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CASTING AND CHARACTERIZATION OF ALUMINIUM BASED METAL MATRIX COMPOSITE

[1]Virendra Kumar Sharma, [2]Dr. D. K. Rao

[1]PhD Scholar (PT), [2]Associate Professor

Mechanical Engineering Department,

Institute of Engineering & Technology, Dr. R.M.L. Avadh University Ayodhya

Abstract: Composite materials which main constituent part is a metal are called Metal Matrix Composites. The other compounds may be metal too, ceramics or even organics. They are well known for their excellent thermo physical and mechanical properties. Reinforcement is used to improve different properties of main material, such as wear resistance, hardness, fatigue resistance, friction coefficient, thermal conductivity and others.As a result, during the last years, MMCs have found a lot of application in automobile industry for the production of breaks and parts of engines and in aerospace industry for the production of structural components, as well as in electrical and electronic industry and in many other applications. MMCs can be produced by many ways, such as, powder blending and consolidation, foil diffusion bonding, electroplating, spray deposition, stir casting and others. In this research stir casting was used as processing technique for the production of Aluminum Metal Matrix composites reinforced by silicon carbide (SiC) particles.The morphologies of the produced composite material were examined using optical microscope. And also, mechanical properties like hardness and tensile strength of developed composite material with varying SiC weight percentage were tested. The composite was prepared by “Stir Casting Method”. Mechanical properties of the samples are measured and validated. The tested samples are examined using Scanning Electron microscope (SEM) for the characterization of microstructure on the surface of composites. The results of the research work show that the proposed composites are compared with Al based metal matrix composites at corresponding values of test parameters.

Index Terms- Stir casting method, Al 6061, Metal Matrix Composite, silicon carbide, Optical Microscopy Test, Micro Hardness Tester.

I. Introduction

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density etc. 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 significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersions used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. It is therefore expected that the incorporation of fly ash particles in aluminium alloy will promote yet another use of this low-cost waste by-product and, at the same time, has the potential for conserving energy intensive aluminium and thereby, reducing the cost of aluminium products. Now a days the particulate reinforced aluminium 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 aluminium matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys. The particulate composite can be prepared by injecting the reinforcing particles into liquid matrix through liquid metallurgy route by casting. Casting route is preferred as it is less expensive and amenable to mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. The only problem associated with this process is the non uniform distribution of the particulate due to poor wet ability and gravity regulated segregation. Mechanical properties of composites are affected by the size, shape and volume fraction of the reinforcement, matrix material and reaction at the interface. A **Composite material** (also called a **composition material** or shortened to **composite,** which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

II. Objective of the Composite Materials

The Objective of Composite Materials can be summarized as follows:

i. Hardness increases with increase in reinforcement particulate of silicon carbide .
ii. Increase in yield strength and tensile strength at room temperature and above while maintaining the minimum ductility or rather toughness.
iii. Increase in creep resistance at higher temperatures compared to that of conventional alloys.

III. Experimental Materials

Aluminium Alloy 6061 and SiC Partical use in this study :

Properties of Al Alloy -Density 2.70g/cm^3 , Melting Point 650^{0}C, Thermal Expansion 23.4*10^{-6}/K, Modulus of Elasticity 70GPa, Tensile Strength 260 Min MPa, Hardness Brinell 95HB.

PROPERTIES OF SILICON CARBIDE are Melting Point 2200-2700˚C, Hardness 2800 Kg/mm2, Density 3.1 g/cm3, Fracture toughness 4.6 MPa etc.

IV. COMPOSITES PREPARATION BY STIR CASTING

A low cost stir casting process has been developed in production lab of Mechanical Engineering department at IIT BHU Varanasi. The schematic diagram of fabricated set-up with different components are given in figure (3). The fabrication of the actual set-up has been done as per the details available in schematic diagram. The maximum rage of furnace temperature was 1000 ^{0}C and maximum stirrer speed was 600 RPM. The furnace has rectangular shape with round opening. Two stepped semi-cylindrical round ceramics bricks were used to cover the opening of the furnace. Speed of stirrer rod was controlled by speed controller. The fabrication process of Al 6061-SiC composites were carried out by stir casting process. The graphical representation of the experimental set up for making of these composites was shown in figure (4). Molten Al 6061+ SiC (Stir Casting) = Al MMC Casting Temperature, °C 650 -820 Stir Casting Different amount of SiC , namely 3%, 6%, 9% and 12% by weight, were added into the Al alloy melt prior to Stir casting.

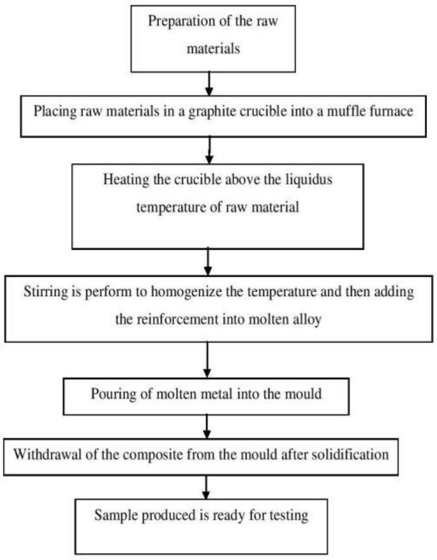


Figure 1: Steps involved in stir casting

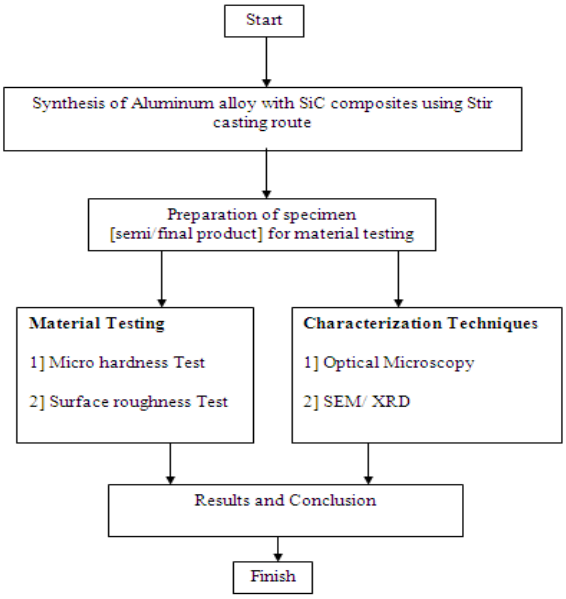


Figure 2: Flow chart of work plan for Experiments

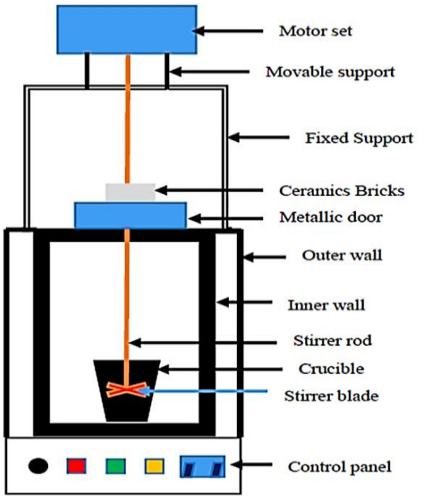


Figure 3: Stir Casting setup

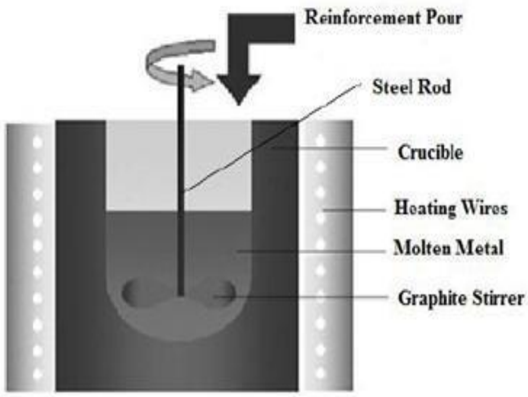


Figure 4: Graphical representation of stir casting

Figure 5: **Muffle furnace and Preparation of samples**

0%SiC 3%SiC 6%SiC 9%SiC 12%SiC

Figure 6: **Work Piece after Casting**

V. EXPERIMENTAL PROCEDURE

Following procedure was followed after the casting preparation

1. Specimens, prismatic in shape with dimensions 10 mm x 10 mm and 10 mm for SEM XRD, Micro hardness and with dimensions 30 mm x 15mm x 5 mm (L x b x t) respectively were cut from the cast composite.
2. Micro hardness of specimen was measured on Vickers Micro hardness testing machine.
3. The SEM and XRD analysis was done for the samples.
4. Analyzing the Microstructure of the specimens by optical microscope and by SEM.

Figure 7: **Surface Grinding**

Figure 8: **Belt Polisher**

Figure 9: **Double Disc Polishing Machine**

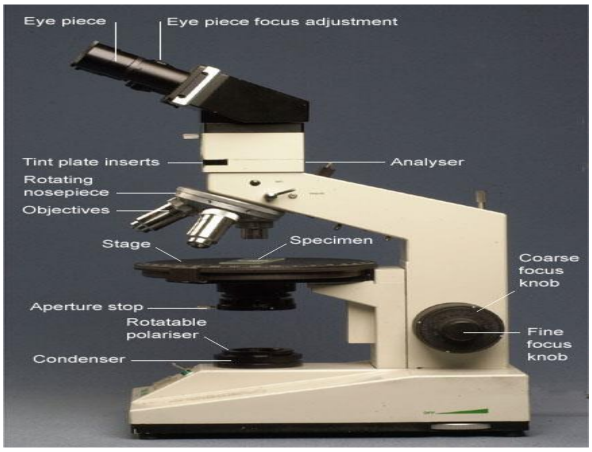


Figure 10: **Optical Microscopy Test**

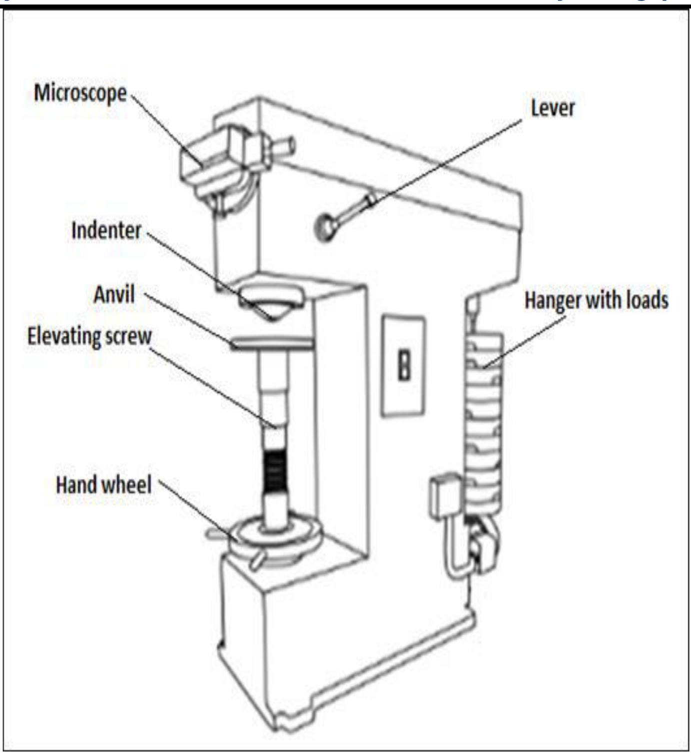


Figure 11: **Micro Hardness Tester**

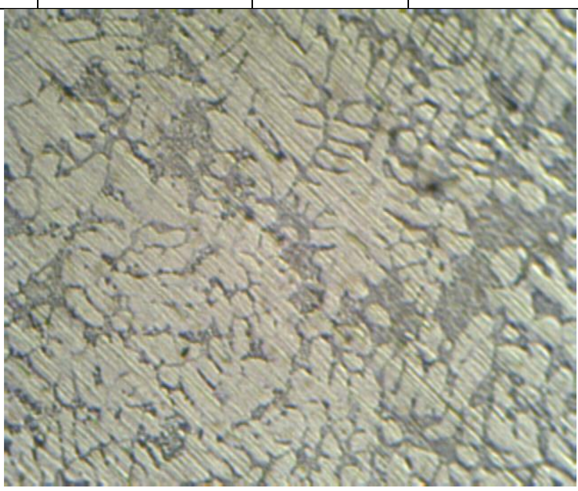
VI. Outline

There are seven chapters in this thesis. Till now, significant work has been done on production of MMCs especially on producing light and durable composites using aluminum. Various works has been done for strengthening aluminum with reinforcements. In this regard, number of researchers conducted experiments on aluminum composite with graphite and SiC reinforcements on various alloys. The issue statement, purpose, and scope of the research are presented in the introductory section of Chapter 1. In chapter two's literature review, the evaluation of prior studies conducted by various researchers. The chapter three is design and fabrication of materials. The chapter four is experimental work done by me and chapter five's are results & discussion. The chapter six are conclusion and chapter seven is the present work will focus on casting and characterization of aluminum alloy reinforcements by SiC.

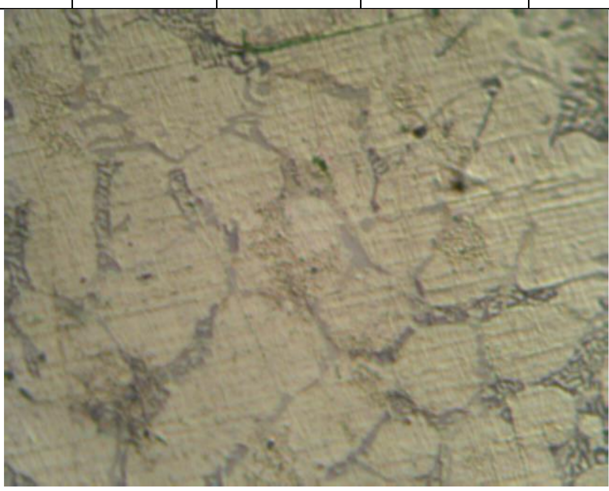
VII. Result and Discussion

Levels of critical parameters

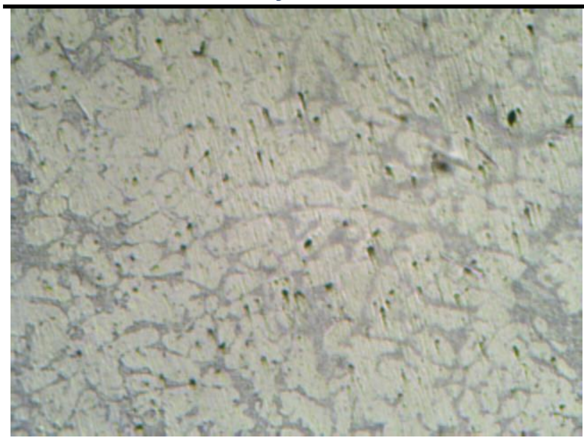
Sr. No.	Factors	Notations	Units	Level 1	Level 2	Level 3	Level 4	Level 5
1	SiC weight %	A	Percentage	0	3	6	9	12
2	Pouring Temperature	B	˚C	660	690	720	750	780
3	Stirring Time	C	Second	20	26	32	38	44

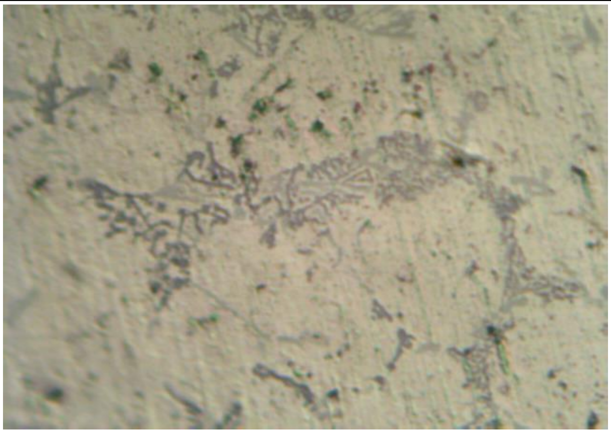


Al 6061 [100X]



Al 6061 [400X]


MMCs 3% SiC [100X]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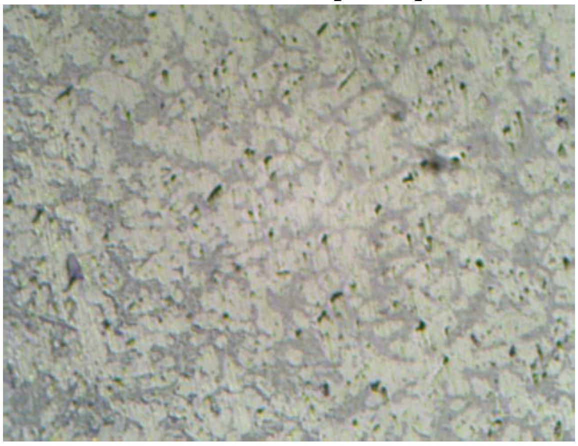
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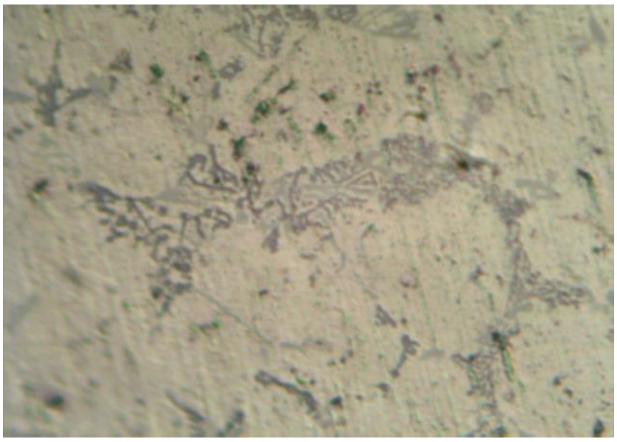
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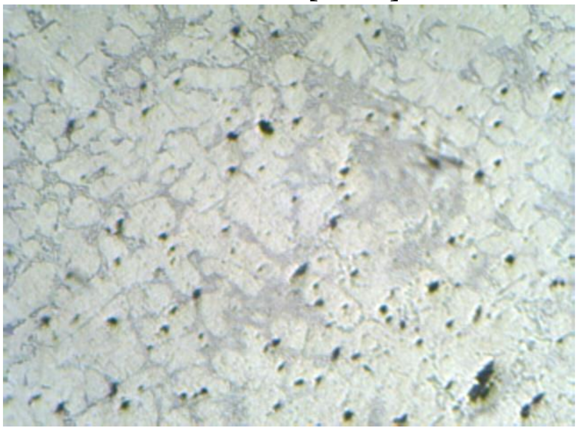
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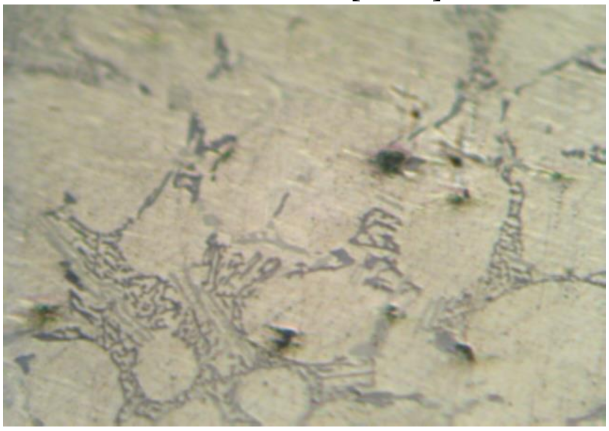
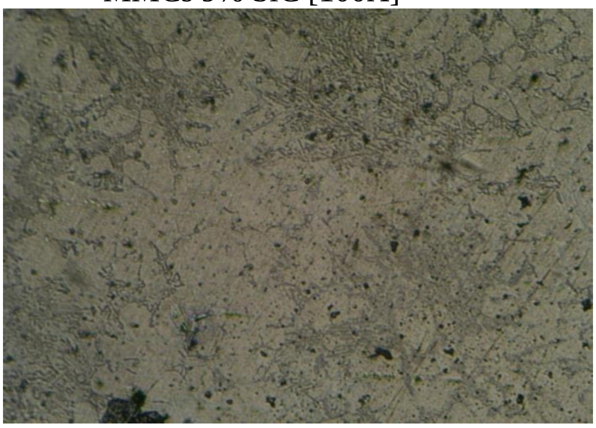

MMCs 9% SiC [400X]


MMCs 12% SiC [100X]

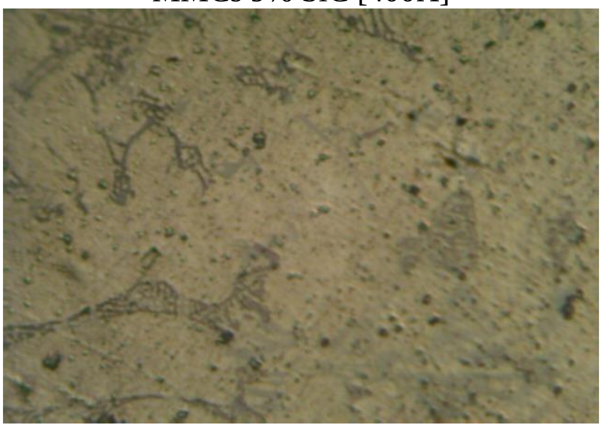

MMCs 12% SiC [400X]

Figure 12: **Optical Micro Structure of MMCs**

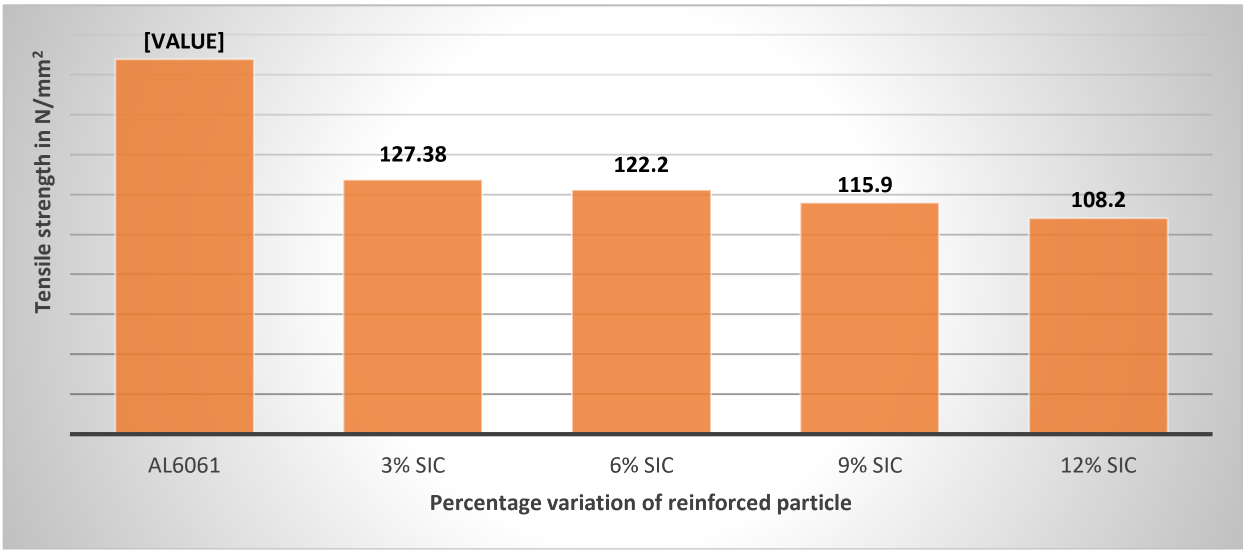


Figure 13: **Tensile Strength**

Specimen	Tensile Strength (N/mm^2)	Hardness HRC
1(3%SiC)	127.38	62
2(6%SiC)	122.2	66
3(9%SiC)	115.9	69
4(12%SiC)	108.2	72

VIII. CONCLUSION

MICROSTRUCTURE- Optical micrographs showed reasonably uniform distribution of SiC particles and this is good agreement with earlier work.

Homogenous dispersion of SiC particles in the Al matrix shows an increasing trend in the samples prepared by applying stirring casting technique.

HARDNESS-

In this current study hardness is measured using Brinell Hardness Testing Machine with 500 Kgf (Load)×10 mm Ball. Range of hardness on desired surface of the part is measured.

Hardness increases with increase in reinforcement particulate of silicon carbide of silicon carbide powder 3wt.% of Silicon Carbide gives hardness 62 HRC, 6 wt. % of Silicon Carbide gives hardness 66HRC, 9 wt. % of Silicon Carbide gives hardness 69HRC And 72 HRC is obtained at 12 wt. % of Silicon Carbide as a reinforcement in aluminum metal matrix.

IX. SCOPE FOR FUTURE WORK

There are numerous industrial machinery parts that should be promoted for superior specific strength and stiffness of MMCs. Still fabrications of MMCs of aluminium.

are not mature. There is a lot of potential for researches especially to optimize the process route, time and cost of production. The following may be the scope of research in the field of Al-SiC MMCs:

1. The gravity casting technique is adopted for investigation of mechanical, machining and wear properties. However improved result can be obtained with better gating system.
2. The prime challenge is controlling the temperature of the melt in the open hearth furnace. Hence the effect of the type of furnace and its temperature control mechanisms are the area of research.
3. In the present work mechanical properties, hardness and impact strength of MMC are investigated. Other mechanical properties as required by the designer for selection of material are to be investigated.
4. Effects of different filler material on the matrix alloy are the areas which are still to be investigated.
5. The effect of mold design, riser design in the production of metal matrix composites may be an interesting field of investigations.
6. The future area of research can include hybrid metal matrix process parameters.
7. Nano SiC MMCs may attract the future researchers.

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