Contemplation of Mechanical and Thermal Properties of Aluminum (1100) with Silicon Carbide

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Abstract— Aluminum (1100) is found wide application for rail coaches, aircraft industry, bearing materials, piston material, transmission lines etc. But due to their low melting point and low hardness they will wear and deformed easily. The metal Aluminum cannot meet all the required properties suitable for various engineering applications. So it is necessary to develop the Aluminum based materials that could have all combinational properties satisfying all our engineering requirements. SiC can be considered as ideal reinforcements, due to their high strength, high aspect ratio and thermo-mechanic properties. However, until now, the main obstacle is to obtain a homogenous dispersion of the SiCs in the desired matrix. Quite a few methods have studied to help improving the dispersion of SiCs in a polymer matrix. The objective of this work is to reinforce light Aluminum with SiC by melt stirring method. Different wt% of SiC was added to Aluminum [1100] separately to make Aluminum composites and its mechanical and thermal properties have been investigated using test like tensile, hardness, coefficient of thermal expansion. The improvement of mechanical and thermal properties for both the cases has been compared with pure Aluminum [1100].

Keywords— Aluminum, Rockwell Hardness, Silicon Carbide, coefficients of thermal expansion.

I. INTRODUCTION

The issue of CO_2 emission has become more and more critical during the last decades. One of the main sources of CO_2 emission is transportation. One litre of petrol consumption induces 2.34 kg CO_2 and the petrol consumption is directly connected to the average weight of a car. European Commission has proposed to reduce the average CO_2 emission from new cars to 130 g/km by 2012. To fulfill this regulation, one of the solutions is to reduce the weight of a car. An average weight for a car of less than 800 kg is required. Therefore the use of light metals is becoming important. Currently lightweight metal alloys are used in relatively small quantities in automotive applications due to their relatively low strength which limits their potential applications.

To overcome the limitations, much research has been done on producing light metal matrix composites to improve the mechanical properties by adding different reinforcements (Qianqian Li, 2010). Metal matrix composite (MMC) is engineered combination of the metal (Matrix) and hard particle/ceramic (Reinforcement) to get tailored properties.

MMC's are either in use or Prototyping for the space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and a variety of other applications.

Like all composites, aluminum-matrix composites are not a single material but a family of materials whose stiffness, strength, density, thermal and electrical properties can be tailored. The matrix alloy, reinforcement material, volume and shape of the reinforcement, location of the reinforcement and fabrication method can all be varied to achieve required properties. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. The addition of high strength, high modulus refractory particles to a ductile metal matrix produce a material whose mechanical properties are intermediate between the matrix alloy and the ceramic reinforcement. Metals have a useful combination of properties such as high strength, ductility and high temperature resistance, but sometimes have low stiffness, whereas ceramics are stiff and strong, though brittle. For example, Aluminum and silicon carbide have very good mechanical properties: Young's moduli of 70 and 400 GPa, coefficients of thermal expansion of 24×10^{-6} and 4×10^{-6}/°C, and yield strengths of 35 and 600 MPa, respectively. By combining these materials, e.g. A6061/SiC/17p (T6 condition), an MMC with a Young's modulus of 96.6 GPa and a yield strength of 510 MPa can be produced (S.Skolianos, 1990). By carefully controlling the relative amount and distribution of the ingredients of a composite as well as the processing conditions, these properties can be further improved. The correlation between tensile strength and indentation behavior in particle reinforced MMCs manufactured by powder metallurgy technique (Williams, 2001). The microstructure of SiC reinforced Aluminum alloys produced by molten metal method. It was shown that stability of SiC in the variety of manufacturing processes available for melt was found to be dependent on the matrix alloy involved (Morris, 1989).

Among discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production. It is also attractive because, in principle, it allows a conventional metal processing route to be used, and hence minimizes the final cost of the product. This liquid metallurgy technique is the most economical of all the available routes for metal matrix composite production (Surappa, 1997), and allows very large sized components to be fabricated.

Contemplation of Mechanical and Thermal Properties of Aluminum (1100) with Silicon Carbide

The cost of preparing composites material using a casting method is about one-third to half that of competitive methods, and for high volume production, it is projected that the cost will fall to one-tenth (Jolla, 1988). In general, the solidification synthesis of metal matrix composites involves producing a melt of the selected matrix material followed by the introduction of a reinforcement material into the melt, obtaining a suitable dispersion.

The next step is the solidification of the melt containing suspended dispersions under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix. In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including the difficulty of achieving a uniform distribution of the Reinforcement material, weldability between the two main substances, porosity in the cast metal matrix composites, and chemical reactions between the reinforcement material and the matrix alloy. In order to achieve the optimum properties of the metal matrix composite, the distribution of the reinforcement material in the matrix alloy must be uniform, and the wet ability or bonding between these substances should be optimized. The literature review reveals that the major problem was to get homogenous dispersion of the ceramic particles by using low cost conventional equipment for commercial applications. In the present work, a modest attempt have been made to compare the dispersion of SiC particles in Al matrix particles in Al matrix fabricated with the help of Melt stirring equipment. Composition of Al-SiC. Above composition done under method of stir casting. An effort has been made to establish a relationship between hardness, tensile test, Coefficient of thermal expansion, for the composition Al-SiC.

MATERIAL USED

The metals identified for the present study are
- Aluminum [1100] (Al).
- Silicon carbide (SiC).

1.2 ALUMINUM [1100]

Aluminum alloy 1100 contains a minimum of 99.00% Aluminum, and is also known as 'commercially pure Aluminum'. It has excellent electrical conductivity, good formability and high resistance to corrosion, and is used where high strength is not needed. It has the low density and excellent thermal conductivity common to all Aluminum alloys.

1.2.1 Equivalent Specifications

USA: AA1100; Japan: JIS A1100P: France: NF 1100; ISO Al 99.0 Cu.

The properties in this data sheet meet Australian/New Zealand Standard AS/NZS 1734:1997 Aluminum and Aluminum alloys - Flat sheet, coiled sheet and plate (equivalent to BS EN 573-1).The material also meets other national standards.

1.2.2 CORROSION RESISTANCE

The '1xxx' series alloys have the best resistance to general corrosion of all the Aluminum alloys. Resistance is excellent in aqueous solutions in the pH range 4 – 9. The corrosion resistance of Aluminum alloys relies on a protective surface oxide film, which when damaged is readily repaired by the rapid reaction between Aluminum and oxygen. However, the high reactivity of the base metal can give rapid corrosion if the film cannot be repaired, so Aluminum alloys are not suitable for use with reducing media. Aluminum 100 can be anodized to improve the corrosion resistance by thickening the protective surface film .Since Aluminum is a reactive metal, it may corrode more quickly when in electrical contact with most other metals. The prediction of galvanic corrosion is complex.

1.2.3 FABRICATION OF THE AMCs

There are many processes viable to fabricate AMCs; they can be classified as solid state, liquid-state and deposition processes.

In **solid-state processes**, the most spread method is *powder metallurgy* PM; it is usually used for high melting point matrices and avoids segregation effects and brittle reaction product formation prone to occur in liquid state processes. This method permits to obtain discontinuously particle reinforced AMCs with the highest mechanical properties . These AMCs are used for military applications but remain limited for large scale productions.

In **liquid-state processes**, one can distinguish the infiltration processes where the reinforcements form a perform which is infiltrated by the alloy melt with pressure applied by a piston or by an inert gas (*gas pressure infiltration* GPI) and without pressure. In the last case, one can distinguish (a) The reactive infiltration processes using the wetting between reinforcement and melt obtained by reactive atmosphere, elevated temperature, alloy modification or reinforcement coating (*reactive infiltration*) and (b) the dispersion processes, such as **stir-casting**, where the reinforcements are particles stirred into the liquid alloy. Process parameters and alloys are to be adjusted to avoid reaction with particles.

In **deposition processes**, droplets of molten metal are sprayed together with the reinforcing phase and collected on a substrate where the metal solidification is completed. This technique has the main advantage that the matrix microstructure exhibits very fine grain sizes and low segregation, but has several drawbacks: the technique can only be used with discontinuous reinforcements, the costs are high, and the products are limited to the simple shapes that by obtained by extrusion, rolling or forging.

1.4 SILICON CARBIDE (SiC)

Silicon carbide (SiC), also known as *carborundum*, is a compound of silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Silicon carbide powder has been mass-produced since 1893 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics which are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. Electronic applications of silicon carbide as light emitting diodes and detectors in early radios were first demonstrated around 1907, and nowadays SiC is widely used in high-temperature/high-voltage semiconductor electronics. Large single crystals of silicon carbide can be grown by the Lely method; they can be cut into gems known as "synthetic moissanite". Silicon carbide with high surface area can be produced from SiO_2 contained in plant material.
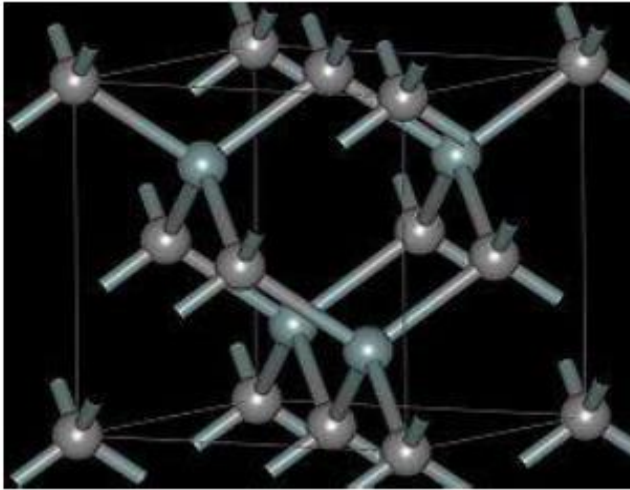
Figure.1 Structure of major SiC polytypes (β) 3C-SiC
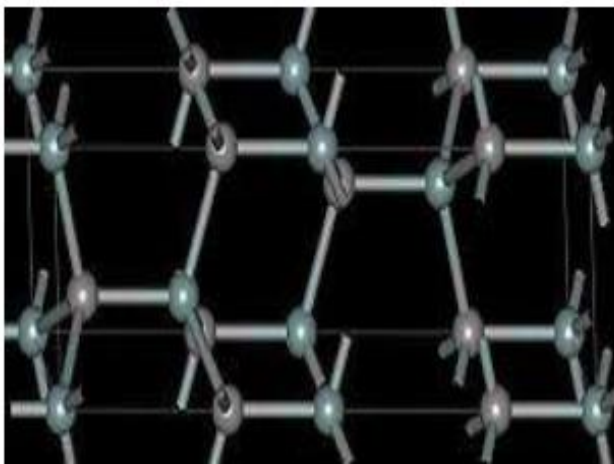

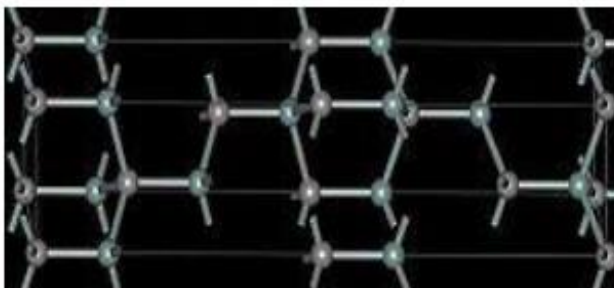**Figure.2** Structure of major SiC polytypes 4H-SiC

Figure.3 Structure of major SiC polytypes (α) 6H-SiC

From the Fig.1,2,3 it could be observed that the Alpha silicon carbide (α-SiC) is the most commonly encountered polymorph; it is formed at temperatures greater than 1700 °C and has a hexagonal crystal structure (similar to Wurtzite). The beta modification (β-SiC), with a zinc blende crystal structure (similar to diamond), is formed at temperatures below 1700 °C (Muranaka, 2008). Until recently, the beta form has had relatively few commercial uses, although there is now increasing interest in its use as a support for heterogeneous catalysts, owing to its higher surface area compared to the alpha form.

Pure SiC is colorless. The brown to black color of industrial product results from iron impurities. The rainbow-like luster of the crystals is caused by a passivation layer of silicon dioxide that forms on the surface.

The high sublimation temperature of SiC (approximately 2700 °C) makes it useful for bearings and furnace parts. Silicon carbide does not melt at any known pressure. It is also highly inert chemically. There is currently much interest in its use as a semiconductor material in electronics, where its high thermal conductivity, high electric field breakdown strength

and high maximum current density make it more promising than silicon for high-powered devices (Baliga, 1993) SiC also has a very low coefficient of thermal expansion(4.0×10^{-6}/K) and experiences no phase transitions that would cause discontinuities in thermal expansion (Goh, 2008).

Table 1 Properties of Major SiC Polytypes

Polytype	3C (β)	4H	6H (α)
Crystal structure	Zinc blende	Hexagonal	Hexagonal
Pearson symbol	cF8	hP8	hP12
Lattice constants (Å)	4.3596	3.0730;	3.0730
Density (g/cm^3)	3.21	3.21	3.21
Band gap (eV)	2.36	3.23	3.05
Bulk modulus (Gap)	250	220	220
Thermal conductivity	3.6	3.7	4.9

Silicon carbide exists in about 250 crystalline forms. The polymorphism of SiC is characterized by a large family of similar crystalline structures called poly types. They are variations of the same chemical compound that are identical in two dimensions and differ in the third. Thus, they can be viewed as layers stacked in a certain sequence as shown in Table 1.

The Literature reveals that most of the studies that has proposed in their journal of improved processing of carbon nanotubes/magnesium alloy composites. In this study, a two-step process was applied. In first stage, a block copolymer was used as a dispersion agent to pre-disperse multiwall carbon nanotubes (MWNTs) on Mg alloy chip. Then the chip with the well dispersed MWNTs on their surface were melted and at the same time vigorously stirred. The molten MWNT Mg alloy composites were poured into a cylindrical mould to solidify quickly. For the pre-dispersion step, the microstructures of the Mg alloy chip were studied under SEM. MWNTswere quite successfully dispersed on the surface of the Mg alloy chips. The mechanical properties of the MWNT/Mg composites were measured by compression testing. The compression at failure, the compressive yield strength and ultimate compressive strength have all been improved significantly up to 36% by only adding 0.1wt% MWNTs to the Mg alloy.

C.S.Goh Wei, et al., (2008) has proposed in their journal of Development of novel carbon nanotubes reinforced magnesium nanocomposites using powder metallurgy technique. Carbon nanotubes (CNTs) reinforced magnesium nano composites were synthesized using the powder metallurgy technique followed by hot extrusion. Up to 0.3 wt% of CNTs were added as reinforcements. The effects of carbon nanotubes on the physical and mechanical properties of Mg were investigated. The thermo mechanical property results show an increase in thermal stability with increasing amount of CNTs in Mg nano composite. Mechanical property characterizations reveal an improvement of yield strength, ductility and work of fracture with higher weight percentages of CNTs incorporated. An attempt is made to correlate the phySiCal and mechanical properties with the increasing weight fractions of carbon nanotubes in pure Mg matrix.

Hansang Kwon,et al., (2009) has proposed in their journal of Investigation of carbon nano tube reinforced aluminum matrix composite material. In this journal the tensile strength without compromising the elongation of aluminum (Al)–carbon nano tube (CNT) composite by a combination of spark plasma sintering followed by hot-extrusion processes.

Contemplation of Mechanical and Thermal Properties of Aluminum (1100) with Silicon Carbide

From the micro structural viewpoint, the average thickness of the boundary layer with relatively low CNT incorporation has been observed by optical, field-emission scanning electron and higher solution transmission electron microscopes. Significantly, the Al–CNT composite showed no decrease in elongation despite highly enhanced tensile strength compared to that of pure Al. We believe that the presence of CNTs in the boundary layer affects the mechanical properties, which leads to well-aligned CNTs in the extrusion direction as well as effective stress transfer between the Al matrix and the CNTs Due to the generation of aluminum carbide. Following test have been undertaken like Tensile strength with no degradation of elongation in Al–CNT composite containing 1 vol% CNT due to successful control of the boundary layer. The boundary layers of the composites were around 100 nm on average. In particular, a small quantity of aluminum carbide was generated in the boundary in tube and sand-particle shapes, which may assist effective load transfer from the matrix to the CNTs through chemical bonding.

E. Carreño-Morelli,et al., (2004)has proposed in their journal of Carbon nanotube/magnesium composites. The Resonant measurements showed an improvement of about 9% in the Young's modulus of Mg–2wt%CNTs (38.6 ± 0.7 Gap) compared with unreinforced sintered Mg (35.3 ± 0.8 Gap). The stress-strain curves measured in tensile tests exhibit a ductile metallic behavior, which suggests good bonding between carbon nanotubes and magnesium matrix. The yield strength $\sigma 0.2$, rupture strength σ TS and strain after fracture if, are similar to those measured in sintered magnesium. Scanning electron microscopy of the fracture surface of a Mg–2wt%CNT specimen reveals that carbon nanotubes are uniformly dispersed in the magnesium matrix. This uniform dispersion of reinforcement, together with the overall performance of the processed composites show that potential Sources of weakness as nanotube agglomerates can be avoided by appropriate mixing and sintering.

A.M.K. Esawi,et al., (2010)has proposedin their journal ofEffect of carbon nanotube (CNT) content on the mechanical properties of CNT-reinforced Aluminum composites. In this study, dispersion of SICs within an Aluminum matrix was achieved using high energy ball milling for 30 min at 400 rpm. Such conditions were found to be generally effective in dispersing the CNTs while limiting strain hardening of the Aluminum powder. Mechanical properties were found to improve significantly with the increase in CNT content and either exceeded or were close to predicted values based on composite theory except at 5 wt. % when the mechanical properties fell short of predicted values. Due to the thermal processing of the samples, carbide formation was observed for the samples containing 5 wt.% CNT. At large volume fractions, the large aspect ratio CNTs used in the present study were found to have a tendency to agglomerate and thus were difficult to disperse. The agglomeration has in turn affected the attained mechanical properties, which although were improved compared to pure Aluminum , were observed to either stay the same or go down at 5 wt. %. Ongoing and future work includes studying the effect of the aspect ratio of CNT and CNT quality as well as degree of interfacial reactions on the strengthening of the Aluminum matrix. Optimization of the ball milling conditions is also being conducted in order to find the most favourable conditions for CNT dispersion coupled with limited cold working of the matrix as well as minimum damage to the CNTs. Achieving improved dispersion at high CNT contents is also being investigated.

A. Esawi,et al., (2006) hasproposed in their journal ofDispersion of carbon nanotubes (CNTs) in Aluminum powder. One of the key issues in the development of CNT/metal matrix composites is controlling the agglomeration of the nanotubes. This has been a major impediment facing the development of these new materials. The results presented in this paper demonstrate that mechanical alloying is a promising technique to overcome this problem. The SEM results showed that the usual CNT clustering often observed when using Tubular mixing was eliminated; moreover, individual nanotubes were observed embedded in the Aluminum matrix after 48 h of milling which did not appear to be damaged by the selected milling intensity (200 rpm) and ball-to-powder ratio (10:1). Very large particle sizes were however obtained after prolonged MA due to the high CNT–Al composite particle ductility which promotes excessive cold-welding. The authors however believe that with an increase in CNT content the composite particles will become less ductile and much lower particle sizes should be obtained, which would then be more suitable for subsequent sintering processes. Another way to reduce the excessive particle welding is to use a process control agent, which are typically used in the MA field. These are however the subject of ongoing investigations by the authors.

II. MATERIALS AND METHODS

2.1. Material Used

The metals identified for the present study are
- Aluminum [1100] (Al).
- Silicon carbide (SiC).

2.2. Experimental Procedure

The components present over in melt stirring machine are Furnace, heating element, sample crucible, mechanical stirrer, argon inlet, argon outlet.

The block copolymer disperbyk-2150 was first dissolved in ethanol in a small beaker. Then SiCs were added to the as-prepared solution. This mixture was put at room temperature into an ultrasonic bath for 15 min. Then it was stirred for 30 min at 250 rpm. After adding Al chip the suspension was further stirred at 250 rpm inside a fume cupboard to evaporate ethanol and homogenize the mixture.

After the mixture was dried, the SiC coated chips were placed in a cylinder sample crucible. This crucible was placed into an oven and heated up to 650 c under an inert gas atmosphere to avoid oxidation. When the Al chips were molten, the liquid was mechanically stirred at 370rpm for 30min to further disperse SiCs. After stirring, the molten SiC/Al composite was poured into a mould. The cooled sample was machined to cylinder shaped specimens for subsequent tests. Reference sample were made using exactly the same procedure but from pure Al.

2.3. Rockwell Hardness Testing Equipment

The Rockwell hardness test method consists of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter is forced into the test material under a preliminary minor load F0 usually 10kgf. When equilibrium has been reached, an indicating device, which follows the movement of the indenter and so responds to changes in depth of penetration of the indenter, is set to a datum position.

When the preliminary load is still applied an major load is applied with resulting increase in penetration. When equilibrium has again been reached, the additional major load is removed but the preliminary minor load is still remained. Removal of additional major load allows a partial recovery, so reducing the depth of penetration. The permanent increase in depth of penetration, resulting from the application and removal of the additional major load is used to calculate the RHN.
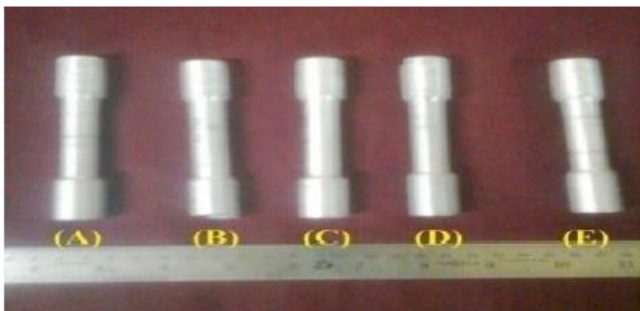
2.4. Tensile Test Equipment

The tensile properties of the Al (1100) and nano composite samples were determined in accordance with ASTM test method E8M-01 the specimen prepared to conduct tensile test for Al – SiC composites. Experiments have been conducted by varying Wt fraction of SiC (5%,10%,15% and 20%).Tensile test were recorded and tabulated. Tensile test has been conducted on each specimen using a Universal tensile testing machine (Model – UNITEK 94100). The corresponding values of Ultimate tensile strength and Yield strength were calculated from the standard formula.
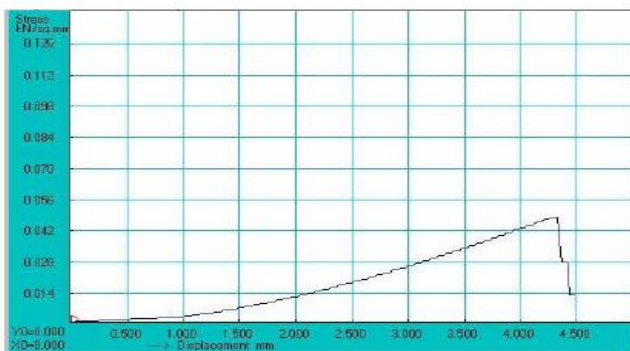
2.5. Coefficient Of Thermal Expansion (Cte)

The coefficients of thermal expansion (CTE) test have been conducted by varying fraction of SiC (5%,10%,15% and 20%) and pure Al (1100) samples were determined by measuring the displacement of the samples as a function of temperature in the temperature range of 50°C to 450°C using an automated DILATOMETER.

III. RESULTS AND DISCUSSIONS

Figure.4 Specimen Prepared for Tensile Test A.) Pure Al B.) Al-5% SiC C.) Al-10%SiC C.) Al-15% SiC 3. D.) Al-20%SiC
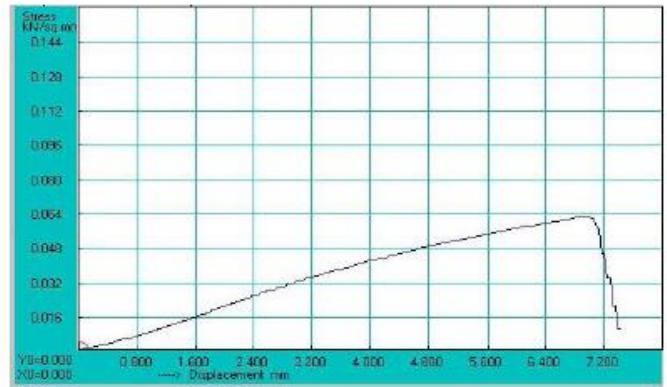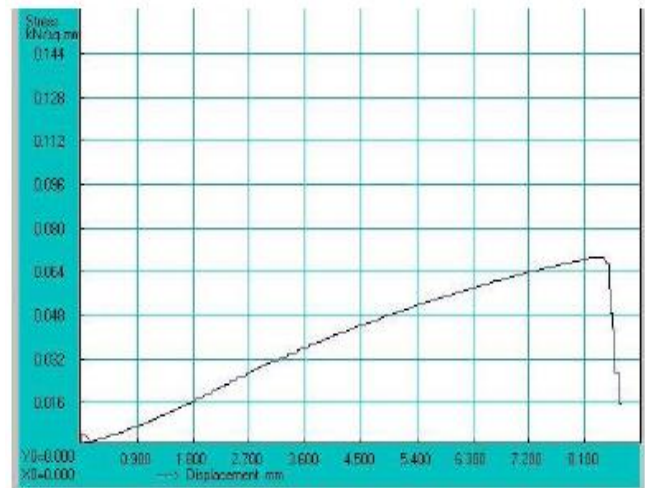
3.1. Tensile Test

Figure 5 Stress Vs Displacement for Pure Al

From the Fig.5, it could be observed that maximum Ultimate tensile strength (UTS) at 48 MPa for pure Al that results at maximum displacement 4.510mm.

From the Fig. 6, it could be observed that maximum Ultimate tensile strength (UTS) at 63 MPafor Al – 5%SiC that results at maximum displacement 7.460 mm
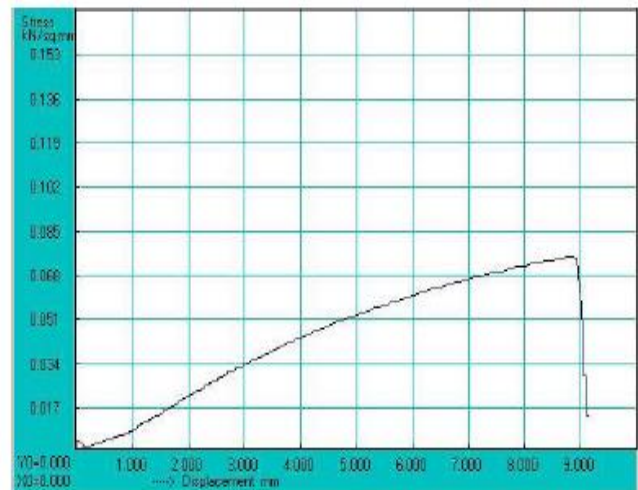

Figure 6 Stress Vs Displacement for Al – 5% SiC

Figure 7 Stress Vs Displacement for Al – 10% SiC

Figure 7, shows that the maximum Ultimate tensile strength (UTS) at 69 MPa for Al – 10%SiC that results at maximum displacement 8.720 mm.

Figure 8 Stress Vs Displacement for Al – 15% SiC

Figure 8, shows that the maximum Ultimate tensile strength (UTS) at 75 MPa for Al – 15%SiC that results at maximum displacement 9.190 mm.

From the Fig. 9, it could be observed that maximum Ultimate tensile strength (UTS) at 74 MPa for Al – 20%SiC that results at maximum displacement 9.250 mm.
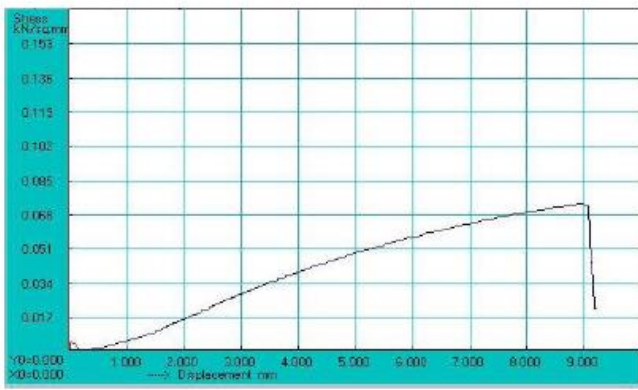
Figure 9 Stress Vs Displacement for Al – 20% SiC

S.No	MATERIAL	PEAK LOAD (kN)	UTS (MPa)	YIELD STRESS (MPa)	ELONGATION %
1	Pure Al	8.487	48	38.4	7.517
2	Al – 5%SiC	12.272	63	50.4	14.533
3	Al –10%SiC	11.102	69	55.2	12.433
4	Al –15%SiC	13.271	75	60	15.417
5	Al –20%SiC	13.001	74	59.2	15.317

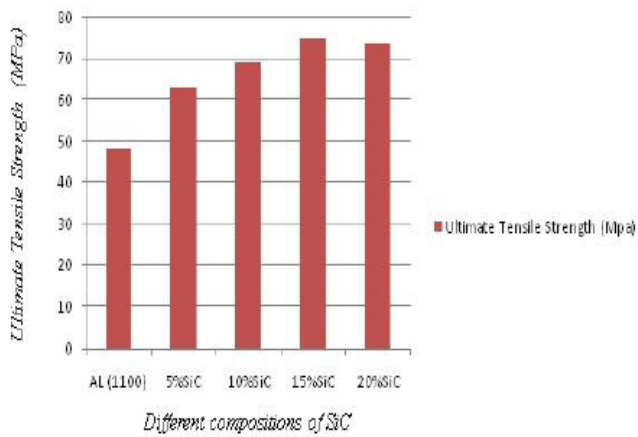**Table 2** Tensile Test Results for Al - SiC Composites

Figure 10 Comparative Bar Chart for Ultimate Tensile Strength with Different Compositions of SiC

Table 2 and Fig.10, illustrate that Ultimate tensile strength increases (UTS)up to 36% while adding 15% of SiC with Al (1100) at a peak load 13.271kN and with increasing amount of SiC, the ductility gradually drops to a level similar to that of pure Al. Breaking load result show that the maximum amount of energy required for breaking is observed for a composition of 15% SiC incorporated. This expenditure of fracture energy for the nanocomposite with 15% SiCs is actually 39% higher than that is observed in pure Al.

Standard Formula:

Yield point (stress) = Yield Load / Original cross sectional area

UTS = Maximum load / Original cross sectional area

Percent Elongation = Total extension / Original gauge Length. (100)

Percent Reduction of Area = Original area- Final area / Original area. (100)

3.2 Rockwell Hardness Test

Hardness test Experiments have been conducted by varying weight fraction of SiC (5%, 10%, 15%, and 20%). Hardness test were recorded and tabulated. Hardness test has been conducted on each specimen using a load of 100Kgf and a steel ball of diameter 1.588mm as indenter.
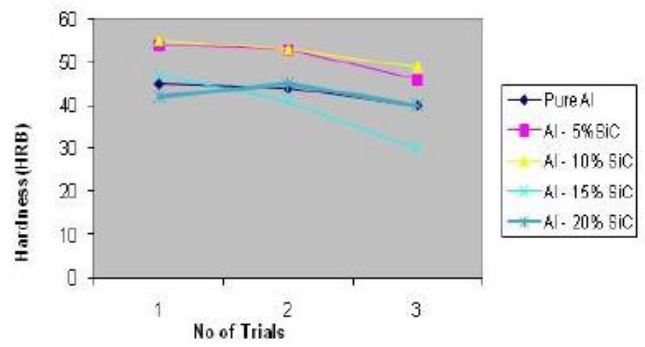

Figure 11. Comparative Analysis of Hardness for Pure Al and Different Composition of SiC.

Table 3 Rockwell Hardness Test for Al – SiC Composites

S.No	MATERIAL	LOAD (Kgf)	ROCKWELL HARDNESS(HRB)			MEAN AVG
1	Pure Al	100	45	44	40	44.5
2	Al – 5%SiC	100	54	53	46	53
3	Al –10%SiC	100	55	53	49	54
4	Al –15%SiC	100	47	41	30	46
5	Al –20%SiC	100	42	45	40	45

The results as indicated in Table 3 and Fig. 11 show the increasing trend of hardness with increase in weight percentage of SiC up to 10% wt fraction. Beyond this weight fraction the hardness trend started decreasing as SiC particles interact with each other leading to clustering of particles and consequently settling down. Eventually the density of SiC particles in the melt started decreasing thereby lowering the hardness. The best value of hardness comes out to be of sample containing 10% SiC i.e. 54 HRB (Hardness).By adding 10% of SiC with Al (1100) the hardness increases up to 18% when compared to pure Al (1100).

3.3 Co-Efficient Of Thermal Expansion

The coefficients of thermal expansion (CTE) test have been conducted by varying weight fraction of SiC (5%, 10%, 15%, and 20%) and pure Al (1100) samples were determined by measuring the displacement of the samples as a function of temperature in the temperature range of 50°C to 450°C using an automated DILATOMETER .
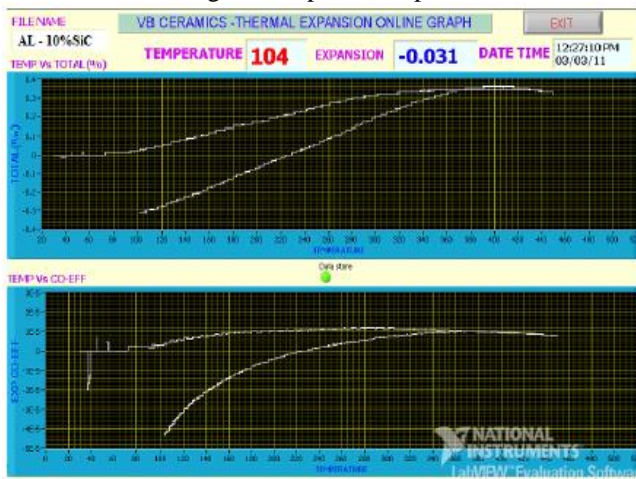

Figure 12 Co-efficient of Thermal Expansion for Pure Al

From the Fig.12, the total percentage of thermal expansion gradually increases up to 0.045 µm/m-℃ for pure Al by increasing the temperature up to 450 ℃.

Figure 13 Co-efficient of Thermal Expansion for Al –5%SiC

From the Fig.13, the total percentage of thermal expansion gradually increases up to 0.043 µm/m-℃ for 5% SiC by increasing the temperature up to 450 ℃.

Figure 14. Co-efficient of Thermal Expansion for Al – 10%SiC

From the Fig.14, the total percentage of thermal expansion gradually increases up to 0.031 µm/m-℃ for 10% SiC by increasing the temperature up to 450 ℃.
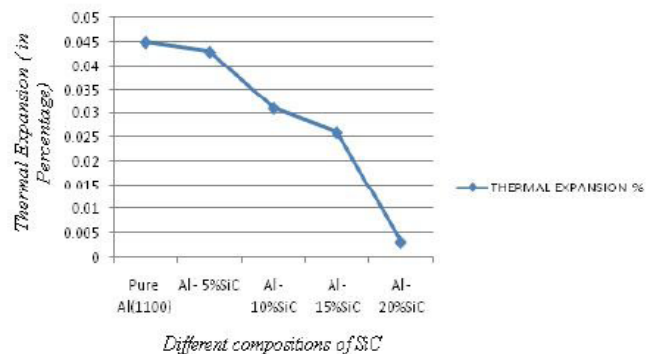

Figure. 15 Co-efficient of Thermal Expansion for Al – 15%SiC

From the Fig.15, the total percentage of thermal expansion gradually increases up to 0.026 µm/m-℃ for 15% SiC by increasing the temperature up to 450 ℃.

Figure 16. Co-efficient of Thermal Expansion for Al – 20%SiC

From the Fig.16, the total percentage of thermal expansion gradually increases up to 0.003 µm/m-℃ for 20%SiCby increasing the temperature up to 450 ℃.

Table 4. Comparison Table for CTE Al – SiC Composites

S.NO	MATERIAL COMPOSITION	CTE µm/m-℃
1	Pure Al	0.045
2	Al + 5% SiC	0.043
3	Al + 10% SiC	0.031
4	Al + 15% SiC	0.026
5	Al + 20% SiC	0.003

Figure 17. Comparative line chart for CTE with different compositions of SiC

Table 4 and Fig.17 illustrate that with addition of SiC up to 20% with pure Al, The CTE of the Al-SiC composite decreases by approximately 90%. It has been shown by Ruoff (R.S.Ruoff, 1995), that the radial coefficient of thermal expansion of SiC is essentially the same as the on-axis coefficient of thermal expansion. This desirable thermal property of SiC could result not only in more thermally stable Al-SiC composites, but also in composites that have isotropic thermal expansion.

IV. CONCLUSION

In the present work reinforcement of SiC in light Aluminum using melt stirring method. The different compositions of specimens Al with 5%, 10%, 15% and 20% were prepared. The mechanical and thermal properties of composites were investigated. The Improvement of mechanical properties has been compared with pure Al. The experimental study reveals following conclusions.

The result of study suggests that with increase in compositions of SiC with Al shows increase in Mechanical properties has been observed.

Hardness Test

The improved result for hardness has been obtained at Al – 10%wt fraction SiC (54 HRB). When compared with pure Al, hardness value increases up to 18% respectively.

Tensile Test

The improved result for UTS has been obtained at Al – 15%wt fraction SiC (75 Mpa). When compared with pure Al, UTS increases up to 36% respectively.

Co-Efficient Of Thermal Expansion

Co-efficient of thermal expansion result indicates that Al – SiC and Al – MWNTs, nanocomposite are thermally more stable than pure Al (1100).

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REFERENCES

[1]. Andreas Viereckl., Goh,C. S., Wei,J., Lee, L. C., Gupta, M.,and Qianqian Li, (2009)"Improved processing of carbon nanotubes/ magnesium alloy composites",Vol.69, pp.1193-1199.

[2]. Bhatnagar, M.,Baliga, B.J., (March 1993)"Comparison of 6H-SiC, 3C-SiC, and Si for power devices",Vol.40 (3), pp. 645–655.

[3]. Carreno-Morelli,E.,Yang,J.,and Couteau,E.,(2004)"Carbon nanotube/magnesium composite", Vol.8, pp.53-55.

[4]. Esawi, A., Morsi, K.,(2010) "Effect of carbon nanotube content on the mechanical properties of CNT- reinforced Aluminum composites", Vol.70, pp.500-507.

[5]. Esawi, A., Morsi, K., (2006) "Dispersion of carbon nanotubes (CNTs) in aluminum powder", Vol.38, pp.646-650.

[6]. Flahaut, E., Bacsa, R., Peigney, A., Laurent, C., (2003). "Gram-Scale CCVD Synthesis of Double-Walled Carbon Nanotubes".Vol.12, pp. 1442–1443.

[7]. Goh, C.,Wei, J.,Lee,L., and Gupta, M.,(2008)"Development of novel carbon nanotubes reinforced magnesium nanocomposites using powder metallurgy technique", Vol.9, pp. 130-135.

[8]. Hansang kwon,Peigney, A., (2009) "Investigation of carbon nanotube reinforced aluminum matrix composite materials", Vol.70, pp.546-550.

[9]. Jensen, J., Mickelson,W., Kis, A., and Zettl,A.,(2007)"Buckling and kinking force measurements on individual multiwalled carbon nanotubes",Vol.76, pp. 230-240.

[10]. Liu,Q., Ren,W., and Chen,Z., Yin, L.,(2009). "Semiconductingpropertiesofcup-stackedCNT", Vol.47, pp.340-345.

[11]. Mintmire, J.W., Dunlap, B.I.,and White, CT., (1992). "Are Fullerene Tubules Metallic", Vol.68, pp. 631-634.

[12]. Muranaka, T., (2008). "Superconductivity in carrier-doped silicon carbide", Vol.9, pp.35-45.

[13]. Park.,Yoon-Soo.,(1998). "SiC materials and devices",Vol.65, pp. 20–60.

[14]. Qianqian Li ., Christian, A., Rottmair., Robert, F., (2010) "CNT reinforced light metal composites produced by melt stirring and by high pressure die casting", Vol.500, pp.200-210.

[15]. Shen, Y.L., Williams, J.J., Piotrowski, G., Chawla, N. and Guo, Y.L., (2001), "Correlation between tensile and indentation behavior of particle reinforced metal matrix composites: a numerical and experimental study," Vol. 49 (16), pp. 3219-3229.

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