Experimental Analysis of Wear Behaviour of Reinforced Aluminum Metal Matrix Composites

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Abstract— The emerging world demands light, inexpensive and quickly processed materials. The Al/SiC/B4C metal matrix composites have light weight, wear resistance and high elastic modulus. The Al/SiC/B4C metal matrix composite has applications in many industries such as automobile, aerospace, marine etc. The main objective of the project is to investigate the wear behavior of Al/SiC/B4C metal matrix composites. In the present investigation, fabrication of Al6063-SiC MMC's containing 0% to 15% weight of SiC/B4C of average particle size of 25 µm was prepared using stir casting method. The composites were also tested to investigate tensile strength, hardness, impact test, in addition to wear behavior as per ASTM standards. The results show the alloy reinforced with SiC/B4C particles exhibit superior hardness, tensile strength, impact, and wear resistance with hardness, ultimate tensile strength and wear resistance increased with increase in SiC/B4C content. The effect of different weight percentages of SiC/B4C in the metal matrix composites on hardness, impact test, microstructure, was studied.

Key words: Al 6063, SiC composite, B4C composite, Stir casting, Wear test

I. INTRODUCTION

Composites are materials in which two phases are combined, usually with strong interfaces between them. They usually consist of a continuous phase called the matrix and discontinuous phase in the form of fibres, whiskers or particles called the reinforcement. Considerable interest in composites has been generated in the past because many of their properties can be described by a combination of the individual properties of the constituent phases and the volume fraction in the mixture.

The interest in metal matrix composites (MMCs) is due to the relation of structure to properties such as specific stiffness or specific strength. Like all composites, aluminium matrix composites are not a single material but a family of materials whose stiffness, density and thermal and electrical properties can be tailored composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than each individual material will do.

II. LITERATURE REVIEW

W.O. Winer et[1] - The low friction and easy cleavage of silicon carbide is intrinsic to the material and a result of its crystal structure. Although it is clear that the presence of condensable vapours is not required for silicon carbide to exhibit low friction, as it is in the case of graphite, it is true that condensable vapours play an important role in determining the friction and wear characteristics of a lubricant film.

The presence of oxidizing agents, particularly water vapour and oxygen, tends to reduce the wear life of the MO & film. This is particularly true in the case of burnished films. Although a great deal of knowledge exists concerning the behaviour of silicon carbide as a lubricant, there are still voids in our understanding of this subject. Because of the importance of silicon carbide as a dry lubricant it has been the subject of considerable research both of a fundamental and applied nature.

There are many articles in the literature where the behaviour of MO& is reviewed and discussed. The list of references of original work of both applied and fundamental research with MO! % is of considerable length.

Rabin Bissessur and Peter K.Y. Liu et[2], Aluminium is an attractive layered structure that has gained a considerable amount of interest in the scientific community, especially in recent years. Aluminium is a relatively cheap material as it occurs in nature as its mineral, molybdenite. It is a very slippery material and, thus, has been commercialized for use as a solid lubricant.

Aluminium could also be used as a cathode material in, for example, lithium rechargeable batteries. Recently, by exploiting the exfoliating and re stacking properties of Li Aluminium in water, a wide range of guest species have been included into Aluminium. To date, it was believed that the guest species needs to be soluble in some solvent system, whether miscible or immiscible with water. However, a significant finding in our research shows that the guest species could also be a colloidal suspension. In that respect, we have Aluminium: C: SIC2 composite top layer.

Since the tribological properties in dependence of RH are anhidrotic for Aluminium and carbon, at certain higher carbon content the tribological properties should be sufficient for both low and high RH. Also, further examinations will be carried out to investigate the tribological properties in vacuum and at higher temperatures.

WilliamP.Boone et[3] Aluminium/titanium coating shows a very good tribological performance, confirmed by the results of all tests made, such as, POD, twin-disc machine, FZG scuffing tests and transfer gearbox efficiency tests. The Aluminium/titanium coating shows the following characteristics:

Excellent adhesion to the steel substrate at high-contact pressure, high-slide-to-roll ratio and low specific lubricant film thickness. Improvement of gearbox efficiency in about 0.5% at high torque and low speed when the friction losses between the gear teeth are most significant. These characteristics shown that the Aluminium coating is of great interest at least in two particular cases: Severe applications involving high-contact pressures and high sliding, frequent start-ups, or deficient lubrication.

T.Morimoto et[4] wear life of Aluminium bonded film lubricants were differently gives an extra low wear property. Optimal resin binder ratio of the bonded film lubricants is significantly affected the tribo contact conditions. Especially the wear life of bonded film lubricants is reduce significantly. Their new applications have been motivated by the increase in anti-seizure capacity of machine contact elements. As the application of Aluminium bonded film lubricant have been expanded to new fields.

Hugh Spikes et[5] the Sputter deposited Aluminium is well known for its solid lubricant properties due to a lamellar structure with only weak van-der-Waals bonding between the planes, but its properties degrade in humid air due to oxidation of Aluminium to MoO3 with resulting increased friction coefficient and decreased lifetime. Furthermore, adhesion on steel substrates is usually poor.

Various studies have shown that adhesion and wear resistance can be improved by co-sputtering of metals as dopants and/or sub layers of multilayer films. Good results were, for example, obtained by sputtering Aluminium and Ti or WSe2.

M.Steinmann, A.Muller, H.Meerkamm et [6] Research paper Industrial technology is growing at a very rapid rate and consequently there is an increasing demand and need for new materials. Particulate reinforced composites constitute a large portion of these new advanced materials. The choice of the processing method depends on the property requirements, cost factor consideration and future applications prospects.

Incorporation of hard second phase particles in the alloy matrices to produce MMCs has also been reported to be more beneficial and economical due to its high specific strength and corrosion resistance properties. In the past, various studies have been carried out on metal matrix composites. SiC, TiC, TaC, WC, B4C are the most commonly used particulates to reinforce in the metal or in the alloy matrix or in the matrices like aluminium or iron, While the study of silicon dioxide reinforcement in LM6 alloy is still rare and scarce. However, very limited studies are scarce and hence make this study a significant one.

M. Steinmann, A. Muller, H. Meerkamm et[7] within the scope of this work, solid lubricant coatings containing silicon carbide, carbon, and titanium diboride (Aluminium: C: SIC2) were deposited onto steel substrates. Examinations were conducted concerning the influence of sputter-etching parameters and layer design on adhesion.

Adhesion could be optimized by a modification of the sputter etching process prior to deposition in combination with a functionally graded interface between SIC2 intermediate layer and Aluminium: C: SIC2 composite top layer. It was found that optimum adhesion was achieved using an r.f. power of 1000 W for 20 min etching time during the sputter-etching process.

III. Methodology

A. Materials

1) Aluminium Property

Aluminium alloy 6063 is taken as the baseline material of this experiment. It is a medium strength alloy with excellent corrosion resistance. It has the highest strength of the 6000 series alloys. Alloy 6063 is known as a structural alloy. In plate form, 6063 is the alloy most commonly used for machining. As a relatively new alloy, the higher strength of 6063 has seen it replace 6061 in many applications. The addition of a large amount of manganese controls the grain structure which in turn results in a stronger alloy.

2) Chemical Composition

Chemical Element	Peresent (%)
Manganese(Mn)	0.40-1.00
Iron(Fe)	0.0-0.50
Magnesium(Mg)	0.60-1.20
Silicon(Si)	0.70-1.30
Copper(Cu)	0.0-0.10
Zinc(Zn)	0.0-0.20
Titanium(Ti)	0.0-0.10
Chromium(Cr)	0.0-0.25
Others(Each)	0.0-0.05
Others(Total)	0.0-0.15

Table 1: Chemical Composition of AL6063

3) Stir Casting Method

Stir Casting is a liquid state method of composite materials fabrication, in which dispersed phase (ceramic particles, short fibres) is mixed with a molten matrix metal by Means of mechanical stirring. Casting process we are taken Aluminium as a base material and then add the other material the liquid composite material is then cast by conventional casting method and may also be processed by conventional Metal forming technologies. Here in the stir casting process we are taken Aluminium as a base material and silicon carbide as reinforcement material are shown in Figure 1

Fig. 1: Stir casting setup

4) Stir Casting Features

Content of dispersed phase is limited (usually not more than 30 vol. %). Distribution of dispersed phase throughout the matrix is not perfectly homogeneous: There are local clouds (clusters) of the dispersed particles (fibres). There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase. Distribution of dispersed phase may be improved if the matrix is in semi-solid condition. The method using stirring metal composite materials in semi-solid state is called recasting. High viscosity of the semi-solid matrix material enables better mixing of the dispersed phase are shown in Figure 2

Fig. 2: Solidification process

5) Equipment and Accessories used

Stir casting furnace: Stir casting furnace consists of a steel shell lined with refractory materials and an inductor attached to the shell. There is a channel connecting the main body with the inductor. The inductor of the stir casting furnace works as a transformer. Stir casting furnaces work at line frequency currents. Stir casting furnaces are commonly used as holding furnaces stir casting furnaces are also used for melting low melting point alloys. Stir casting furnaces offers good melt quality and absence of products of combustion.

They have heating elements in the form of coils or strips. These induction furnaces are popular and are used in small foundries to the large foundries. Low to medium frequency induction coils transfer energy directly into the melt. Low and high frequency induction furnaces are used for the melting of nonferrous metals. In induction furnace melting is fast and combustion products are absent making minimum oxidation losses. In a coreless induction furnace a graphite crucible lined with suitable refractory is used for melting non-ferrous metals.

a) Tongs

Tongs are made up of mild steel and are used for holding out the hot crucible from the hot stir casting furnace and guide the pouring process. The tongs are made long enough in order to prevent our hands from getting burnt.

b) Stirrer

The stirrer used was made up of stainless steel as it has high melting point and does not react with the aluminium. It was used for the proper mixing of molten Aluminium with Sic powder for uniform distribution.

c) Degasser

The principal function of degassing is to strip out absorbed hydrogen which, if allowed to remain in the metal, contributed to casting porosity. At the same time an effective degasser will entrain and sweep out oxides. The most effective degassers depend on fully chlorine-saturated hydrocarbons which are hydrogen free. The importance of proper fluxing and degassing cannot be over-emphasized. Proper fluxing will improve finish and mechanical properties of the casting by removal on non-metallic inclusions. Fluidity is also improved.

d) Cover Flux

No single flux works well for all aluminium alloys. Variables which demand different fluxes include differences on oxidation rate, melting and casting temperatures, alloy end use and type of furnace, e.g., induction, reverberator, etc. Cover fluxes form a liquid cover or blanket over the melt; these fluxes reduce oxidation and gas absorption during melting and holding.

6) Casting Process

The casting process which is one of the most integral parts of the manufacturing process can be categorised in various stages. There lies a relationship between the processes, the sequence of which needs to be followed.

a) Stages of casting

The aluminium of grade AL6082 was cleaned and then chopped to the required size. They were then weighed.

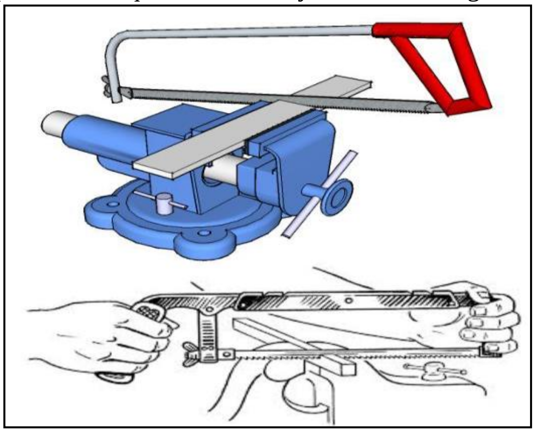


Fig. 3: Chopping process

Melting of base metal the aluminium bars were placed in the crucible and then kept inside the stir casting furnace. The furnace is programmed to reach 800 °C and maintained for half an hour. Preheating the die was preheated by pouring molten aluminium into it.

7) Addition of reinforcement

Desired amount preheated SiC /B4C added according to the specimen requirements. The complete process was accompanied with continuous uniform stirring with the help of stainless steel stirrer.

8) Addition of Degasser

Degassing agent in the form of Hexamethyelene diamine was added during the melting period. The principal function of degassing is to strip out absorbed hydrogen which, if allowed to remain in the metal, contributed to casting porosity.

9) Slag Removal

The removal of slag was performed with the help of stainless steel and G.I sheets. This was done in order to remove the impurities and maintain proper fluidity of the molten composite during pouring process.

B. Specimen Preparation for Testing

1) Hardness Test (Brinell Hardness)

Test procedure. The indenter is pressed into the sample by an accurately controlled test force. The force is maintained for a specific dwell time, normally 10 – 15 seconds.

After the dwell time is complete, the indenter is removed leaving a round indent in the sample. The size of the indent is determined optically by measuring two diagonals of the round indent using either a portable microscope or one that is integrated with the load application device.

The Brinell hardness number is a function of the test force divided by the curved surface area of the indent.

The indentation is considered to be spherical with a radius equal to half the diameter of the ball. The average of the two diagonals is used in the following formula to calculate the Brinell hardness.

Fig. 3: Hardness Testing

2) Impact Test (Charpy)

The impact toughness of a material can be determined with a Charpy or Izod test. Impact properties are not directly used in fracture mechanics calculations, but the economic impact tests continue to be used as a quality control method to notch sensitivity and for comparing the relative toughness of engineering materials. For both tests, the specimen is broken by a single overload event due to the impact of the pendulum. A stop pointer is used to record how far the pendulum swings back up after fracturing the specimen.

Fig. 4: Charpy test piece

The impact toughness of a metal is determined by measuring the energy absorbed in the fracture of the specimen. This is simply obtained by noting the height at which the pendulum is released and the height to which the pendulum swings after it has struck the specimen.

The height of the pendulum times the weight of the pendulum produces the potential energy and the difference in potential energy of the pendulum at the start and the end of the test is equal to the absorbed energy.

Since toughness is greatly affected by temperature, a Charpy or Izod test is often repeated numerous times with each specimen tested at different temperature.

3) Microstructure Testing

The microstructure expresses a high number of properties of a material. For this reason material graphic or if we use the older, more common terminology, metallographic preparation is important for both production - and research work.

The microstructure specimens at the worn out surfaces was carried out using scanning electron microscope (SEM) The worn out material of the specimens in the form of wear debris were also inspected using energy dispersive spectrometer. The examination of the SEM micrographs reveals several significant results.

The cast samples were cut into four equal pieces and their microstructure was examined to check the distribution of the SiCp across the length.

IV. Result and Discussion

A. Hardness Test Result

The effect of change in percentage of particles on the hardness of the composites is illustrated in Figure 4.1 and the values are given in Table 3. The complete range of hardness is calculated.

The hardness test shows a marginal increase in hardness with the increase in the addition of SiC/B4C. The hardness test shows a greater increase with stir casting process. The casting of the matrix and the composites further increases the hardness.

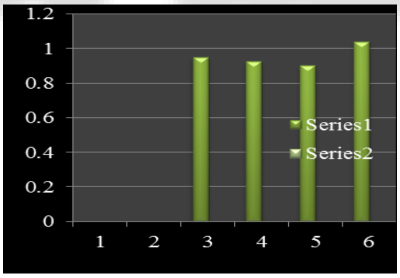


Fig. 5: Hardness Test Result (Brinell)

For the matrix alloy a peak hardness of 73 HV was achieved. However, with the addition of 10 % of SiC and 2.5% of B4C the level of increase in hardness was started decreasing due formation of voids.

S. No	Composite Material	Hardness Brinell Hardness			Mean Hardness	Surface area	BHN
		Trial 1	Trial 2	Trial 3			
1	AL6063	4.5	4.5	4.4	4.46	21.5	0.95
2	AL6063+10%SIC+2.5%B4C	4.4	4.5	4.6	4.5	22.14	0.925
3	AL6063+10%SIC+5%B4C	4.6	4.5	4.5	4.53	22.63	0.90
4	AL6063+10%SIC+7.5%B4C	4.3	4.3	4.4	4.33	19.69	1.041

Table 2: The Hardness of the matrix alloy and the –variation of Silicon carbide / B4C fraction – Average particle size 25µm

B. Impact Test Results

S. No	Composite Material	Impact Test Charpy Test	Impact Strength (Nm)
		TRAIL 1	
1	AL6063	140	280
2	AL6063+10%SIC+2.5%B4C	142	284

3	AL6063+10%SIC+5%B4C	150	300

Table 3: The Impact Test Result

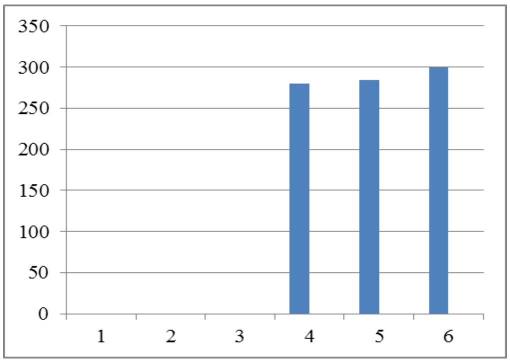


Fig. 6: Impact Strength

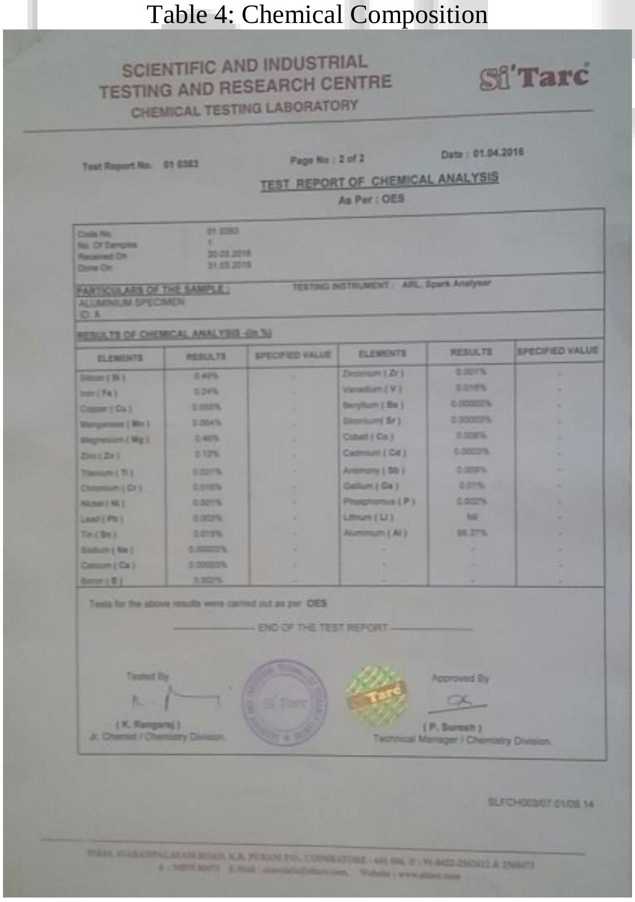
It was observed that the reinforcement had more randomness and diffused intermetallic spacing. It was seen that alumina particles were deposited on the aluminium matrix. Alumina has a certain attraction towards aluminium.

The Charpy impact test, also known as the Charpy v-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness.

C. Chemical Composition

Grades	Aluminum	Silicon Carbide	Boron Carbide
A	0.5Kg	0%	0%
B	0.5Kg	10%	2.5%
C	0.5Kg	10%	5%
D	0.5Kg	10%	7.5%

Table 4: Chemical Composition



SCIENTIFIC AND INDUSTRIAL TESTING AND RESEARCH CENTRE
CHEMICAL TESTING LABORATORY
Si'Tarc

Test Report No. 01 0383 Page No : 2 of 2 Date : 01.04.2016

TEST REPORT OF CHEMICAL ANALYSIS
As Per : OES

Code No : 01 0383
No. Of Samples : 1
Received On : 30.03.2016
Done On : 31.03.2016

PARTICULARS OF THE SAMPLE : ALUMINIUM SPECIMEN ID: A
TESTING INSTRUMENT : ARL. Spark Analyser

RESULTS OF CHEMICAL ANALYSIS -(in %)

ELEMENTS	RESULTS	SPECIFIED VALUE	ELEMENTS	RESULTS	SPECIFIED VALUE
Silicon (Si)	0.49%	-	Zirconium (Zr)	0.001%	-
Iron (Fe)	0.24%	-	Vanadium (V)	0.016%	-
Copper (Cu)	0.003%	-	Beryllium (Be)	0.00002%	-
Manganese (Mn)	0.004%	-	Strontium(Sr)	0.00003%	-
Magnesium (Mg)	0.46%	-	Cobalt (Co)	0.006%	-
Zinc (Zn)	0.12%	-	Cadmium (Cd)	0.0002%	-
Titanium (Ti)	0.021%	-	Antimony (Sb)	0.009%	-
Chromium (Cr)	0.016%	-	Gallium (Ga)	0.01%	-
Nickel (Ni)	0.021%	-	Phosphorous (P)	0.002%	-
Lead (Pb)	0.003%	-	Lithium (Li)	Nil	-
Tin (Sn)	0.015%	-	Aluminium (Al)	98.37%	-
Sodium (Na)	0.00003%	-	-	-	-
Calcium (Ca)	0.00003%	-	-	-	-
Boron (B)	0.002%	-	-	-	-

Tests for the above results were carried out as per OES

END OF THE TEST REPORT

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Jr. Chemist / Chemistry Division

Approved By
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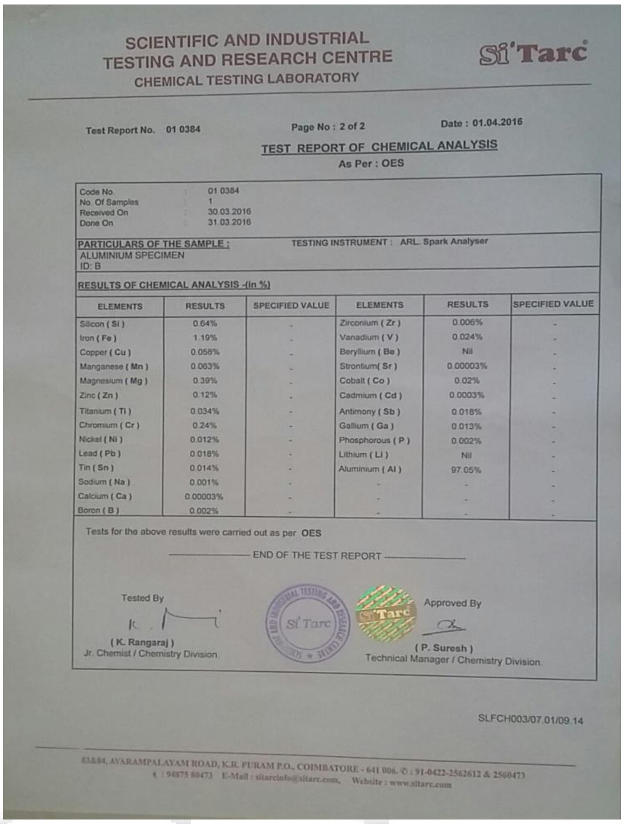
Technical Manager / Chemistry Division

SLFCH003/07 01/09.14



SCIENTIFIC AND INDUSTRIAL TESTING AND RESEARCH CENTRE
CHEMICAL TESTING LABORATORY
Si'Tarc

Test Report No. 01 0384 Page No : 2 of 2 Date : 01.04.2016

TEST REPORT OF CHEMICAL ANALYSIS
As Per : OES

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PARTICULARS OF THE SAMPLE : ALUMINIUM SPECIMEN ID: B
TESTING INSTRUMENT : ARL. Spark Analyser

RESULTS OF CHEMICAL ANALYSIS -(in %)

ELEMENTS	RESULTS	SPECIFIED VALUE	ELEMENTS	RESULTS	SPECIFIED VALUE
Silicon (Si)	0.64%	-	Zirconium (Zr)	0.006%	-
Iron (Fe)	1.19%	-	Vanadium (V)	0.024%	-
Copper (Cu)	0.058%	-	Beryllium (Be)	Nil	-
Manganese (Mn)	0.063%	-	Strontium(Sr)	0.00003%	-
Magnesium (Mg)	0.39%	-	Cobalt (Co)	0.02%	-
Zinc (Zn)	0.12%	-	Cadmium (Cd)	0.0003%	-
Titanium (Ti)	0.034%	-	Antimony (Sb)	0.018%	-
Chromium (Cr)	0.24%	-	Gallium (Ga)	0.013%	-
Nickel (Ni)	0.012%	-	Phosphorous (P)	0.002%	-
Lead (Pb)	0.018%	-	Lithium (Li)	Nil	-
Tin (Sn)	0.014%	-	Aluminium (Al)	97.05%	-
Sodium (Na)	0.001%	-	-	-	-
Calcium (Ca)	0.00003%	-	-	-	-
Boron (B)	0.002%	-	-	-	-

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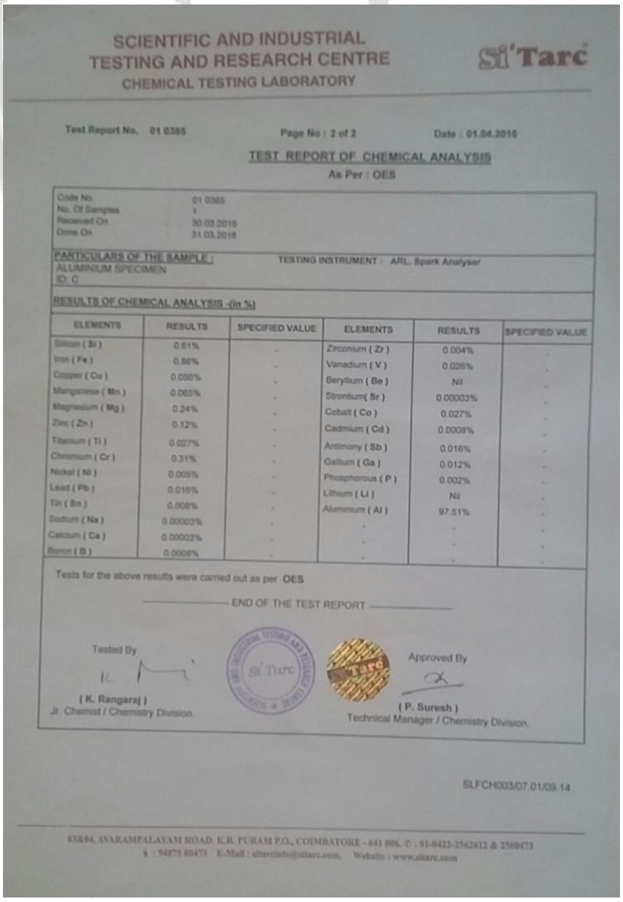
SLFCH003/07 01/09.14



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Test Report No. 01 0385 Page No : 2 of 2 Date : 01.04.2016

TEST REPORT OF CHEMICAL ANALYSIS
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Code No : 01 0385
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PARTICULARS OF THE SAMPLE : ALUMINIUM SPECIMEN ID: C
TESTING INSTRUMENT : ARL. Spark Analyser

RESULTS OF CHEMICAL ANALYSIS -(in %)

ELEMENTS	RESULTS	SPECIFIED VALUE	ELEMENTS	RESULTS	SPECIFIED VALUE
Silicon (Si)	0.61%	-	Zirconium (Zr)	0.004%	-
Iron (Fe)	0.86%	-	Vanadium (V)	0.026%	-
Copper (Cu)	0.056%	-	Beryllium (Be)	Nil	-
Manganese (Mn)	0.065%	-	Strontium(Sr)	0.00003%	-
Magnesium (Mg)	0.24%	-	Cobalt (Co)	0.027%	-
Zinc (Zn)	0.12%	-	Cadmium (Cd)	0.0008%	-
Titanium (Ti)	0.027%	-	Antimony (Sb)	0.016%	-
Chromium (Cr)	0.31%	-	Gallium (Ga)	0.012%	-
Nickel (Ni)	0.005%	-	Phosphorous (P)	0.002%	-
Lead (Pb)	0.016%	-	Lithium (Li)	Nil	-
Tin (Sn)	0.008%	-	Aluminium (Al)	97.51%	-
Sodium (Na)	0.00003%	-	-	-	-
Calcium (Ca)	0.00003%	-	-	-	-
Boron (B)	0.0006%	-	-	-	-

Tests for the above results were carried out as per OES

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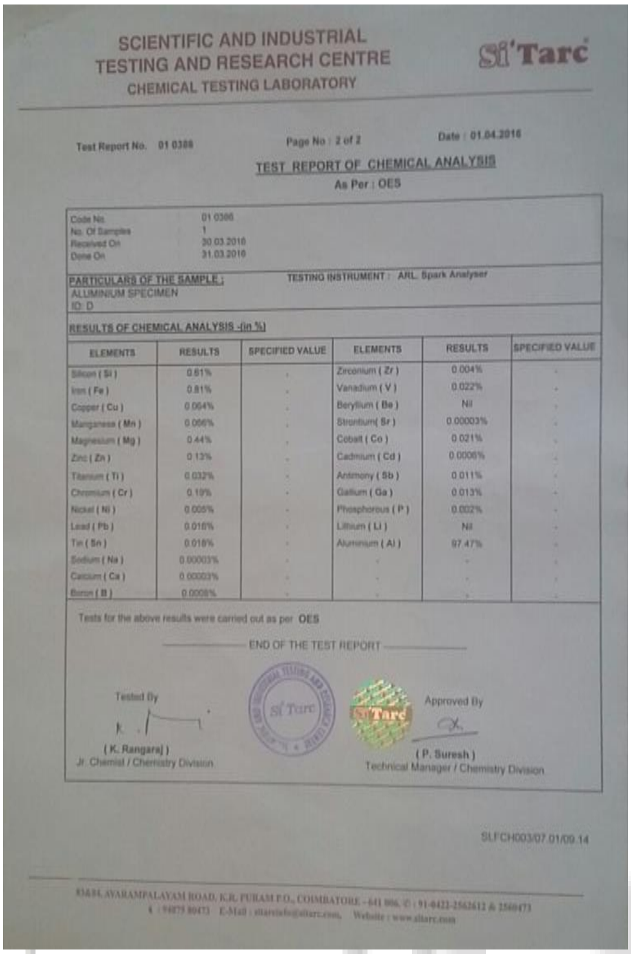

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Test Report No. 01 0388 | Page No : 2 of 2 | Date : 01.04.2016

TEST REPORT OF CHEMICAL ANALYSIS
As Per : OES

Code No. 01 0388
No. Of Samples 1
Received On 30.03.2016
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PARTICULARS OF THE SAMPLE : ALUMINIUM SPECIMEN ID: D
TESTING INSTRUMENT : ARL Spark Analyser

RESULTS OF CHEMICAL ANALYSIS -(in %)

ELEMENTS	RESULTS	SPECIFIED VALUE	ELEMENTS	RESULTS	SPECIFIED VALUE
Silicon (Si)	0.61%	-	Zirconium (Zr)	0.004%	-
Iron (Fe)	0.81%	-	Vanadium (V)	0.022%	-
Copper (Cu)	0.064%	-	Beryllium (Be)	Nil	-
Manganese (Mn)	0.066%	-	Strontium(Sr)	0.00003%	-
Magnesium (Mg)	0.44%	-	Cobalt (Co)	0.021%	-
Zinc (Zn)	0.13%	-	Cadmium (Cd)	0.0006%	-
Titanium (Ti)	0.032%	-	Antimony (Sb)	0.011%	-
Chromium (Cr)	0.19%	-	Gallium (Ga)	0.013%	-
Nickel (Ni)	0.005%	-	Phosphorous (P)	0.002%	-
Lead (Pb)	0.016%	-	Lithium (Li)	Nil	-
Tin (Sn)	0.018%	-	Aluminium (Al)	97.47%	-
Sodium (Na)	0.00003%	-	-	-	-
Calcium (Ca)	0.00003%	-	-	-	-
Boron (B)	0.0008%	-	-	-	-

Tests for the above results were carried out as per OES

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SI.FCH003/07.01/09.14

Fig. 7: Snapshots

V. CONCLUSION

A stir casting process is used to fabricate the metal matrix composites of Al 6063 reinforced with SiC,B4C.

The influences of change in particle fraction of SiC and the mechanical properties of the cast, Al6063/SiC/B4C composites were studied. Three different percentages of particle fractions (10, 10, 10%) of SiC and (2.5, 5, 7.5%) of B4C and particle sizes (average particle size 25µm) were considered. Based on the analysis the following points may be concluded.

Due to the formation of weak compounds in the interface of the matrix and Silicon carbide and Boron carbide reinforcement, the impact strength of the composites decreases with the increase in Sic fraction of the cast composites. An increase in the addition of SIC/B4C restricts the deformation of aluminum matrix material with respect to load, hence the wear rate of composites increased with increase in load. 5.1Scope of Future Work

This can further be extended by varying geometrical angle of Stirrer & by varying stirring speed. Heat treatment can be done to improve the properties. A study can be done by reinforcing different grain size with the matrix. The reinforcement - Silicon carbide/Boron carbide particulates could be coated with titanium or Copper, to study the effect of interfacial bonding and the fracture properties of the composites. Behaviour of various other reinforcements can be studied. Study on corrosion, machining, fatigue, forming, welding etc., can be done. Study can be done by mixing solid lubricants with the matrix.

Sl.No	Composite Material	Impact Charpy Test	Impact Izod Test	Brinell Hardness	Rank
1	AL-6063	280	264	0.95	4
2	AL6063+10%SIC+2.5%B4C	284	272	0.925	3
3	`AL-6063+10%SIC+5%B4C	300	296	0.90	2
4	AL-6063+10%SIC+7.5%B4C	316	302	1.041	1

Table 5: Comparison Table for Tests

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