Studies on Properties of Composite Material (Al-Sic MMC) for Valve Development of Light Vehicle Petrol Engine - A Technical Research

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Abstract

Material science and Engineering has experienced a tremendous growth in the field of micron and Nano composites developed with enhanced chemical, mechanical and physical properties. Aluminium based Metal matrix composites (MMCs) are appropriate material for engineering sector which are prepared by powder metallurgy and casting method. The present work described that Al-SiC composite as possible alternate materials with its unique capacity to give required properties for different engineering applications. In this paper, describe the microstructure of Al-6061-T6 (Aluminium alloy) and SiC- 1200 mesh (Silicon carbide powder) composites having 0, 5, & 15 volume percentage are produced by Stir casting method (Liquid metallurgy Route). Mechanical Tests like microstructure, Hardness, Strength etc. will be conducted. After developing MMCs compared properties with various existing material and result revealed that can use this composite material for making valves of light vehicle petrol engine.

Keywords- MMCs, Stir Casting Method, Valves, Properties

I. INTRODUCTION

A. Composite Material

It is a truism that technological of development depends on advances in the field of materials. A composite material (Composition material) is material made from two or more constituent material with significantly different physical and chemical properties that when combined developed a material with different characteristics from the individual components. There are two main classification of constituent materials are matrix and reinforcement. [1]The matrix material supports & surrounds with reinforcement materials by maintain their relative positions. The reinforcement imparts its special mechanical and physical properties to enhance the matrix properties. So, composite material is a combination of a matrix and a reinforcement which gives good properties to the properties of the individual components.

1) Types of Composite Material

1) Composite building materials such as cement, concrete.
2) Fiber reinforced composite (Fibrous composite)
- Single-layer composite including composite having continuous or discontinues fiber reinforced in same orientation and properties in each layer.
- Multi-layer composite including laminates and hybrids composites with multi layers.

3) Metal reinforced composite (Particle composite) including ceramic and metal matrices.
4) Natural and man-made composite materials
5) Carbon fiber and glass fiber reinforced composite materials

B. Metal Matrix Composite (MMC)

A metal matrix composite (MMC) which consists of in soluble alloying with two or more constituents in order. They will be obtain a combination of properties which can't be achieved by main matrix materials. The main difference between composite and an alloy is, in composite constituent materials are insoluble in each other whereas in alloys constituents materials are soluble in each other. After developing a new material which has different properties from their constituents. [3]The ceramic particles reinforced with metallic matrix are termed as new generation material and these can be tailored and engineered with specific required properties for specific requirements in engineering purpose.

1) Experimental Preparation of Al-Sic MMCs

Two major techniques that have been found to suitable for these composites are:

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1) Powder metallurgy
2) Solidification processing (Casting Process)

– Stir casting process

The synthesis of metal matrix composite used in the study was carried out by stir casting process. A Stir casting setup consisted of a resistance muffle furnace and a stainless steel stirrer assembly which was used to synthesize the composite. A stirrer connected to a variable speed vertical drilling machine with range of 80-890 rpm by means of a steel shaft. The stirrer was made by cutting and shaping a stainless steel block to desired shape and size manually and consisted of three blades at an angle of 120° apart. Clay graphite crucible of 1.5kg capacity was placed inside the furnace. The graphical representation of stir casting was shown in Fig-1.

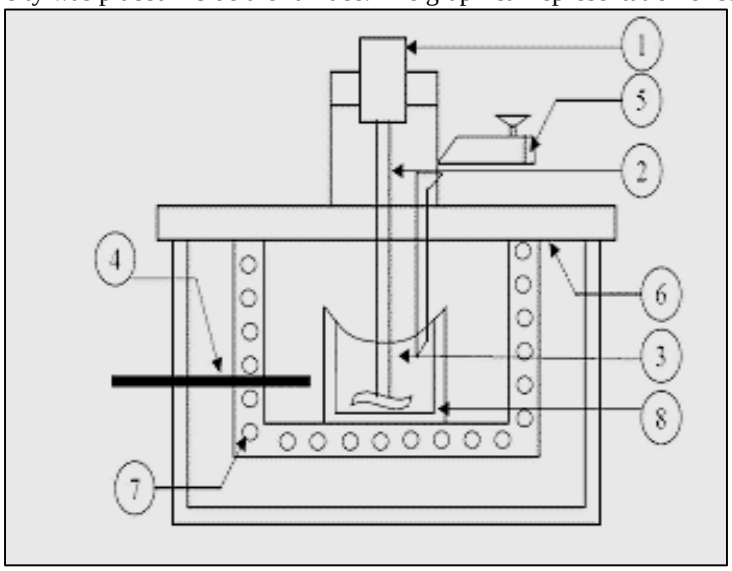

Fig. 1: Stir Casting Method

1) Motor
2) Shaft
3) Molten Aluminum
4) Thermocouple
5) Particle Injection Chamber
6) Insulation Hard Board
7) Furnace
8) Graphite Crucible

The following steps has been followed for stir casting Process:

1) Heating and melting of Al-6063 Alloy by around 720°C which is above the melting point temperature of the alloy.
2) Addition of preheated silicon Nano particles for the preparation of the composites.
3) Mechanical stirring at 400rpm for 15 min for the uniform distribution of the particles.
4) Degassing of melt with N2 gas for removing the air inclusion in the material.
5) Insert Ultrasonic probe for uniform desperation for Nano SiC particles in the melt. The ultrasonic power was 1.2 KW and frequency was 21.21 KHz. The ultrasonic vibrations were given in the melt for about 5 minutes.
6) Pouring of molten metal to the preheated die.
7) Removal the specimen of composite material

II. SELECTION OF METAL MATRIX COMPOSITES

There has been interest in using aluminum based metal matrix composites (MMCs) for valves and valve seat material in recent years. While much lighter than other material. The material used for the valves and valve seat should have the required physical, mechanical and thermal properties apart from being light weight.[4,5] The failure of the valve and valve seat is due to high temperature generated inside the cylinder and also due to the high stresses applied on the valve.

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A. Development Procedure of Al-Sic MMCs

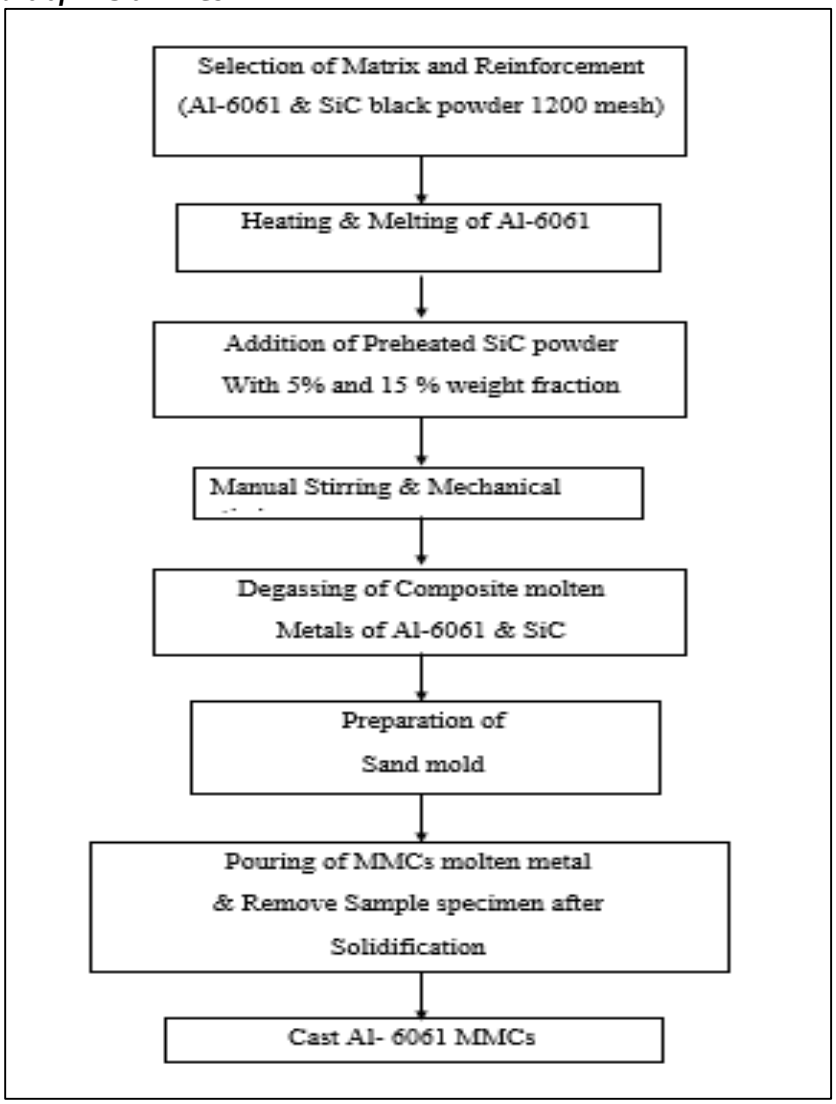

Fig. 2: Flow Chart of Development procedure

III. CALCULATION & TESTING RESULTS

A. Sample Calculation

1) Density: Mass/Volume
2) Specific Yield Strength:- Yield Strength/Density
3) Specific Ultimate Strength:- Ultimate Strength/Density To find the above parameters following calculation has been done for aluminium alloy.

Table 1: Sample Calculation

	Yield Strength	*Ultimate Strength*	*Density*	*Specific Yield Strength= Yield Strength/density*	*Specific Ultimate Strength= Ultimate Strength/density*
Al 6061-0% SiC	*209*	*269*	*2.65*	*209/2.65 =78.86792453*	*269/2.65 =101.509434*
Al 6061-5% SiC	*249*	*304*	*2.69*	*249/2.69 =92.56505576*	*304/2.69 =113.0111524*
Al 6061-15% SiC	*278*	*354*	*2.77*	*278/2.77 =100.3610108*	*354/2.77 =127.7978339*

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B. Specific Yield Strength

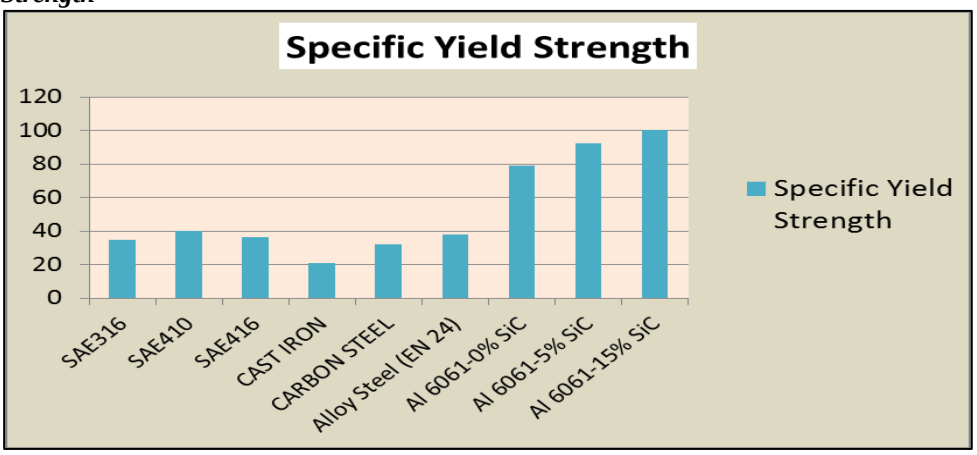

Fig. 3: Comparison of Specific yield strength with MMCs

From the above graph, it can be analysed that MMCs have very high Specific Yield Strength in comparison to other materials. Also, it can be seen that as we increase the percentage of SiC, the specific strength of MMC increases. The highest specific strength among all is of Al6061-15%SiC, which is 100.36 MPa-gm/cm3.

C. Specific Ultimate Strength

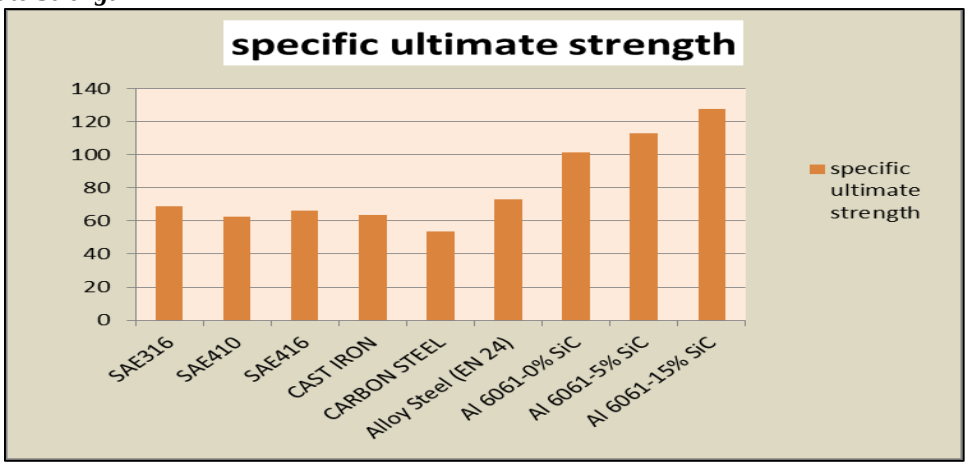

Fig. 4: Comparison of Specific ultimate strength with MMCs

From the above graph, it can be analysed that MMCs have very high Specific ultimate Strength in comparison to other materials. Also, it can be seen that as we increase the percentage of SiC, the specific strength of MMC increases. The highest specific ultimate strength among all is of Al6061-15%SiC, which is 127.797 MPa-gm/cm3.

D. Enlongation %

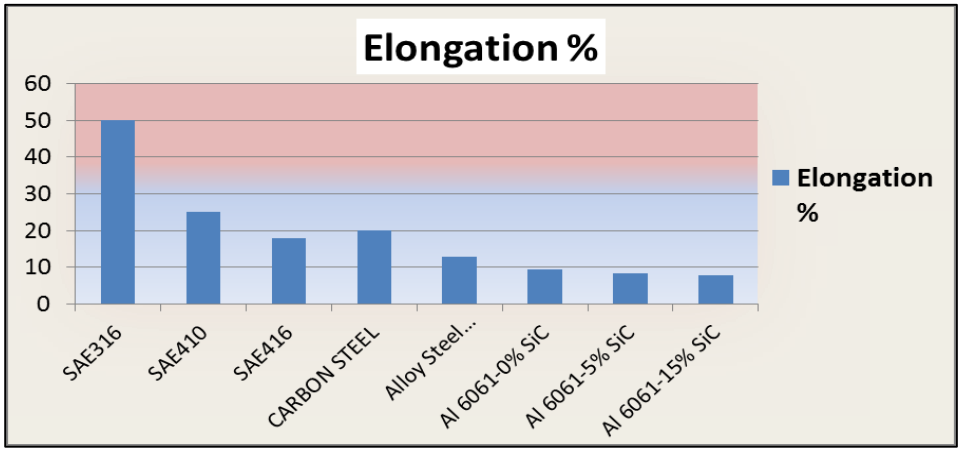

Fig. 5: Comparison of elongation with MMCs

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The above graph shows a comparison of elongation% or strain of different material. The graph shows that AL-SiC composites have very less elongation as compared to other material. On comparing in between different percentages of AL-SiC composites, we can see that elongation decreases as the percentage of SiC increases. The lowest elongation is of Al6061-15%SiC, which is 7.84.

IV. CONCLUSION

The Al6061-SiC MMCs with 5% and 15% weight fraction produced by stir casting method and the microstructure, chemical composition, density, yield strength, ultimate strength, elongation % were measured and compared with various materials which are used to making different types of valves. Also were tested corrosion resistance and fatigue strength are tested.

- Hardness, Density, yield strength, ultimate strength are increases with the increase reinforcement particles of silicon carbide.
- The Elongation % is decrease with the increase reinforcement particles of silicon carbide.
- Development of Al-SiC MMCs for making valves is possible by comparing different properties with existing materials which are used to making valves. Valves are manufactured with casting and forging processes and it is possible both processes after developing MMCs for making valves.
- Also this research revealed that MMCs of Aluminium alloy 6061 with SiC powder will be produced corrosion resistant material.

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