A Study of Microstructure and Mechanical Properties of Aluminium Silicon Carbide Metal Matrix Composites (MMC's)

Mr.Manjunath.C.Melgi [1] and Dr.G.K.Purohit [2]

[1] *M.Tech in production engineering, Department of Mechanical Engg, PDA College of Engg, Gulbarga.*

[2] *Head of the Department, Department of Mechanical Engg, PDA College of Engg, Gulbarga.585 102.*

ABSTRACT

In the present study, silicon carbide particulate reinforced LM6 alloy matrix composites were produced by gravity die casting process by varying the particulate addition by weight fraction on percentage basis. Mechanical properties such as tensile, impact and wear test studies were conducted to determine the tensile strength, ductility, toughness and wear characteristics of cast MMC's. Micro structural properties of the as cast composites have also studied by using optical microscope. The experimental result reveals that the tensile property increases with increase in Sic, the toughness of composite decreases as silicon carbide percentage increases and the composite showed accountable increase in wear rate of cast MMC.

INTRODUCTION

Aluminium is the most abundant metal and the third most abundant chemical element in the earth's crust, comprising over 8% of its weight. Aluminium alloys are broadly used as a main matrix element in Composite materials. Aluminium alloys for its light weight, has been in the net of researchers for enhancing the technology. The broad use of aluminium alloys is dictated by a very desirable combination of properties, combined with the ease with which they may be produced in a great variety of forms and shapes[1].A composite is a material made with several different constituents intimately bonded. a composite is a material that consists of constituents produced via a physical combination of pre-existing ingredient materials to obtain a new material with unique properties when compared to the monolithic material properties. Composite materials are composed of at least two phases; a matrix phase and a reinforcement phase. Matrix and reinforcement phase work together to produce combination of material properties that cannot be met by the conventional materials. It is very important to study the composite materials because it is the material for advanced technology, high temperature application where high strength / stiffness to-weight ratio is required. Composite Technology combines the most important properties of the components together in order to obtain a material with overall properties suitable for the design of the engineering part required. So it is a technology where you can tailor the material for the purpose set up. A lot of work was done in this subject for the last decades since the production advances was highly affected by composites where you can tailor material properties as you need by mixing two different materials without chemical reaction. Most of the studies on metal matrix composites (MMC) has focused on aluminium (Al) as the matrix metal. The combination of lightweight, environmental resistance and adequate mechanical properties has made Al and its alloys composites very popular. The melting point of aluminium is high enough to satisfy many application requirements, yet low enough to render composite processing reasonably convenient. It can accommodate a variety of reinforcing agents [2]. It has been proved that particle reinforced aluminium matrix composites can improve considerably the strength and hardness of aluminium and its alloys. However, at the same time, the plasticity and ductility can substantially reduced. This will severely affect the safety and reliability of components fabricated from Al matrix composites (AMCs). In aluminium matrix composites system (AMCs), one of the constituent is aluminium/ aluminium alloy, which forms percolating network and is termed as matrix phase. The other constituent is embedded in this aluminium/ aluminium alloy matrix and serves as reinforcement, which is usually non-metallic and commonly ceramic such as Sic and Al2O3. Properties of AMCs can be tailored by varying the nature of constituents and their volume fraction [3].

2. EXPERIMENTAL PLAN

2.1 Material

The discontinuous reinforced metal matrix composite material selected for present investigation was based on LM6 matrix alloy, designated by the British standards. The alloy in ingot form was converted into discontinuous flake form for convenience to use it in weight percentage. The nominal chemical composition (in % wt) of the matrix alloy is given in the table1. The reinforcement was silicon carbide particles in powder form of size 150 microns was used as a dispersoid. Liquid metallurgy method was used for processing of the composite.

Table.1.Chemical Composition of LM6 alloy.

Elements	Percentage (%)
Si	10-13.0
Cu	0.1
Mg	0.1
Fe	0.6
Mn	0.5
Ni	0.1
Zn	0.1
Pb	0.1
Sb	0.05
Ti	0.2
Al	Remaining

2.2 Preparation of composite

In the present investigation the matrix material in the flake form was used by weight percentage. The material was weighed before melting using digital weighing machine. Crucible made of graphite was used to melt pre weighed matrix material. Silicon carbide (black) with two weight percentage of 5% & 15% were used in matrix alloy. In this process, matrix alloy (LM6) was first superheated above its melting temperature in induction furnace. The temperature is lowered gradually below the liquidus temperature to keep the matrix alloy in the semisolid state. At this temperature, preheated silicon carbide powder (450 deg) was introduced into the slurry & mixed manually. Manual mixing was used because; it is very difficult to mix using automatic device when the alloy is in semi liquid state. After sufficient manual mixing, the composite slurry temperature was increased to fully liquid state & stirring was continued with mild steel impeller to about five minutes at a speed of 400 rpm. The melt was then superheated above liquidus temperature & finally poured into the cast iron permanent mould.

Fig.1. Stir Casting setup

Fig.2. Cast iron die

3. RESULTS & DISCUSSION

3.1 Microstructure

The micrograph illustrating the microstructure of the metal matrix composites was used in this investigation. Samples for the microscopic examination were prepared by standard metallographic procedures etched with Keller's reagent under optical microscope. The optical microstructure of as cast LM6 alloys, LM6/5%/Sic and LM6/15%/Sic composite are near uniformly distributed as shown in fig 4(a), (b) and (c).

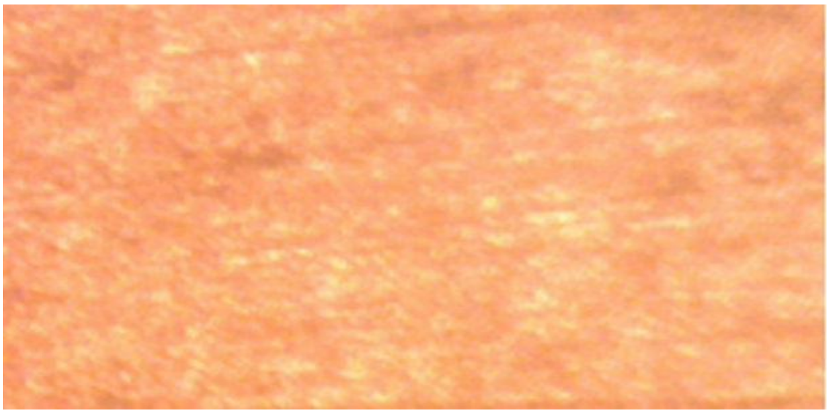


Fig 3(a). LM6 alloy

Fig.3(b). LM6 with 5 % Sic

Fig. 3(c). LM6 with 15 % Sic

3.2 Impact tests

Impact test are designed to measure the resistance of failure of a material to a suddenly applied force. The test measures the impact energy, or the energy absorbed prior to fracture. Charpy V test was conducted to study the behaviour of composite with specimen of size 10mm X 10mm X 55mm as per **ASTM A370** as shown in figure.5. The variation of toughness with silicon carbide in LM6 alloy is shown in fig.8

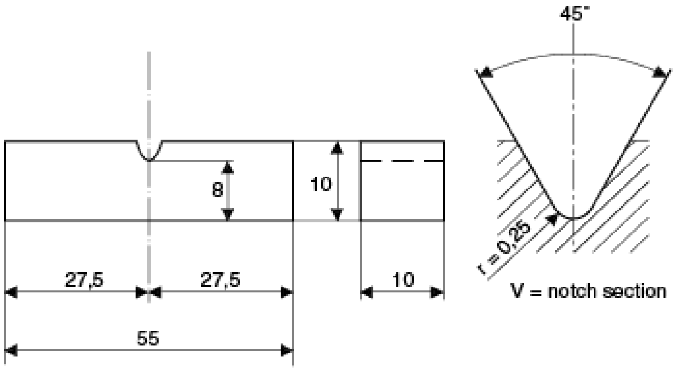
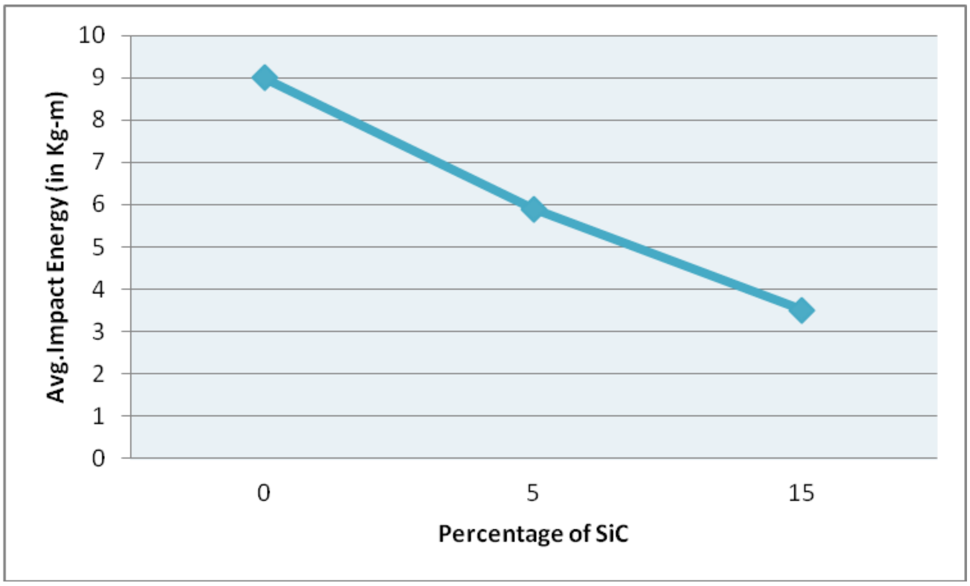


Fig.4. Specimen dimension for charpy V test

Fig.5. Impact testing machine

Fig.6. Impact energy shown in the scale



Graph.1. Average energy consumed (in kg-m) with varying % of SiC

3.3 Tensile test

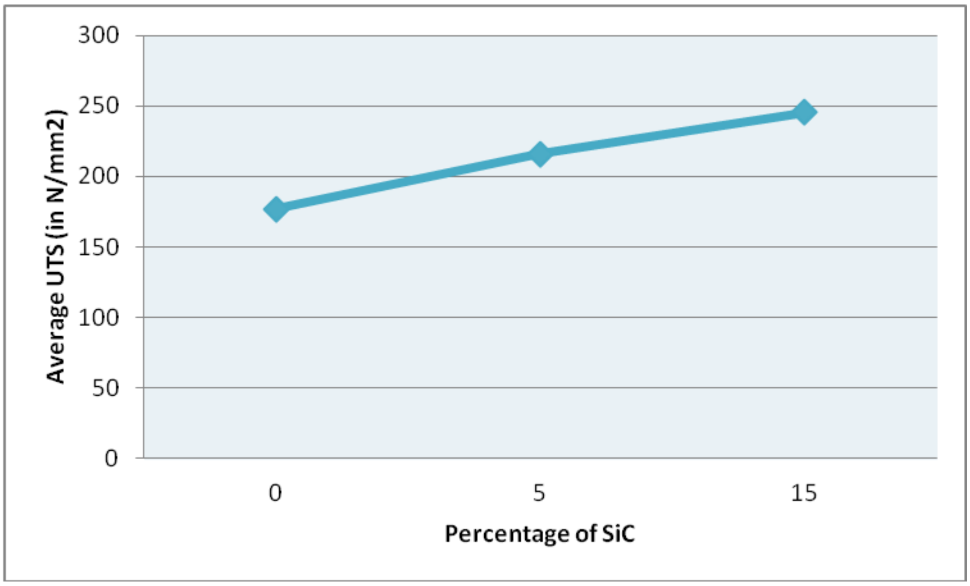
As per **BS:18:1962** the standard round tensile specimens were produced with a guage length of 50mm with tolerance of 0.1mm. Three specimens were tested for each trail and their average reading was noted using universal testing machine (UTM). The behaviour of composite material developed with varying percentage of silicon carbide was studied. The graph depicts the ultimate tensile strength with varying silicon carbide in LM6 base alloy.

Fig.7. Specimen preparation on lathe

Fig.8 (a). Tensile specimen for base LM6 alloy

Fig.8 (b).Tensile specimen with 5% SiC in lm6 alloy

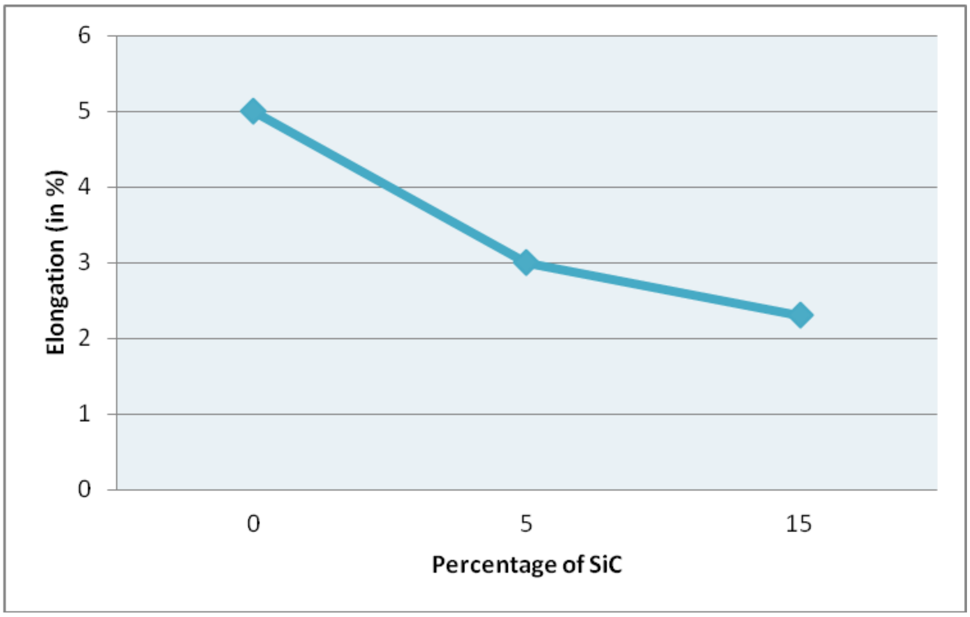
Fig.8(c).Tensile specimen with 15% of SiC in base lm6 alloy



Graph.2. Average tensile strength with varying percentage of SiC

3.4. Ductility

Ductility is a measure of how much strain a material can take before rupturing. A material with high ductility will be able to be drawn into long, thin wires without breaking. Figure.11 shows the percentage elongation of composite material with varying percentage of silicon carbide. Elongation for Unreinforced alloy is also shown. We can see that elongation decreases with increase in weight percentage of SiC, due to increase in hardness of cast composite.

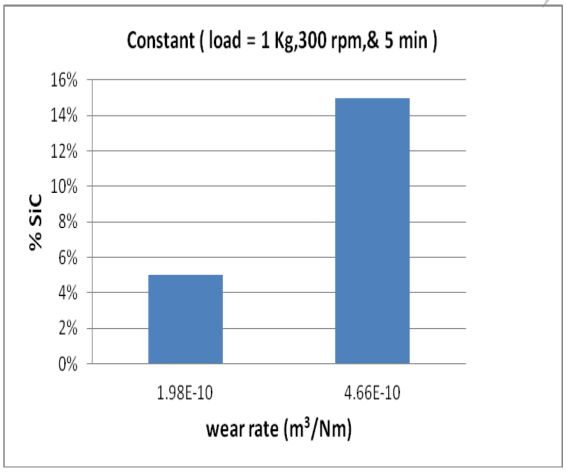


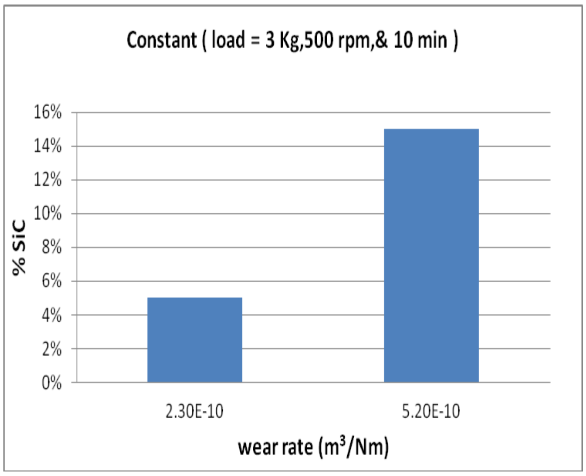
Graph.3.Percentage Elongation with varying % of SiC

3.5 Wear Test

For accounting wear behaviour of produced composite standard specimens of size Φ8mmX 24mm length was prepared on lathe machine Wear test was performed on Pin-on-Disc wear testing machine in dry sliding condition at atmospheric temperature. Weight of the specimen was measured before and after each reading. Each specimen was examined with two tests with different settings of parameters of wear test viz. rpm, load applied & time.

Fig.9. Wear Test equipment





Graph.4. Abrasive wear with varying percentage of SiC for different parameters

4. CONCLUSIONS

Based on the experimental evidence from this research work the following conclusions have made and listed below:

1. The results of the study suggest that with the increase in weight percentage of SiC, an increase in tensile strength has observed.
2. Ductility on the other hand suffered. In otherwords, ductility of the prepared MMC decreased with increase in weight percentage of SiC in base alloy.
3. Impact strength of the base alloy LM6 is high. When the reinforcing material SiC (with 5% & 15%) is added in LM6 alloy, the impact strength is reduced note ably.
4. The abrasive wear resistance of MMC has increased with increase in SiC content. But wear has increased with increase in sliding velocity and normal load.
5. The microstructural results reveal that the silicon carbide particles have near uniformly distributed throughout the MMC castings.

5. FUTURE SCOPE:

This experimental work can be extended by studying:

1. Corrosion behaviour testing of composite.
2. Torsion test to evaluate plastic & fatigue behaviour of the prepared cast.
3. Fractional factorial design for wear rate.

REFERENCES

[1] *Studies on Mechanical Properties and Tribological characteristics of LM25-Graphite-Silicon Carbide and LM25-Flyash-Silicon Carbide –Hybrid MMC's* by Basavaraju.S, Arasukumar.K, Dr.Chandrashekhar Bendigeri, Dr.C.K.Umesh.

[2] *Strengthening of Aluminium by SiC, Al2O3 And MgO* by A.R.I. Khedera,G.S. Marahleh, D.M.K. Al-Jameaa.

[3] *Mechanical properties Of MMC'S- An Experimental Investigation* by S.Basavarajappa, G.Chandramohan, A. Dinesh.

[4] Effect of magnesium enhancement on mechanical property and wear behaviour of lm6 aluminium alloy by R. S. Rana and Rajesh Purohit Mechanical Engineering Department, Maulana Azad National Institute of Technology, Bhoapl-462051. E-mail: ravindrarana74@gmail.com, r_purohit73@hotmail.com, International Journal of Scientific & Engineering Research Volume 3, Issue 7, July-2012 ISSN 2229-5518.

[5] *Mechanical properties of the as-cast silicon carbide particulate reinforced aluminium alloy Metal matrix Composite* by Sourav Kayala, R. Beherab, G.Sutradhara. International journal of current engineering & technology, Vol.2, No.3 (sept 2012)

[6] *Study of abrasive wear behaviour of Al-Si (12%)-sic metal matrix composite synthesised using vortex method* by M.Ramachandra and K. Radhakrishna. International Symposium of Research Students on Materials Science and Engineering December 20-22, 2004, Chennai, India. Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras.

[**7**] "*Castability of al-sicp metal matrix composites in thin walled castings*" by SOURAV KAYAL, RABINDRA BEHERA AND G SUTRADHAR, International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462 Vol. 4 No.07 July 2012, pages 3481-3488.