Studies on Properties of Al–SiC Metal Matrix Composite Material for Making IC Engine Valves

Nilamkumar S. Patel, Ashwin D. Patel, Ritesh Kumar Ranjan, Vikas Rai

***Abstract*-Automobile industries are using material substitution for to build lighter weight, and fuel efficient engines, offering better properties materials of engine components, including engine poppet valves and valve seats. Valves and valve seats are very important components that are used at high operating temperature to control the flow and volumetric efficient at desired level of engine performance. The present work describes that Al-SiC composite as possible alternate materials with its unique capacity to give required properties for engine poppet valves and valve seats. Al-SiC MMC is prepared by powder metallurgy and various casting techniques. In the research a composite is developed by stir casting process by using aluminium alloy with silicon carbide Nano particles and substitute sintering operation at 600^{o}C temperature for one hour. Mechanical tests like microstructure, hardness, crushing load, surface roughness, etc. are conducted.**

Index Terms—MMC, Al SiC, Valve material, Stirring casting, Engine valve.

I. INTRODUCTION

The composite material is naturally occurring substance which is made up of 2 or more than two materials with various properties like physical & chemical, which will remain separate & distinct on the macroscopic and microscopic level within the finished structure. The elements retain their identity i.e. They do not dissolve or mix complete into one another, although they act together.[1] The individual material that makes up composite is called constituent. Most composite has 2 constituent materials: one is binder or matrix (polymer, metal, or ceramics) and other is reinforcement (like particles, fibers, flakes & fillers).[3] The reinforcement is much powerful & stiffer than the matrices and gives the composite required/desired properties.[4] The matrix keeps the fiber or reinforcement in an appropriate/orderly pattern. Since the reinforcements are necessarily discontinuous and reinforcement.[5] Dinesh kumar koli, [2] stated as ―The the matrix also helps to transfer load among the composite is compound material which differs from alloy due to fact that all the individual component retain its characteristic.

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A. Nilamkumar S. Patel is a PhD research student at the RAI University, Ahmedabad, India and is currently working as Head of Department in Mechanical Engineering at Sardar Patel College of Engineering, Gujarat,India.(email: nilam5272@gmail.com)
B. Ashwin D. Patel is Principal of CSPIT, Charusat University, Gujarat, India. (email: astorcan@hotmail.com)
C. Ritesh Kumar Ranjan is currently working as Head of Department in Automobile Engineering at IIET, Dharmaj, Gujarat, India.(email: riteshranjan.mech@gmail.com)
D. Vikas Rai is currently working as Assistant Professor in Automobile Engineering Department at IIET, Dharmaj, Gujarat, India.(email: vikasrai085@gmail.com)

II. EXPERIMENTAL SET-UP

Stir casting process is liquid state processing. It is simple and flexible process. In this process, there is mixing of matrix and reinforcement.

In this process, reinforcement particles are added into the molten matrix metal. And then the proper mixture is done by hand stirring as well as Mechanical stirring. And then this mixture is allowed to pour into the mould shape.

In the below Figure 1, it is shown the Mechanical Stirring Set up. In this Setup, There is resistance heating furnace, which is work on the basic principle of resistant heating.

The Process parameters of stir casting method are listed below.

- Stirring speed and temperature
- Stirring time
- Reinforcement of preheat temperature
- Blade angle
- Powder feed rate
- Preheated temperature of mould

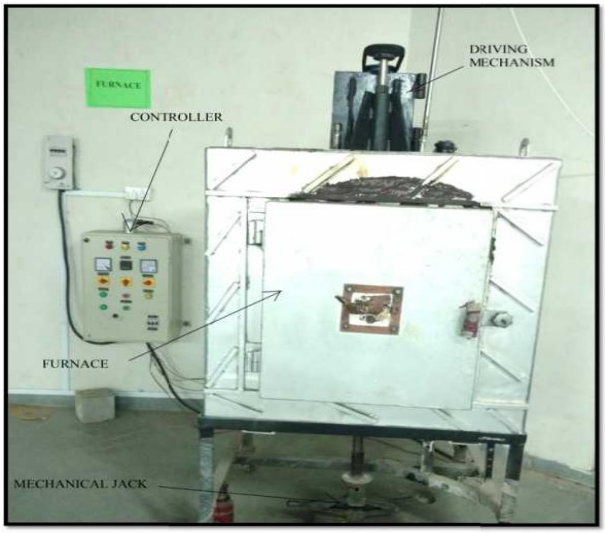

Fig. 1. Mechanical stirring setup

The Main Parts of Mechanical Stirring setup is listed below.

1) Resistance Furnace
2) Graphite Crucible
3) Stirrer
4) Mechanical Jack

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5) Driving Mechanism
6) Insulation hard board
7) Particle Injector
8) Controller

A. Stir Casting Process

The following steps have been followed for stir casting Process:

1. Heating and melting of Al-6061 Alloy by around 750°C which is above the melting point temperature of the alloy.

Fig. 2. Molten Al-6061

2. Addition of preheated silicon micron particles for the preparation of the composites. The preheated silicon micron was added in percentage 5, 15.

Fig. 3. Feeding SiC micron powder

3. Mechanical stirring at 200rpm for 15 min for the uniform distribution of the particles.

Fig. 4. Stirring process

4. Degassing of melt removing the air inclusion in the material.
5. Prepared a Sand mold for to make sample specimen.

Fig. 5. Sample of sand mold

6. Pouring of molten material in to the sand mold.

Fig. 6. Pouring process

7. Removal the specimen of composite material.

Fig. 7. Sample specimen

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III. EXPERIMENTAL TESTING OF MMCs

A. CHEMICAL ANALYSIS

TABLE I
CHEMICAL ANALYSIS OF MMCS

Elements	Al6061 0%SiC	Al6061 5%SiC	Al6061 15%SiC
Al + Other	98.38	95.706	87.382
Si	0.52	3.364	11.473
Mg	1.10	0.930	1.145

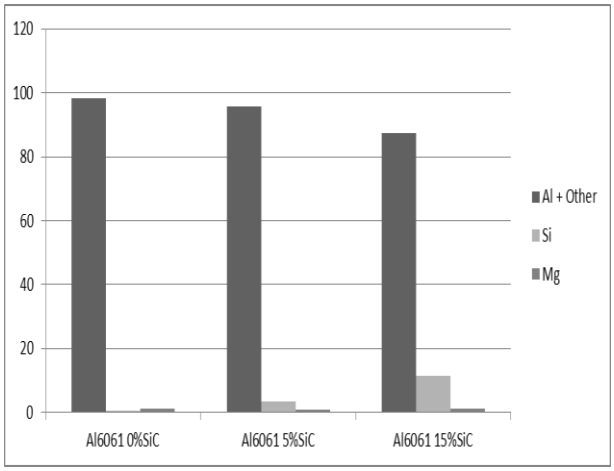

Fig. 8. Chemical analysis comparison of MMCs

B. DENSITY TEST

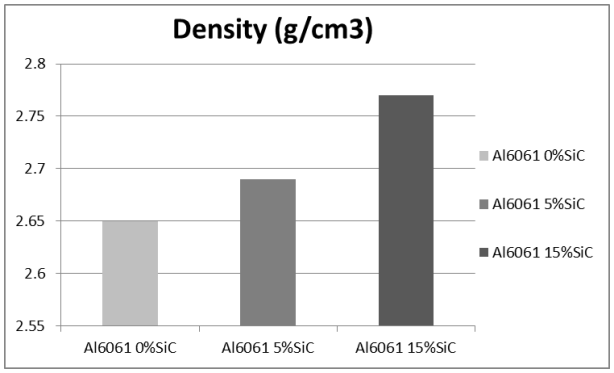

Fig. 9. Density Comparison of MMCs

C. HARDNESS TEST

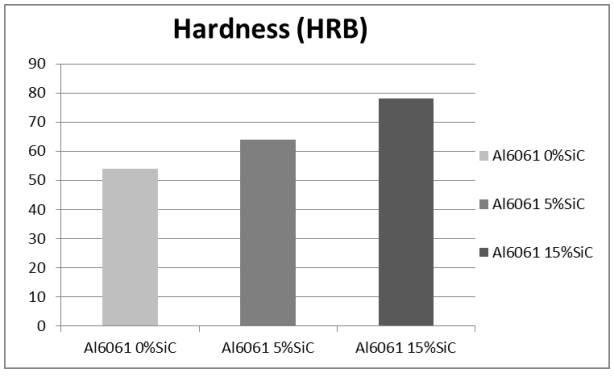

Fig. 10. Hardness comparison of MMCs

D. TENSILE TEST

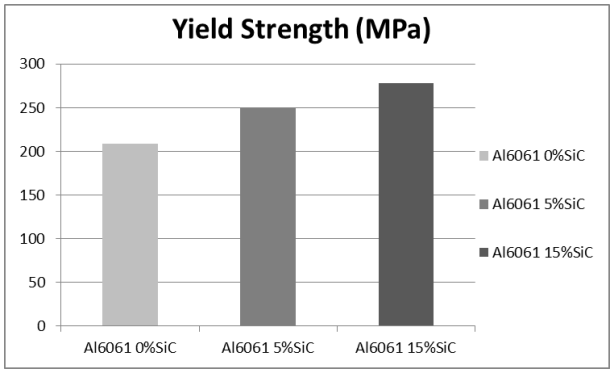

Fig. 11. Yield strength comparison of MMCs

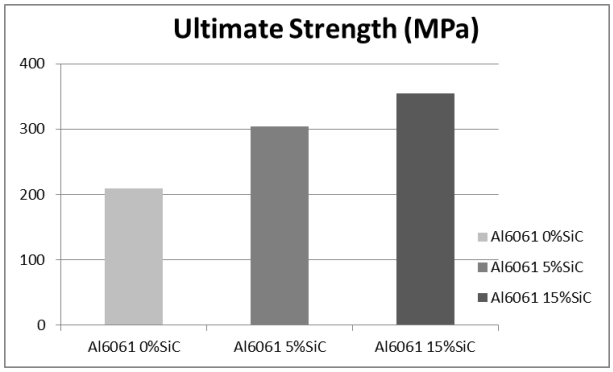

Fig. 12. Ultimate strength comparison of MMCs

E. ELONGATION %

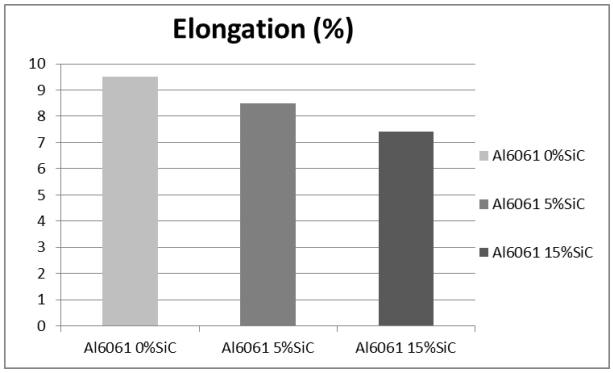

Fig. 13. Elongation % comparison of MMCs

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 outlet valves. Corrosion resistance was also tested.

a) Hardness, Density, yield strength, ultimate strength are increases with the increase in reinforcement particles of silicon carbide which increases the life of exhaust valve.

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b) The Elongation % is decreases with the increase reinforcement particles of silicon carbide. Since the elongation percentage is low which will decrease the fatigue load also on an exhaust valve.
c) Development of Al-SiC MMCs for making outlet valves is possible by comparing different properties with existing materials which are used to making outlet valves. Outlet valves are manufactured with casting and forging processes and it is possible both to use processes after developing MMCs, for making outlet valves.
d) Also this research revealed that MMCs of Aluminium alloy 6061 with SiC powder will be produced corrosion resistant material. Hence water particle coming from exhaust gas will generate less corrosion as compare to existing material in the market.
e) Hence water particle coming from exhaust gas will generate less corrosion as compare to existing material in the market.
f) Now a day 5% ethyl alcohol is using as a blend in petrol. We can use more % of ethyl alcohol blending with petrol but we don't use because it generate corrosion, so we have to modify the engine material to reduce corrosion.
g) Since Al6061 15%SiC generate very less corrosion so we can use this material in present engine for making valve. .

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