International Journal of Advanced Technology and Engineering Exploration, Vol 5(47)
ISSN (Print): 2394-5443 ISSN (Online): 2394-7454
http://dx.doi.org/10.19101/IJATEE.2018.547002

Research Article

Investigation of mechanical behavior of Al 6063 & SiC composite materials

Yogesh Kumar[1*], Amit Tiwari[2], Himanshu Vasnani[2] and Neeraj Kumar[3]
M.Tech Scholar, Department of ME, Suresh Gyan Vihar University, Jaipur, India[1]
Assistant Professor, Department of ME, Suresh Gyan Vihar University, Jaipur, India[2]
Professor and HOD, Department of ME, Suresh Gyan Vihar University, Jaipur, India[3]

Abstract
The purpose of this work is to focus about involved in designing metal matrix composite material is to combine the desirable attributes of metal and ceramics. The microstructures, mechanical properties of silicon carbide (SiC) reinforced aluminum 6063 (Al 6063) matrix composites (AMCs). AMCs of varying SiC content (5 wt. %) were prepared by stir casting process. Microstructures, Rockwell hardness test, tensile strength and Impact (Izod) Test performance of the prepared composites were analyzed. AMCs materials than unreinforced materials such as greater strength and high specific modulus, improved stiffness. Aluminium was used as a base material where SiC used for reinforcement material. SiC particle is preheated at 80 °C for three hours. For mixing of material we are used electric furnace attached with graphite stirrer which is used for uniformly distribution of material. During mixing of SiC. it was stirred for 10 minutes at 100 rpm. The melt convert into solid in the mould. The results found that SiC in Al 6063 increased hardness and tensile strength and 5 wt. % SiC reinforced AMC showed maximum hardness and tensile strength. The scanning electron microscopy (SEM) test was done to know the distribution of SiC and aluminium particles in aluminium alloy, where energy dispersive X-Ray (EDX) tests was performed to know the presence of the phase of reinforced material and it was found that the composite had better properties than pure aluminium.

Keywords
Al 6063, AMCs, SiC, EDX.

1.Introduction
The current study deals with the testing and investigation of behaviour of composite materials; here aluminum (Al 6063) materials mix with silicon carbide (SiC) for fabrication of composite material by Stir casting process. Aluminum 6063 based metal matrix composites (MMCs) whereas reinforcement used is SiC. Aluminium are generally used in different engineering field, industries etc. due to their low density, high specific mechanical properties and lower weight. But due to low hardness and strength we should try to increase properties of hardness and toughness by mixing of another material with them by which we will achieve desirable properties in aluminum material. For that we have done experiment by mixing of aluminum as a base material and SiC as a reinforcement material the reason for select SiC is to their good hardness and high strength as well as high melting point.

Proper mixing if material is very important factor because if mixing of material is not in proper way then the material is not coming in desirable properties for that we are using stir casting machining its help to mix up both materials in proper form [1].

Stir casting process is a liquid state process that helps in aluminium composites. Usually, the particulate reinforcement is distributed into the aluminium melt by mechanical stirring. The materials fabricated using stir casting process has excellent mechanical properties when compared to traditional materials. The hardness, thermal conductivity, melting point and some other behaviors changes in a composite material when compared with the traditional material. In recent years, aluminum and its alloys have had high rate of consumption compared to iron-steel products and are being used more in industries such as electrical, chemical, medicine, construction, automotive and aviation and their sub-industries, increasing their importance the more Al-Mg-Si alloys, apart from their importance in the aluminum industry and being called 6000 series. In the present work Al6063 material is used due to known for their

*Author for correspondence

good extrude ability, high corrosion resistance, and having lower costs of processes.

In 2014, Kumar and Mishra [1] fabricated hybrid material and used Al 6063/ molybdenum disulfide (Mos2)/ Al2o3 MMC's. It is found that by addition of Mos2 in different percentage hardness of material increased but decreased ultimate tensile strength by adding 3% and 9 % of Mos2.

In 2015, Vyas et al. [2] this paper mention that authors are fabricated CMC material by using Cu as a metrix form and TiB2 as a reinforcement casting composite by stir casting method. The reason behind this is CMC one of the most constituent is Cu, which forms percolating network and is termed as matrix phase.

In 2015, Bodunrin et al. [3] reviewed the different combination of reinforcing materials used in the processing of hybrid aluminium matrix composites and how it affects the mechanical, corrosion and wear performance of the materials. The major techniques for fabricating these materials are briefly discussed and research areas for further improvement on aluminium hybrid composites are suggested.

In 2016, Kansari and Dwivedi [4] mentioned that the fabrication of composite material through base material Al 6063 mixing with reinforcement material Sic and graphite (Gr) for increasing mechanical properties of material. They are produced four number of specimen after the manufacturing of composite. These composites are the A1(Al 6063), A2(Al 6063+2 % SiC+ 2 % Gr), A3(Al 6063+ 4 % SiC+ 2 % Gr), and A4(Al 6063+ 6 % SiC+ 2 % Gr). Form this experiment the result are shown positive and it increased strength of material rather than pure aluminium material.

In 2017, Niranjan et al. [5] fabricated the hybrid material by using stir casting technique. The hybrid materials are Al6061/ SiC /Gr where after fabrication of material and some test are conducted they found that hardness is decreased with the increasing in % of Gr, as well as tensile strength and compressive strength is increased with the increasing percentage of Gr particles.

In 2018, Ajagol et al. [6] fabricated composite material by using stir casting method. Aluminium and SiC are used as a material. After investigation it found that addition of SiC in aluminium increase hardness and ultimate tensile strength from 23 HV to 47 HV and 84 MPa to 130 MPa respectively.

In 2018, Aybarc et al. [7] fabricated composite material by using stir casting method. Aluminium and SiC are used as a material. After investigation, it is found that addition of SiC in aluminium increase hardness and ultimate tensile strength. Major point is SiC is very effective material to increasing strength of alumnium.

In 2017, Kumar and Nagendram [8] investigated the study of Al6063, SiC and Gr particles are used to fabricate hybrid material by using stir casting technique. It is found that all three materials is mixed together where by addition of Gr it is more effective than SiC.

This present research work deals with the fabrication of reinforced composite material with Al 6063 by using liquid stir casting technique will performed and compared with the base metal and its metallographic structure of its each proportions were characterized by SEM and EDX test to improve properties of the composite material.

To increase the hardness, high strength and reducing the corrosion problem in pure aluminium by fabricate a composite material Al 6063 with Sic material through using stir casting. The aim of this work is to the study the effect of variation of the percentage composition to predict the mechanical properties of the MMC.

2.Experimental setup

2.1Materials

The reason for selecting aluminum as matrix material and SiC were added as a reinforcement to prepare composite material in this research work. The chemical Composition of aluminum is given in *Table 1*. The SiC of mesh size is 120 μm and aluminium was used in casting.

Table 1 Composition of aluminum 6063 used as matrix material (wt %)

Sr. No	Elements	Minimum %	Maximum %
1	Silicon	0.2	0.5
2	Iron	-	0.35
3	Copper	-	0.10

Sr. No	Elements	Minimum %	Maximum %
4	Manganese	-	0.10
5	Magnesium	0.45	0.9
6	Chromium	-	0.10
7	Zinc	-	0.10
8	Titanium	-	0.10

2.2Preparations of composition

The furnace temperature was first raised above the liquid us temperature of aluminium near about 805^{o}C to melt the Al alloy completely and was then cooled down just below the liquid us to keep the slurry in Semi solid state. Aluminium was melted in furnace and when the temperature of the liquid aluminium reached 805°C. Heat treated SiC particles were added in molten metal through funnel at 805°C, where SiC particles preheated at 50°C for about three hours. An electric resistance furnace as assembled with Gr impeller used as stirrer was for stirring purpose. After SiC addition the liquid metal reinforcement's mixture was stirred for 10minutes at a RPM of 100Automatic stirring was carried out with the help of sitr casting machine at rate of 100 RPM. After this fabrication of material it is used for testing EDX and SEM test, or mechanical property.

The *Figure 1* shows that experimental procedure for fabrication of composite material to testing samples with final results obtained.

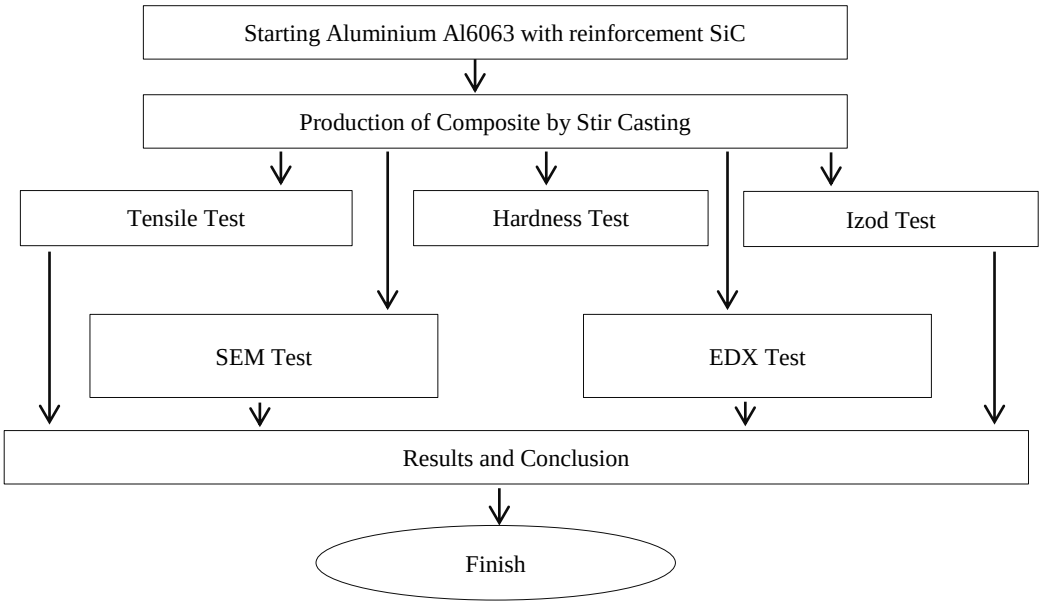

Figure 1 Flow chart experimental techniques followed

2.3Experimental testing

There are many test performed to find out Microstructures, Rockwell hardness test, tensile strength and Impact (Izod) test performance of the prepared composites were analyzed.

A sample used for find out tensile property of composite material on UTM M/C at workshop lab, Suresh Gyan Vihar University, Jaipur, India (*Figure 2*).

Figure 2 Sample Al 6063+Sic for tensile test on UTM M/C

A sample used for find out compressive property of composite material on UTM M/C at workshop lab, Suresh Gyan Vihar University, Jaipur, India.(*Figure 3*).

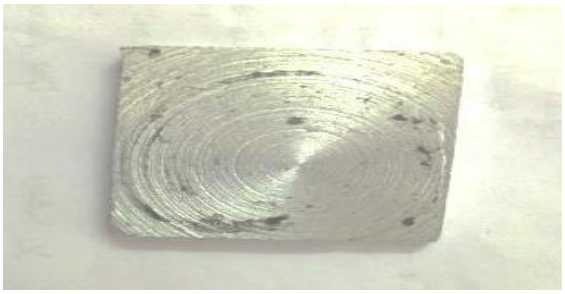

Figure 3 Sample Al 6063 +Sic for compression test on UTM

A sample used for find out Hardness property of composite material on UTM M/C at workshop lab, Suresh Gyan Vihar University, Jaipur, India (*Figure 4*).

Figure 4 Sample Al6063 + Sic for impact (Izod Test)

The sample show final structure of material after breaking during conducted Izod test at workshop lab, Suresh Gyan Vihar University, Jaipur, India (*Figure 5*).

Figure 5 After breaking material on impact (Izod) Test

Aluminium and SiC is heated in furnace at (805°C), after string process the mixture was pour in the other mould to get desired shape of specimen (*Figure 6*).

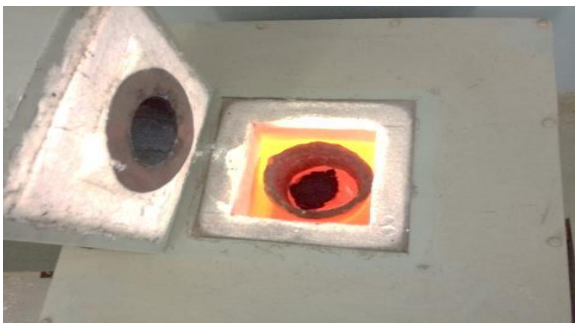

Figure 6 Mixing of Al 6063+Sic in furnace at (805°C)

Sample after melting mixture Al 6063+Sic Mould at 805 °C at workshop lab, Suresh Gyan Vihar University, Jaipur, India (*Figure 7*).

Figure 7 After melting mixture Al 6063+Sic mould

Melting of Al 6063 up to Temperature reached at 799 °C in Furnace, at workshop lab, Suresh Gyan Vihar University, Jaipur India (*Figure 8*).

Figure 8 Melting of Al 6063 up to temperature reached at 799 °C in furnace

2.4Hardness test

The resistance of materials against surface identification is termed as hardness. The micro hardness of composite evaluates the interface bonding strength between reinforcing particles and matrix. For hardness test of Al6063 with reniforcement material Sic of fabricated composite,

from the hardness test results, it is observed that the hardness of AMC's is greater than unreinforced Al 6063. It increased the hardness with mixing of SiC reinforced due to applied load transfer to the strongly bonded SiC reinforcement in Al 6063 matrix.

After conducted Brinell Hardness Test we found that it is increased the Hardness form 25HB to 38 HB by mixing of Sic reinforced due to applied load transfer to the strongly bonded Sic reinforcement in Al 6063 matrix (*Table 2*).

Table 2 Brinell hardness Test

Sr. No	Material	Hardness (HB)
1.	Al 6063 with 100 %	25 HB
2.	Al 6063 with 100% + Sic 5 %	38 HB

2.5Tensile strength

For tensile test of Al6063 with reniforcement material SiC of fabricated composite, from the tensile test results it is observed that the tensile strength of AMC's is greater than unreinforced Al 6063 [9]. It is increased the tensile strength with mixing of Sic reinforced due to applied load transfer to the strongly bonded SiC reinforcement in Al 6063 Matrix.

After conducted the tensile strength test we found that it increased the strength form 130 MPa to 142 MPa by mixing of SiC reinforced due to applied load transfer to the strongly bonded SiC reinforcement in Al 6063 matrix (*Table 3*).

Table 3 Tensile strength test

Sr. No	Material	Tensile strength (MPa)
1.	Al 6063 with 100 %	130 Max MPa
2.	Al 6063 with 100% + Sic 5 %	142 Mpa

2.6Impact test

For impact test of Al6063 with reniforcement material SiC of fabricated composite, from the Impact test results, it is observed that the impact strength of AMC's is greater than unreinforced Al 6063. It increased the strength with mixing of SiC reinforced due to applied load transfer to the strongly bonded SiC reinforcement in Al 6063 matrix.

After conducted impact strength test we found that it is increased the strength form 130 MPa to 138 MPa by mixing of SiC reinforced due to applied load transfer to the strongly bonded SiC reinforcement in Al 6063 Matrix (*Table 4*).

Table 4 Impact strength test

Sr. No	Material	Impact strength (MPa)
1.	Al 6063 with 100 %	130
2.	Al 6063 with 100% + Sic 5 %	138

3.Results and discussions

3.1Microstructures

The properties of composite material is depend on microstructure analysis show the optical microstructures of 5 wt. % SiC reinforced AMC respectively. During microstructural test clustering and non-homogeneous distribution of SiC particle in Al matrix were observed. This was due to the variation of contact time between SiC particles and molten. Porosities were observed in all microstructures due to addition of SiC particles. It introduced air in the melt entrapped between the particles. Therefore increasing wt. % of SiC particles increased entrapped air resulted in higher amount of porosity [6]. *Figure 9* shows the EDX of point Al with (27.5) and SiC with (26). *Figure 10* shows the EDX spectrum of a SiC particle over Al particles. *Figure 11* shows the SEM test for mixing of Al 6063 with SiC properly. *Figure 12* shows the microstructure image of mixing of SiC. *Figure 13* shows the microstructure image of mixing of SiC. *Figure 14* shows the hardness value for composite material. *Figure 15* shows the tensile values for composite material.

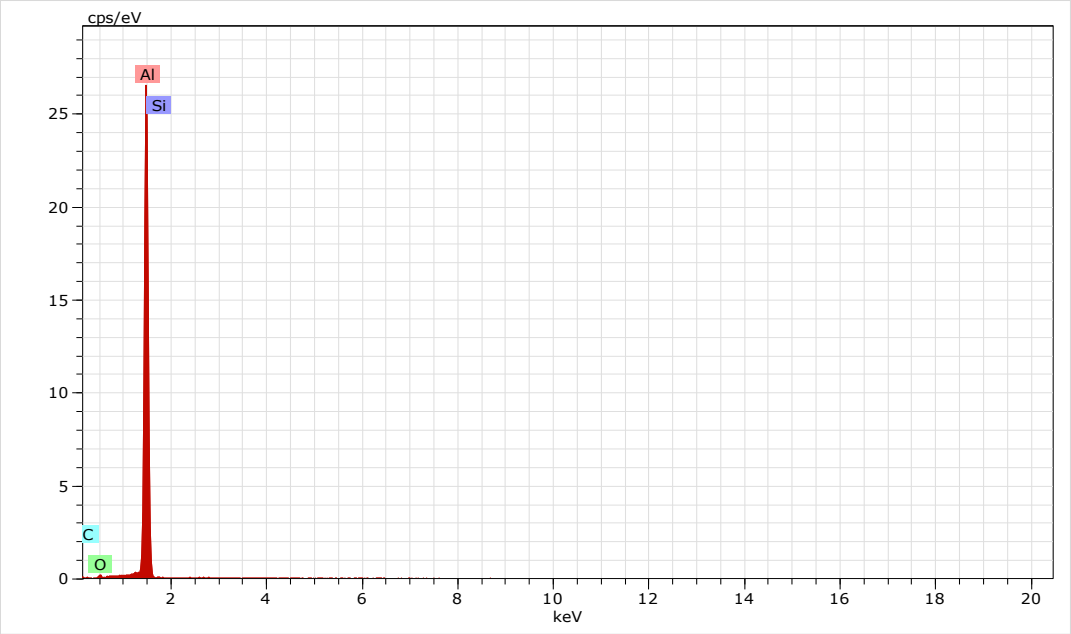

Figure 9 EDX of point Al with (27.5) and SiC with (26)

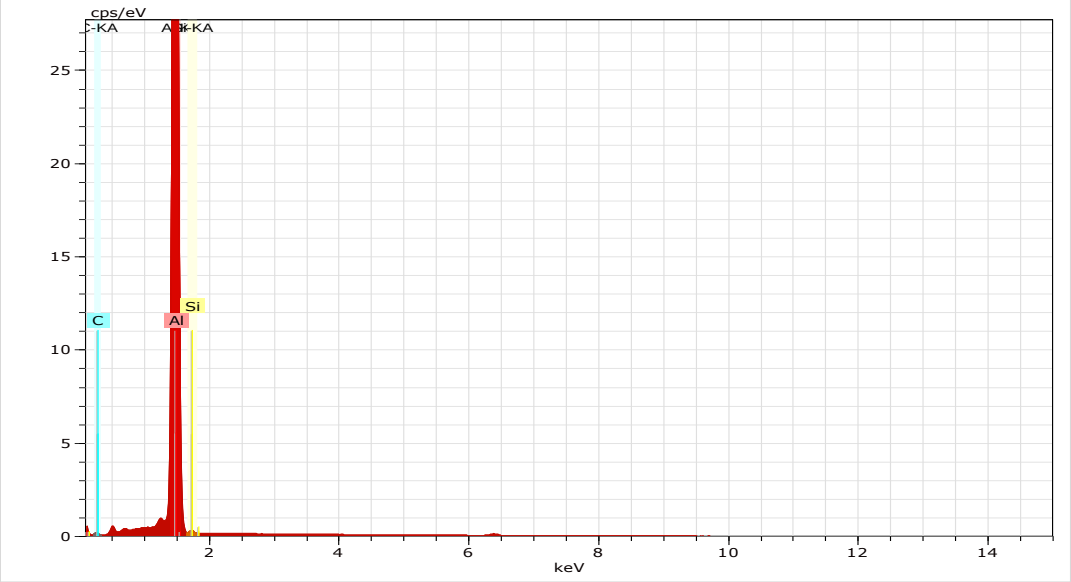

Figure 10 EDX spectrum of a SiC particle over Al particles

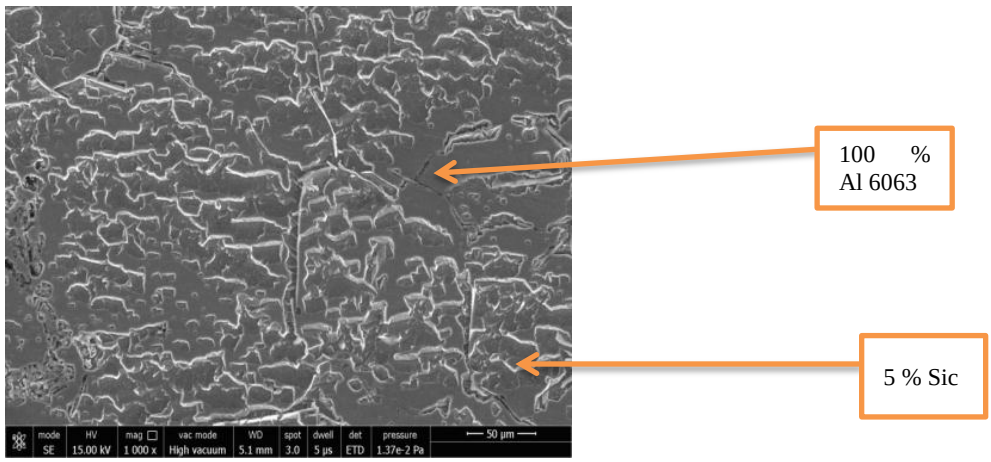

Figure 11 SEM test for mixing of Al 6063 with SiC properly

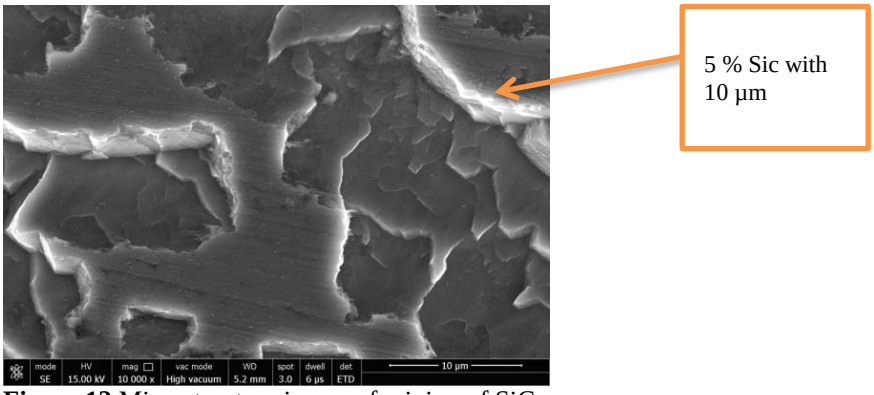

Figure 12 Microstructure image of mixing of SiC

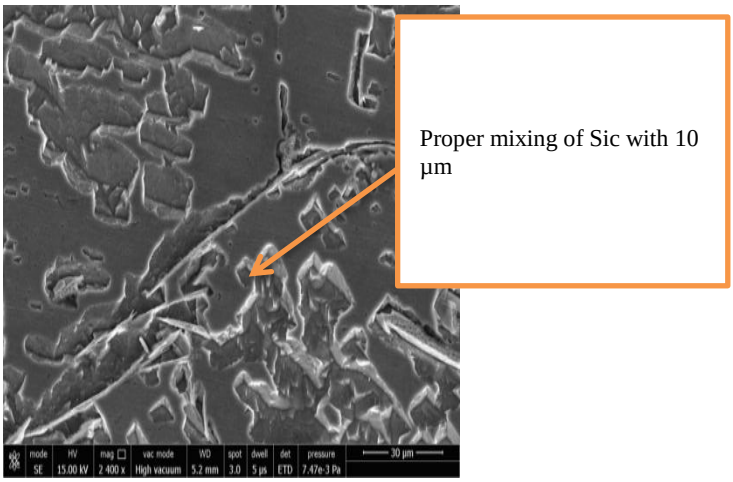

Figure 13 Microstructure image of mixing of SiC

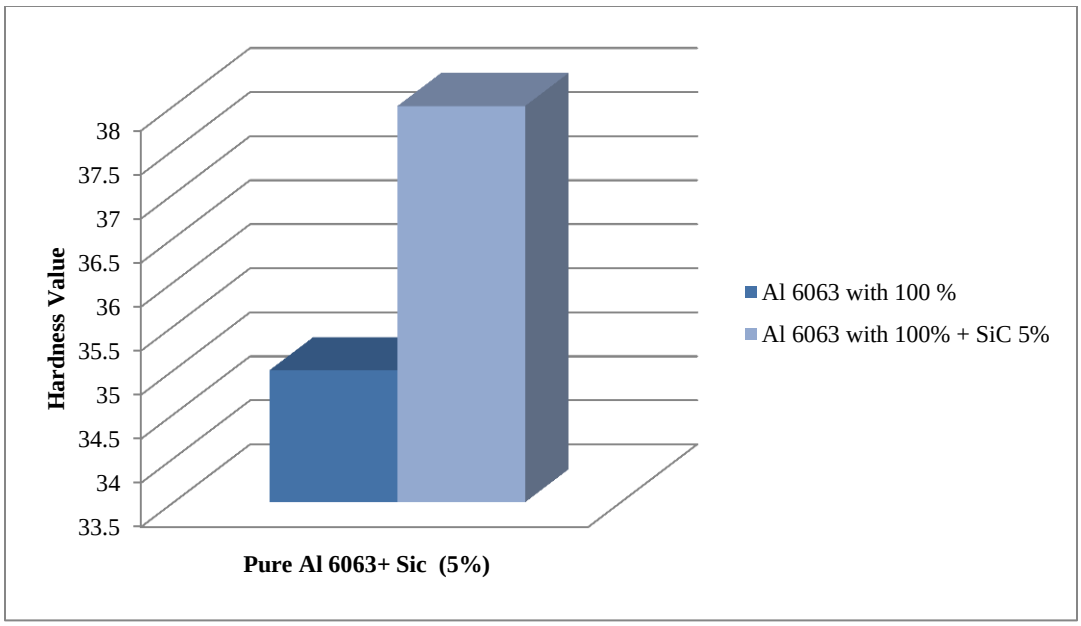

Figure 14 Hardness value for composite material

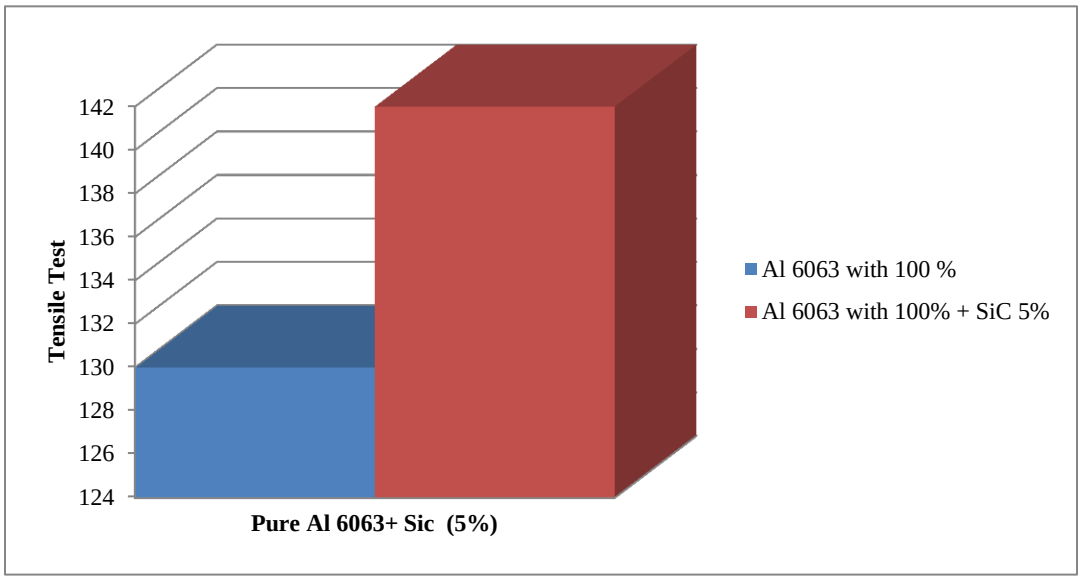

Figure 15 Tensile values for composite material

4.Conclusion

The current experimental study about AMCs of varying SiC content were prepared using stir casting technique. The microstructural aspects, hardness, tensile strength and Impact strength of prepared composite were studied. Based on experimental evaluation the following conclusion can be expressed.

1. The SiC particles in Al matrix were observed in the microstructures are completely mixing each other.
2. Due to addition of Sic in Al 6063 matrix its increased hardness, tensile strength and impact strength the ratio of composition is 100% pure Al and 5% of Sic reinforcement.
3. Aluminium matrix composites have been successfully fabricated by stir casting technique with fairly uniformly distribution of SiC and Al 6063
4. Impact strength is increased by adding SiC & Al 6063.

From the result above, the composite material Al 6063 mixed with SiC reinforcement showed that good mechanical properties and the results are positive.

5. Future scope

1. This can further be extended by varying geometrical angle of stirrer & by varying stirring speed.
2. Heat treatment can be done to improve the properties.
3. Results can be varying by reinforcement grain size.

Acknowledgment

None.

Conflicts of interest

The authors have no conflicts of interest to declare.

References

[1] Kumar M, Mishra AK. Mechanical behavior of Al 6063/Mos2/Al2o3 hybrid metal matrix composites. International Journal of Scientific and Research Publications. 2014; 4(12):1-4.

[2] Vyas TK, Pandey A, Patel H. A review on investigation of copper matrix composite by using stir casting method. Indian Journal of Applied Research. 2015; 5(1):75-7.

[3] Bodunrin MO, Alaneme KK, Chown LH. Aluminium matrix hybrid composites: a review of reinforcement philosophies; mechanical, corrosion and tribological characteristics. Journal of Materials Research and Technology. 2015; 4(4):434-45.

[4] Kansari S, Dwivedi A. Mechanical properties of aluminium 6063 alloy based graphite particles reinforced metal matrix composite material. Journal of Emerging Technologies and Innovative Research. 2016; 3(10):152-60.

[5] Niranjan KN, Shivaraj BN, Sunil KM, Deepak AR. Study of mechanical properties On Al 6061 hybrid composite by stir casting method. International Research Journal of Engineering and Technology. 2017; 4(1):1036-40.

[6] Ajagol P, Anjan BN, Marigoudar RN, Kumar GP. Effect of SiC reinforcement on microstructure and mechanical properties of aluminum metal matrix composite. In IOP conference series: materials science and engineering 2018 (pp. 1-9). IOP Publishing.

[7] Aybarc U, Dispinar D, Seydibeyoglu MO. Aluminum metal matrix composites with SiC, Al2O3 and grapheme-review. Archives of Foundry Engineering. 2018; 18(2):5-10.

[8] Kumar ND, Nagendram BA. Experimental investigation on mechanical properties of hybrid metal matrix composite reinforced with alumina, graphite and silicon carbide. International Journal of Modern Engineering Research. 2017; 7(5): 44-50.

[9] Sijo MT, Jayadevan KR. Analysis of stir cast aluminium silicon carbide metal matrix composite: a comprehensive review. Procedia Technology. 2016; 24:379-85.

[10] TURBALIOĞLU K, Yavuz SU. The improvement of the mechanical properties of AA 6063 aluminum alloys produced by changing the continuous casting parameters. Scientific Research and Essays. 2011; 6(13):2832-40.

Yogesh Kumar, Pursuing (Master of Technology) degree in Manufacturing & Industrial Engineering from Suresh Gyan Vihar University, Jaipur Rajasthan, India.

Email: yogeshbhaskar59@gmail.com

Amit Tiwari received his M.Tech degree in Production Engineering from Pacific University, Udaipur Rajasthan India. He published five books and 36 research papers. He currently works as an Assistant Professor in the Department of Mechanical Engineering at Suresh Gyan Vihar University, Jaipur Rajasthan India.

Himanshu Vasnani received his M.Tech degree in Manufacturing & Industrial Engineering from Suresh Gyan Vihar University, Jaipur Rajasthan, India. He published one books and 6 research papers. He currently works as an Assistant Professor in the Department of Mechanical Engineering at Suresh Gyan Vihar University, Jaipur, Rajasthan, India.

Dr. Neeraj Kumar holds Ph.D (Mechanical), M.Tech (Manufacturing System Engineering) & B.E (Mechanical) with 11 years' of experience inclusive of 10 year as Engineering Teaching Faculty. Published four Books and 50 research papers. Presently Associate with Suresh Gyan Vihar University, Jaipur as a Professor & Head of Mechanical Department.