International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | Apr -2017 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation on Mechanical Behavior's of Stir Cast Aluminium 6061-SiC MMC using Taguchi Technique

C . Manikandan

Assistant Professor, Dept of Mechanical Engineering,
CMS College of Engineering and Technology, Coimbatore-641 032,Tamilnadu.

---***---

Abstract - *The metal matrix composites are mostly used in aerospace applications and in automobile sectors due to its light weight to strength ratio. Aluminium 6061 has been used as matrix and SiC as reinforcement. A liquid metallurgy route of stir casting technique was adapted to prepare cast composites .Taguchi method orthogonal array of* $L_9\ 3^3$ *is used to design experiments. The weight fraction of SiC 6%, 9% and 12%, stirrer speed of 200 rpm, 250 rpm, and 300 rpm and reinforcement preheating temperature of 450°C, 475°C and 500°C are used. Tensile test, hardness test and impact tests were conducted on the specimens. The ultimate strength, tensile strength and yield strength are appeared in maximum level of 6% of SiC . The hardness improvement and impact values are appreciable in 12% of SiC.*

Key Words: Metal Matrix Composite, Stir Casting, Toughness, Tensile Test, Yield strength, Hardness

1.INTRODUCTION

Present days with the modern development need of advanced engineering materials for various engineering applications. To meet such demands metal matrix composite is one of the reliable source, among the several categorization, aluminum based composite are used in spread acceptance especially in application where weight and strength are of prime concern. Mostly Al 6061 has been preferred in the automobile industries for the production of different types of automobile components.

Rajeswari et al [1] have concluded that the hardness of the Al7075 composite material was increased with the addition of 2.5% and 7.5% SiC. The stir casting method maintains the uniform distribution of Al 7075 alloy with SiC/Al_2O_3 reinforced composites in clearly superior form to the base of Al alloy. Dispersion of SiC /Al_2O_3 particles in Al 7075 matrix improves the micro hardness of the matrix material.

Rajeswari, et al [2] noticed that the most significant parameters of 12% weight of reinforcement, 550 rpm stirring speed and 800°C influences the mechanical properties of A7075- SiC-Al_2O_3 hybrid MMC. At high temperatures, the wettability of the reinforcements is enhanced considerably thereby ensuring homogenous mixing.

Gyanendra Singh et al [3] stated that the aluminum composite material having good mechanical properties while increasing the percentage of magnesium. Strength and ductility are increased at less than 2.7% Cu along with Mg and Zn contents in aluminum matrix as in case of alloy.

Siddanna Awarasan et al [4] indicated that the LM25 Al alloy and steel wire not shows any defects on its boundary area of the part. The composite impact strength increased about 45 % compared to LM25 Al of impact strength .

Najib Souissi et al [5] stated Taguchi method reduces the number of experiments for the observation. The optimal state of ductility of 2017A wrought Al alloy was influenced with the contribution of squeeze pressure, melt temperature, and die preheating temperature to the quality characteristic (ductility) is 83.75, 10.26, and 5.71 %, respectively. It is noted that squeeze pressure is the major contributing factor and present a significant influence on the microstructure of the alloy.

Saravanakumar et al [6] showed squeeze casting has the potential to obliterate the defects like porosity and shrinkage due to the pressurization on the molten melt. Researchers were identified the squeeze pressure range 40-150 MPa, 650-800° C of melt temperature and 150-300° C of die temperature as the optimal parameters for the production of sound castings.

S.R.Durairaju,et al [7] proved the tensile strength, hardness, compressive strength of the piston is being improved in squeeze die casting process. The grain structure of the piston manufactured by centrifugal casting process is improved up to 78% when compared to piston manufactured by squeeze die casting process. The porosity formed during casting process is reduced up to 90%.The fluidity property of aluminium LM6 is improved at 750°C temperature. Along with heat treatment process the aluminium alloy gains a greater value of hardness.

S. Venkat Prasat, et al [8] noticed from the various studies , that the tensile and hardness properties increased with increasing of AL203 weight percentage and also inferred that wettability is inversely proportional to the weight of reinforcement. 2% of SiC only influences the tensile strength of Al MMC.

Md.Azhar Farooq Maniyar et al[9] studied the stir casting methodology effect on microstructure and tribological characteristics of LM25/SiC/Mica hybrid composites . In Al/SiC/Mica that Silicon Carbide produced good results on the properties of the composite. up to the certain limit the composition of the mica direct maximum hardness on the composite.

Neelima Devi.et al [10] found that the weight to strength ratio for Aluminium silicon carbide is about three times greater than mild steel during tensile test. 6061 Al alloy/ SiC composites two times less in weight than the aluminium alloy of the same geometric characteristics. The maximum tensile strength has been obtained at 15% SiC ratio.

P. Senthil et al [11] found that the optimum parametric conditions of squeeze casting process using Taguchi method and genetic algorithm. They concluded that the experimental time was reduced significantly and quality of the process was improved by using these statistical techniques. Taguchi method had used a set of orthogonal array for the design of experiments. The concept of signal to noise (S/N) ratio which jointly consider show the mean value (signal) of the parameter has been achieved and the amount of variability (noise) has been experienced in the process. The quality characteristics are frequently used as nominal-the-best, lower-the-better and higher-the-better. The S/N ratio depends on the quality characteristics of the process to be optimized.

Lakhan Rathod et al [12] has successfully fabricated **t**he Aluminium matrix composites by stir casting technique with fairly uniform distribution of Al2O3 particles. the Al alloy LM6 with Al203 reinforced composites has the significant improvement in the tensile strength , wear resistance and impact strength. the elongation of composite is inversely proportional to particles weight percentage. Though , the addition of the alumina increases the brittleness property.

From the literature review, it is cleared the stircasting technique is the mostly influenced methodology to prepare Al based composite with desirable states. In this investigation, an attempt has been made to study about the mechanical behaviors of Al6061/SiC composite through experimental investigation. Composite prepared with varying the weight ratio of 6%SiC, 9%SiC and 12% SiC and remaining of Al6061. The tensile test, hardness test, impact test and micro structure have been analyzed.

2.MATERIALS AND METHODS

2.1 Materials

Al 6061 T6 material in the cylindrical form was used. The composition of Al6061 is identified using spectrum analysis in table1. Silicon Carbide 99% (powder basis) with different mass fraction of 6%, 9% and 12% is used as reinforcement. the stirrer rpm ranged from 200 to 400 has been selected and that the preheating temperature for the reinforced material of SIC is maintained with the range of 400 °C to 500°C.

Table - 1: Composition % of Al 6061T6 alloy

Al	97.81	Si	0.607
Fe	0.167	Cu	~ 0.026
Mn	0.545	Mg	- 0.814
Cr	0.0094	Ni	~ . 0013
Zn	0 .0018	Sn	~ . 0027

2.2 Taguchi Method

Taguchi method is a statistical tool for analyzing the performance of the design process and product with the considerable reduction of time on investigation and cost. it employs the concept of orthogonal array , which defines the set of well defined experiment and signal to noise (S/N ratio) ratio . Taguchi defines three quality characteristics, such as lower the better, the larger the better and the nominal the best. also, a statistical analysis of variance (ANOVA) can be used to identify the most influencing factor affecting the quality characteristics. a three level three parameter L9 orthogonal array with nine experiments was conducted. the S/N ratio used for the larger better is given in Equ.(1).

$$S/N(db) = -10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y^2}\right] \quad ....(1)$$

Where, i = 1, 2,....n, and y is the response value for an experimental condition repeated in 'n' times.

1. The input process parameters are identified, which influencing output response of the process.
2. suitable orthogonal array selected to perform the experiments.
3. The results are examined to identify the optimum parametric condition.

2.3. Experimental Procedure

The experimental set up for a stir casting process is shown in fig 1. The aluminum was melted into a graphite crucible inside an electric heating furnace at 750°C.

Fig -1: Stir casting setup

Table -2: Experimental Parameters Settings

S.NO	Factors	Levels		
		1	2	3
1	% of SiC (A)	6	9	12
2	Stirrer speed in rpm (B)	200	250	300
3	Reinforcement preheating temperature (ºC)	400	450	500

Table-3: Orthogonal Array

Ex.no	Casting Parameters			Parameters Setting
	%of SiC	Stirrer speed	Reinforcement pre heating Temp	
	A	B	C	
1	6	200	450	A1B1C1
2	6	250	475	A1B2C2
3	6	300	500	A1B3C3
4	9	200	475	A2B1C2
5	9	250	500	A2B2C3
6	9	300	450	A2B3C1
7	12	200	500	A3B1C3
8	12	250	450	A3B2C1
9	12	300	475	A3B3C2

The samples prepared from the stir casting technique are shown in the fig.2. The samples were machined as per the ASTM Standards for the tensile, hardness and impact tests .

Fig -2: Sample specimen of Al-SiC composite

2.4. Tensile , Hardness and impact Tests

Tensile test was carried out at room temperature using a computerized universal testing machine. It is apparent that an increase in the volume fraction of silicon carbide particle results in an increase in the tensile strength. the tensile tested specimens are shown in the fig.3. and the relation between stress and strain parameters are represented graphically as shown in fig.4. The % of elongation, tensile strength, yield strength and load at peak are obtained from Universal Testing Machine and tabulated in table 4.

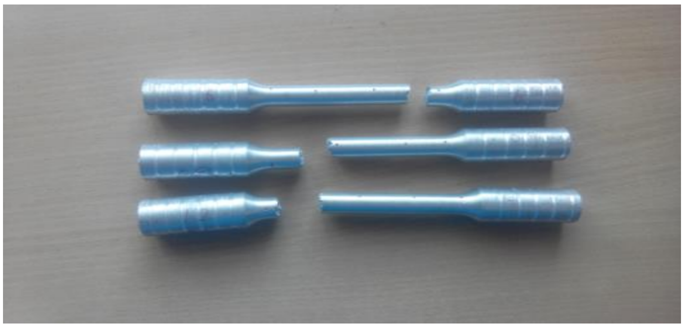


Fig -3: Specimen after tensile test

Table -4: Experimental Results from Universal Testing Machine

S. No	Details Observed	A1B1C1	A2B2C3	A3B3C2
1	% of Elongation in mm	3	2.20	3
2	Tensile Strength (N/mm²)	126.394	97.05	86.455
3	Yield Strength (N/mm²)	100.89	76.679	68.65
4	Load at peak (kN)	15.76	11.72	10.78

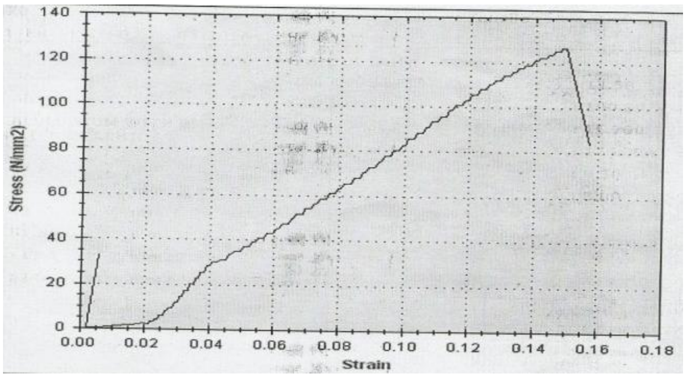
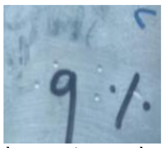


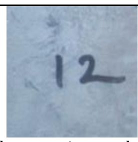
Fig-4: Stress-Strain Graph for **A1B1C1specimen**

Hardness test was carried out at room temperature using Brinell hardness tester with at least six indentations of each sample and then the average values were utilized to calculate hardness number. Load used on Brinell hardness tester 250Kgf at dwell time of 20 seconds for each sample.

Hardness testing sample (6% SiC).- **A1B1C1**



Hardness testing sample (9% SiC).- A2B3C1



Hardness testing ample (12% SiC)- A3B2C1

Fig-5: Hardness test specimens

According to size and weight fraction of SiC particles specimens Al/Sic-MMC's of square cross section of size (10*10*55) with single V-notches are planned. The size of V-notches is 45^{o} and 2 mm in depth.

Fig-6: Experimental setup for Impact

From the experimental results , tensile strength, brinell hardness and impact strength are observed and recorded the in the table 4.

Table-4: Experimental Results

Ex.no	Casting Parameters			Tensile strength in N/mm^2	Brinell hardness-scale C value	Impact Strength J/mm^2
	%of SiC	Stirrer speed	Reinforcement pre heating temp			
	A	B	C			
1	6	200	450	126. 39	68	278
2	6	250	475	121.00	63	290
3	6	300	500	124.78	62	287
4	9	200	475	95.64	70.2	279
5	9	250	500	97.05	71	281
6	9	300	450	94.87	72.4	291
7	12	200	500	92.38	73	284
8	12	250	450	90.74	76	292
9	12	300	475	86.45	72	289

3. S/N Ratios

In Taguchi method , response variation are studied with the help of signal- to- noise (S/N 0 ratio. the uncontrollable parameters are affected quality of the characteristics. the undesirable parameter values are expressed as "noise"(standard deviation) and desirable parameters values are termed as "signal (mean). Under the investigation , the product quality determined factors , which are assigned in the design of experiment elevated as response factor of the analysis .The external uncontrollable factors , outcome quality of the product is affected. in this study, specimens are prepared based on L_9 orthogonal array and the S/N ratios are calculated using MINITAB software. From the S/N ratio for "larger is better" is used to identify the optimum parameters because a higher hardness and tensile strength and impact strength values of composites are desired.
The S/N ratio for the responses are shown in the table.5.

Table-5: S/N ratio for the responses

Experiment No	Tensile strength dB	Brinell hardness dB	Imact Strength dB
1	42.0074	36.6502	48.8809
2	41.6557	35.9868	49.2480
3	41.9229	35.8478	49.1576
4	39.6128	36.6502	48.9121
5	39.7399	36.5215	48.9741
6	39.5426	37.1466	49.2779
7	39.3116	37.2665	49.0664
8	39.1560	37.6163	49.3077
9	38.7353	37.1466	49.2180

The S/N ratio values at different levels for the responses of tensile strength, hardness and impact strength are analyzed using MINITAB SOFTWARE, shown in the figures 7, 8 and 9respectively.

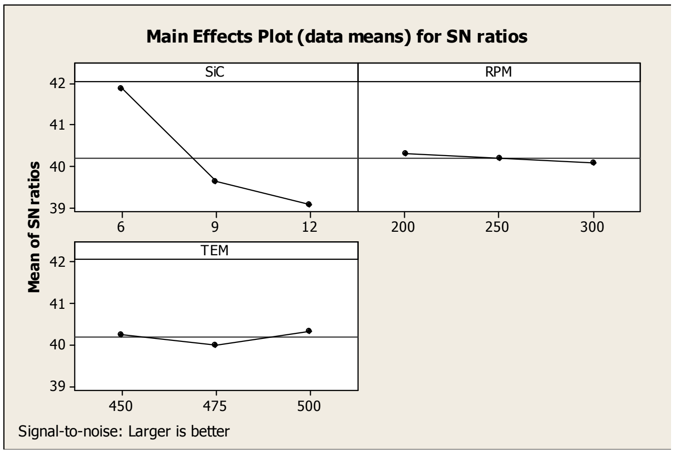


Fig-7: S/N Ratio graph for Tensile strength

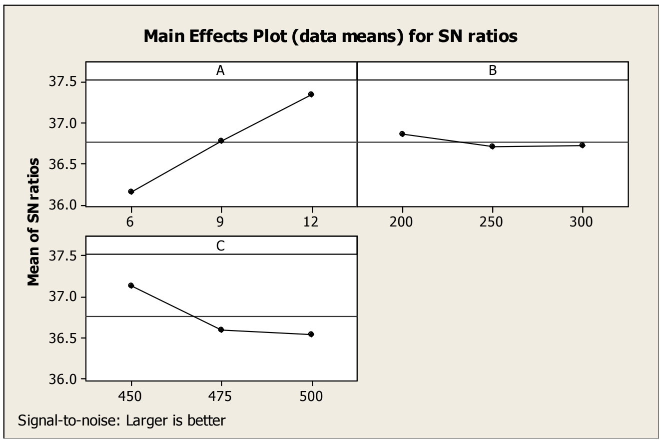


Fig-8: S/N Ratio graph for Hardness

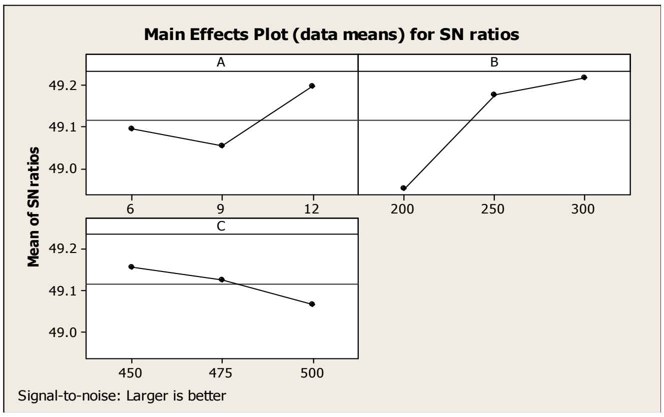


Fig-9 : S/N Ratio graph for Impact Strength

The table 6 shows the optimal parameter values of % SiC, stirrer speed and reinforcement pre heating temperature which are influencing the responses such as Tensile Strength, Hardness and Impact strength.

Table-6: optimal parameter values

S.No	% SiC	Stirrer Speed in rpm	Reinforcement pre heat temperature in '°C'
Tensile Strength	6	200	500
Hardness	12	200	450
Impact value	12	300	450

4. CONCLUSION

From the experimental study , it is noticed, that the 12% of SiC and 450°C preheat temperature of the reinforcement improves the hardness and impact strength of the composite. At 6% of SiC , 200 rpm of stirrer speed and 500°C reinforcement pre heat temperature attains the improved level of tensile strength . The hardness and impact strength to values are directly proportional to the SiC composition rate. the minimal percentage of elongation is obtained in the 9% of SiC, 250 RPM and 500 °C pre heating temperature of reinforcement.

REFERENCES

[1] B.Rajeswari, K.S.Amirthagadeswaran, and K.Ramya, Micro structural Studies of Aluminium 7075- Silicon Carbide- Alumina Metal Matrix Composite, Advanced Materials Research Vols. 984-985 (2014) pp 194-199.

[2] Rajeswari,B., Amirthagadeswaran, K.S. and Anbarasu,K.G. 2015,"Investigation on mechanical properties of aluminium 7075-silicon carbide-alumina hybrid composite using Taguchi method", Australian Journal of Mechanical Engineering, Vol. 13,No. 2, June, pp. 127-135

[3] Gyanendra Singh, Tanuj Giri, Fabrication of Aluminum/Magnesium Composite Material and Optimization their Mechanical Properties. International Journal of Science and Research (IJSR) Volume 5 Issue 11, November 2016.

[4] Siddanna Awarasan Prof.N.S. , Study The Microstructure and Impact Strength Of Lm 25 Aluminium Alloy Reinforced With Steel Wire , International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 09 | Sep -2016 www.irjet.net p-ISSN: 2395-0072

[5] Najib Souissi, Slim Souissi and Jean-Pierre Lecompte, Improvement of ductility for squeeze cast 2017 A wrought aluminum alloy using the Taguchi method, Int J Adv Manuf Technol January- 2015.

[6] Saravanakumar. P, Soundararajan. R, Deepavasanth. P.S, and Parthasarathi. N, A Review on Effect of Reinforcement and Squeeze Casting Process Parameters on Mechanical Properties of Aluminium Matrix Composites, International Journal of Innovative Research in Science, Engineering and Technology, Volume 5, Special Issue 7, April 2016.

[7] S.R.Durairaju, Naveenkumar.A, Prem Kumar.S,and Logeshwar.V"A Review On Material Processing Of Aluminium Metal Matrix Composites' , International Journal of Advanced Scientific and Technical Research Issue 6 volume 5, page 26- 34,September-October 2016.

[8] VenkatPrasat.S,Saravanan.M,Sakthivel.S.,andSivaprakash.R, Studies On Mechanical Property, Wear Behavior And Microstructure Of LM-25 AMMCS - A Review , International Journal of Advanced Scientific and Technical Research Issue 6 volume 5, September-October 2016.

[9] Md.Azhar Farooq Maniyar, B.S.Motgi, A study On Microstructure And Tribological Characteristics Of LM25/Sic/Mica-Hybrid MMC's., International Journal of Advance Research, IJOAR .org Volume 1, Issue 8, August 2013.

[10] Neelima Devi. C , Mahesh.V,and Selvaraj. N , "Mechanical characterization of Aluminium silicon carbide composite", International Journal of Applied Engineering Research, Dindigul, Volume 1, no 4, 2011.

[11] P. Senthil, K.S .Amirthagadeswaran " Experimental Study and Squeeze Casting Process Optimization for High Quality AC2A Aluminium Alloy Castings " Arabian Journal For Science and Engineering · March 2013.

[12] Lakhan Rathod and G.K.puthori Study of Microstructure and Mechanical Property of Aluminium – Alumina Metal Matrix, International Journal of Engineering Research & Technology ,Vol. 2 Issue 9, September - 2013.