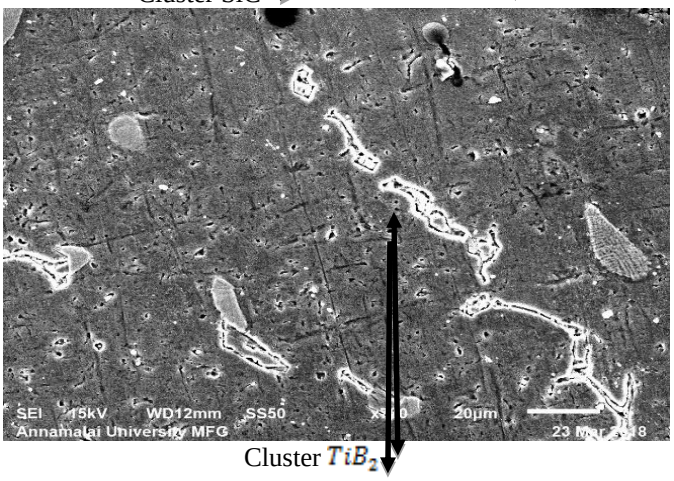


Image 1 Sem Image for 5% (Al/SiC) Composite

Cluster SiC



Cluster TiB_2

Image 2 Sem Image for 5% (Al/TiB_2) Composite

Conclusions

From the Tensile Test

The size of TiB_2particle is very much smaller than the size of SiC particle The % of TiB_2 content is more than that of the % of SiC content, in the respective MMC's.The SiC particles could have agglomerated due to slow hand stirring.

From the Hardness Test

The average hardness value of the Al/ TiB_2 is higher than the average hardness value of the Al/TiB_2.From the comparison of both sample, Al/TiB_2has more advantages than Al/SiC.

From the Sem Analysis

In the Al/TiB_2 the particles are uniformly distributed without the clusture formation due to increased weight percentage in Al/Sic clusture formation occurs.