Manufacturing of Aluminium Reinforced With Quartz in Composites

Dr. Thirumalai.T[1,a] , Dr. Boopathi. L [2] and Shreedhar.T[3,c]

[1]Assistant Professor, Erode Sengunthar Engineering College, Erode, Tamilnadu, India
[2]Principal, EIT Polytechnic College, Kavindapadi.
[3]PG scholar, Erode Sengunthar Engineering College, Erode, Tamilnadu, India

Abstract

In recent years the demand for the light weight material, low cost and high performance material was needed. Due to that the aluminium matrix composite is developed. Stir casting is the simplest and economical way for producing aluminium matrix composite. In present work the production of aluminium matrix composite is reinforced with various weight percentage of quartz by stir casting method. The resulting composites cast to be test for their mechanical properties. Experimental result shows that addition of quartz in aluminium alloy resulted in improvement in hardness and tensile strength. Dry sliding wear behavior of AMC was analyzed with the help of pin on disc wear and friction monitor. The wear test revealed the addition of quartz helped to decrease the wear rate. The micro structural of fabricated alloys were analyzed by scanning electron microscopy. From the SEM result the casting defect and improper defect was analyzed. The present analyze reveal the improved hardness which result in increasing the wear resistance.

Keywords: *AMC, Hardness, Tensile strength, Wear resistance*

Nomenclature

- AMC-Aluminum matrix composites
- MMC-Metal matrix composite

1. Introduction

In the recent years, the demand for light weight, low cost and high quality Performance materials have increased. Many researches have been done to develop new materials that meet these requirements. One of the newly developed materials is aluminum metal-matrix composites (AI-MMCs). Nowadays, there are various products used of MMCs especially for automotive and engineering applications. This is because of their high strength, high elastic modulus, and low co-efficient of thermal expansion, light weight, low thermal shock, good wear resistance and many more advantages.

2.Literature survey

Aluminum alloys are used in advanced applications because their combination of high strength, low density, durability, machinability, availability and cost is very attractive compared to competing materials. However, the scope of these properties can be extended by using aluminum matrix composite materials. Al based MMCs make up a distinct category of advanced engineering materials over conventional Al alloys. With the development of new forming methods and use of low cost particulate reinforcement materials, the use of these composites is increasing in a wide variety of industries.[1] David raja Selvam et al, studied and fabricated the aluminium matrix composite adding reinforced as SiC and constant weight of fly ash by stir casting method. By adding magnesium the wettability of SiC and fly ash gets improved. By adding fly ash the dissolution of SiC_p was prevented and Al_4C_3 formation was also prevented. The tensile strength of the aluminium matrix gets increased by adding silicon carbide.[2] A.Rutecka et al, studied and investigate the strain rate, fatigue properties, creep resistance and life time of Al/SiC MMC. By adding silicon carbide in aluminium the fatigue properties gets increased. The rate of damage parameters increase becomes greater for higher content of the SiC content particles. Magnitude of the mean strain decreased by adding silicon carbide.[3] C.Dhavamani et al, studied and investigate the drilling of aluminium silicon carbide. By desirable functional approach the minimizing surface roughness and maximizing metal removal rate is studied. To represent the relationship between input and output variable a multiple regression model is used and genetic algorithm is used to optimize the process. Based on speed, feed and dia of cut finishing of drilling of the composite will be good.[4] T.S.Mahesbabu et al, studied and investigate the turning operation in Al356 aluminium MMC adding silicon carbide and boron carbide as reinforcement. Poly crystalline diamond is used for turning operation. Based on the feed rate only the surface roughness will get increased or decreased. In ANOVA when feed rate change to 0.1mm/ rev the surface roughness gets decreased.[5] J.Jebeebmoses et al, studied and described about the fabrication of aluminium with reinforcement of various amount of silicon carbide. By adding silicon carbide particles the hardness and tensile strength gets increased. Due to the increase in reinforcement particles the mechanical properties gets increased compared to matrix composite and also it changes the fracture mode.[6] Hamid Reza Ezatpour et al, studied and investigate the effect of nano alumina when added to Al606 alloy and extrusion properties on mechanical and micro properties. In this the milled nano-Al_2O_3/Al composite powder was inject into melt by argon gas. The sample has fine grain micro structure with high porosity using extrusion nano Al_2O_3 were dispersed with low agglomeration, so that the strength and ductility gets increased.[7] K.Kalaiselvan et al, studied and worked on fabrication of aluminum matrix composites reinforced with boron carbide by stir casting method. The microstructure and mechanical properties has been analyzed. The wear resistance also gets increased by using boron carbide as reinforcement. The micro hardness and macro hardness were increased with respect to addition of boron carbide particles.[8] Himanshukala et al, studied and presents a review on mechanical properties and tribological properties of stir cast aluminum matrix composites containing single and multiple reinforcement. For the better hardness yield strength and tensile strength the addition of alumina, silicon carbide, boron carbide is needed. Organic reinforcement like coconut ash, rice husk ash increased the mechanical properties of the composites.

3.Material and method

A.QUARTZ

Quartz is the second most abundant mineral in the Earth's continental crust, after feldspar. It is made up of a continuous framework of SiO_4 silicon–oxygen tetrahedra, each oxygen being shared between two tetrahedra, giving an overall formula SiO_2. Quartz is a chemical compound consisting of one part silicon and two parts oxygen. It is silicon dioxide (SiO_2). It is the most abundant mineral found at Earth's surface and its unique properties make it one of the most useful natural substances.

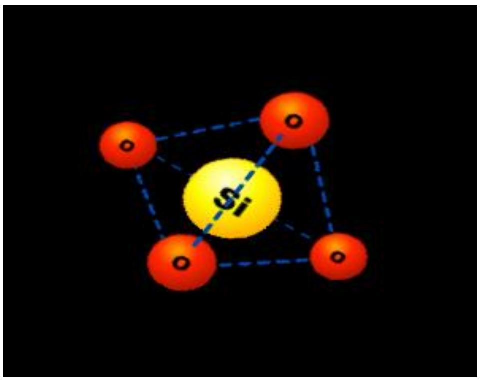


Fig. No. 1 Micro structure of quartz

Table No. 1 Chemical composition of Aluminium LM9

Material	% of Composition
Copper	0.04
Magnesium	0.51
Silicon	11.37
Iron	0.48
Manganese	0.42
Nickel	0.002
Zinc	0.02.
Lead	0.009
Tin	0.002.
Titanium	0.01
Aluminum	Remaining

B. Machining Process

Stir casting process has been employed for producing discontinuous particle reinforced metal matrix composites for decades. In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. In preparing metal matrix composites by the stir casting method, there are several factors that need considerable attention, including the difficulty of achieving a uniform distribution of the reinforcement material, wettability between the two main substances, porosity in the cast metal matrix composites, and chemical reactions between the reinforcement material and the matrix alloy.

Table No. 2 Process parameters of Stir Casting.

Parameters	Units	Value
Spindle speed	RPM	400
Stirring time	Min	5
Temperature of melt	°C	920
Preheated temperature of quartz particles	°C	300
Preheated temperature of mould	°C	250
Powder feed rate	g/s	0.8-1.2

C. Design of experiments

Taguchi methods are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering. Professional statisticians have welcomed the goals and improvements brought about by Taguchi methods, particularly by Taguchi's development of designs for studying variation, but have criticized the inefficiency of some of Taguchi's proposals. The Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varies.

4. Methodology

A batch of aluminum alloy was melted at 920°C using an muffle furnace. Before string the Quartz should be pre-heated at a temperature of 300°C.When the melting temperature attains the aluminium alloy will melt and then stirring process should be done by using the mechanical stirrer. The melt was agitated with the help of a mechanical stirrer to form a fine vortex. The mixtures of preheated SiO_2 particles were added at a constant feed rate into the vortex. The process parameters employed are given in Table. After stirring the molten mixture, it was poured down into the preheated permanent mould. The MMCs having different weight percentages (3,4.5, 6 and 9) of quartz were fabricated by the same procedure.

5. Data reduction

Sliding Velocity, V = (3.14*D*N)/60
Weight loss = before test – after test
Wear rate = Volume loss/sliding distance in mm^3/m
Volume loss = mass loss/density

6. Results and Discussion

Hardness VS volume fraction % of Quartz

Table No. 3 Increasing of hardness value

S.NO	Amount of quartz added in LM9(%)	Rockwell hardness in MPa
1	0	48.04
2	3	48.87
3	4.5	50.45
4	6	51.33
5	9	52.53

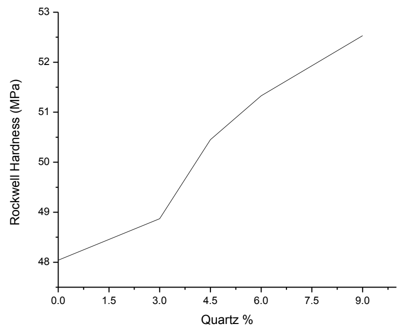


Fig. No. 2 Increasing of hardness value

Tensile strength VS Volume fraction % of Quartz

Table No.4 Tensile strength values

S.No	Amount of Quartz added in LM9 (%)	Tensile strength in MPa
1	0	168.75
2	3	170.86
3	4.5	176.37
4	6	179.49
5	9	183.67

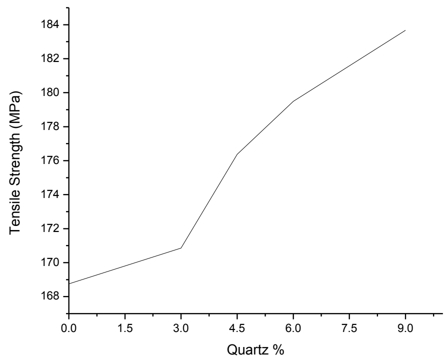


Fig. No. 3 Increasing in tensile strength

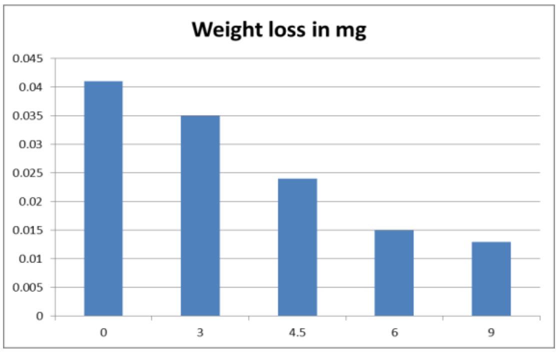


Fig. No. 4 Wear rate of AMC

Data of cumulative wear loss of Aluminium alloy

Table No. 5 Data of cumulative wear loss of Aluminum alloy

Length 50 mm	Diameter 8mm	Velocity 5 m/s	Track Diameter 100 mm	Weight 1Kg	Time 600 Sec
Sample no	**Specimen name**	**Initial weight (gm)**	**Final Weight(gm)**	**Weight loss(gm)**	
1	LM9	7.824	7.787	0.041	
2	LM9 + 3% of Quartz	7.456	7.421	0.035	
3	LM9 + 4.5% of Quartz	8.49	8.466	0.024	
4	LM9 + 6% of Quartz	7.921	7.906	0.015	
5	LM9 + 9% of Quartz	8.106	8.093	0.013	

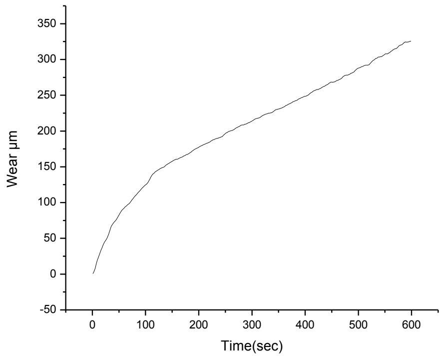


Fig. No. 5.1 Sample 1 (LM9 97% and quartz 3%)

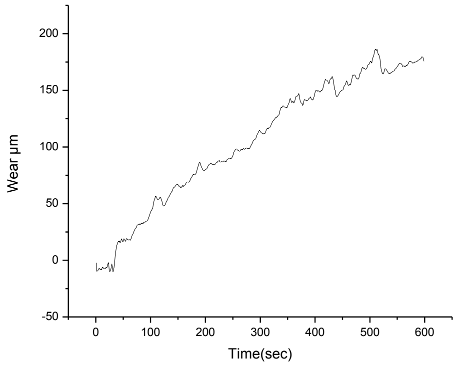


Fig. No. 5.2. Sample 2 (LM9 94.5% and quartz 4.5%)

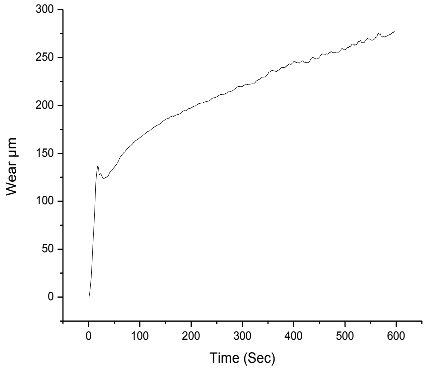


Fig. No. 5.3. Sample 3 (LM9 94% and quartz 6%)

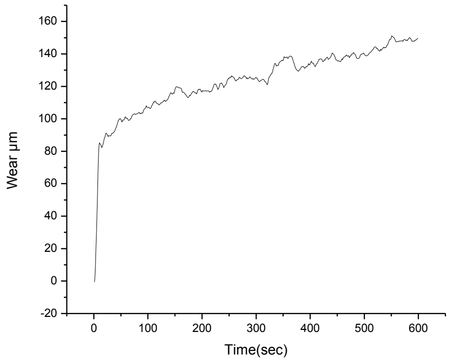


Fig. No. 5.4. Sample 4(LM9 91% and quartz 9%)

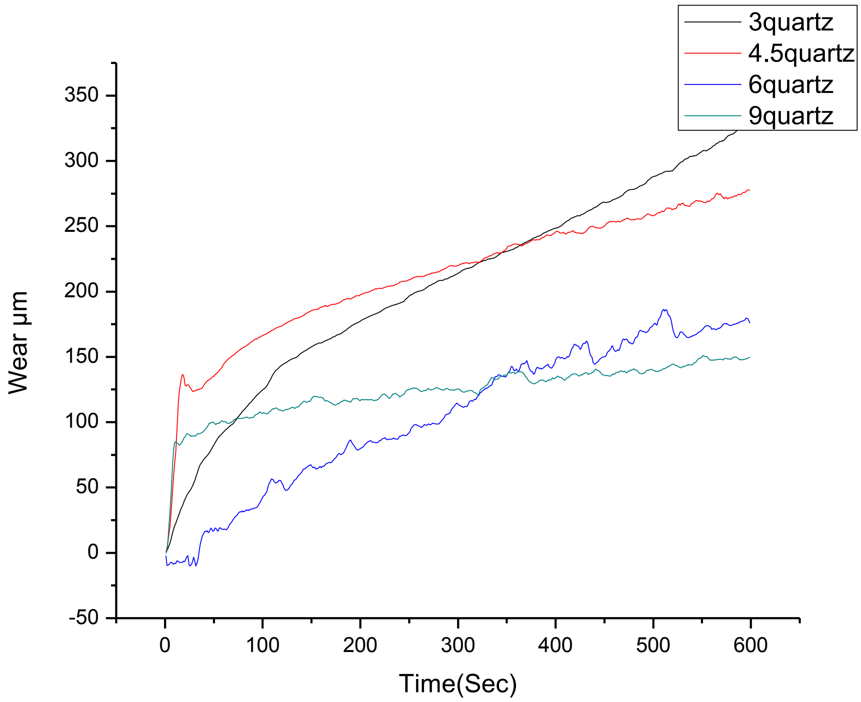


Fig. No. 6. Wear Comparison

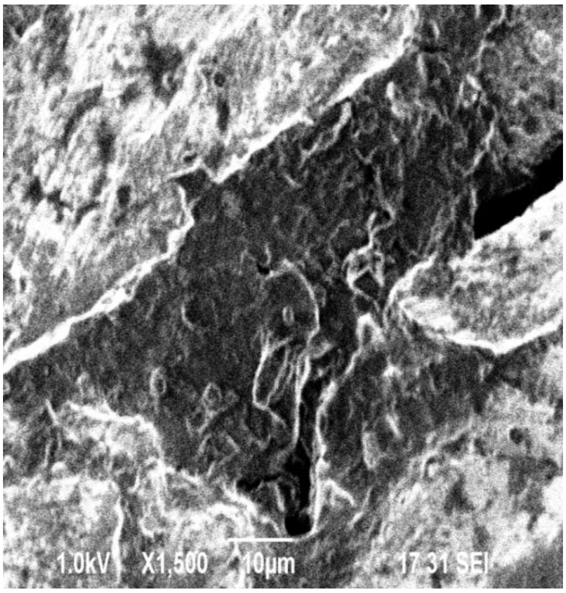
Table No. 6 Wear µm Vs Wear rate in mm^3/m

S.No.	Composition	Wear rate in µm	Wear rate in mm^3/m
1	LM9	349.26	0.0148
2	LM9 + 3% of Quartz	325.43	0.0119
3	LM9 + 4.5% of Quartz	277.6	0.0086
4	LM9 + 6% of Quartz	175.66	0.0054
5	LM9 + 9% of Quartz	149.77	0.0047

Wear of components is a critical factor and it influences the service life span. Wear is defined as the progressive loss of material from the surface of a solid body due to mechanical action i.e., contact or relative motion against a solid or liquid contact body. Advanced engineering materials, composites are used where high wear resistance is required. The abrasive wear resistance of the
particle reinforced with metal matrix composites increases with increase in the volume fraction addition of particles, under both high and low stress abrasive wear conditions.

6.2 MICROSTRUCTURAL ANALYSIS RESULT (SEM ANALYSIS)

From microstructural characterization of aluminum reinforced LM9 with different % quartz was shown in below. For the sample 1 containing 97%of LM 9,3% of quartz the SEM micrographs under various magnifications reveal the surface defects of the sample which may be caused due to stirring effect of the composite and casting.



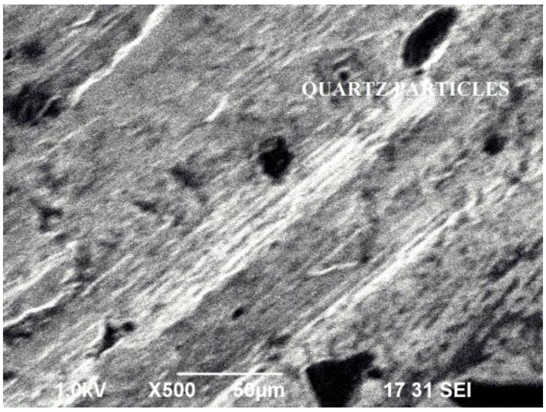


Fig. No. 7. SEM images for mixture 2

For the sample 2 containing 95.5%of LM 9,4.5% of quartz the SEM micrographs under various magnifications reveal the surface defects of the sample which may be caused due to stirring effect of the composite and casting. It shows the improper defect in microstructural characterization. Due to the addition of quartz the hardness gets increased with result in the decrease of wear rate. Henceforth the microstructural characterization of wear tested specimens reveal the defects caused at the time of preparation of the composite which resulted in material loss of composite and there was a decrease in wear resistance of the composite with increase in quartz content proving its credibility and its potential towards application usage.

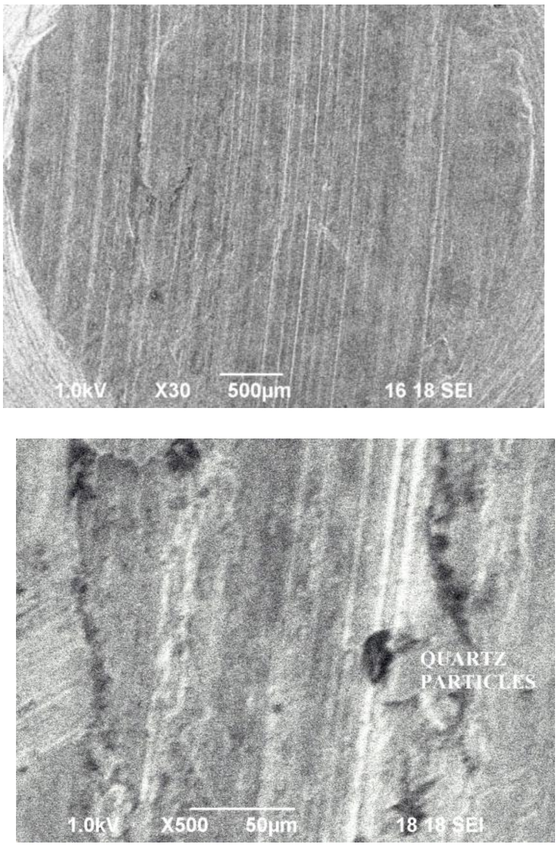


Fig. No. 8. SEM images for mixture 3

Figure 8 shows the effect of normal load on the wear rate. As the normal load increases the coefficient of friction also increase which leads to more wear rate. This is most common phenomenon in most of the material. Normal load has the highest effect on the sliding wear rate.

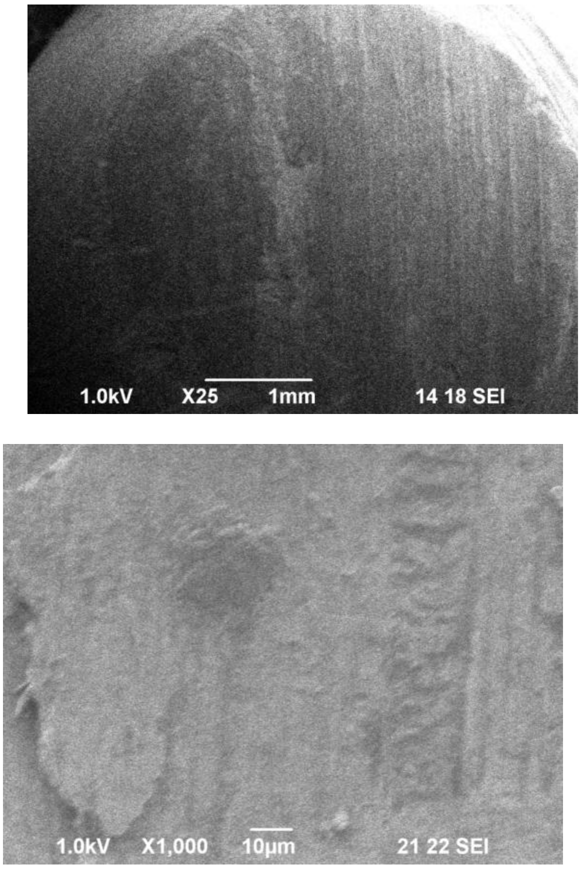
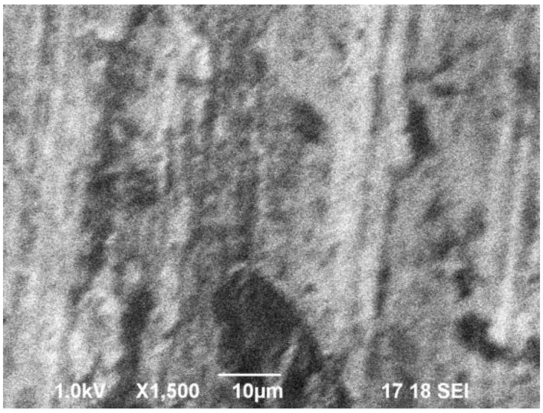


Fig. No. 9 SEM image for mixture 4

Figure 9 gives the numerous scratches on the wear surfaces. This suggests that the primary wear mechanism is abrasive wear. The examine of wear surface of the alloy and composite of lower magnification reveals distinct pattern of grooves and ridges running parallel to one another in the sliding direction



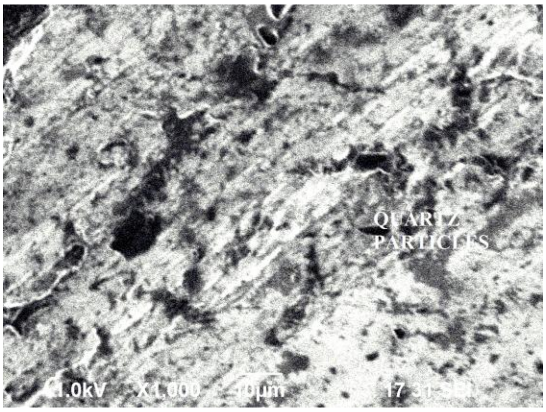


Fig. No. 10 SEM images for mixture 5

8. Conclusion

Stir casting method can be successfully used to manufacture aluminium matrix composite reinforcing quartz with desire properties. Reinforcing quartz with aluminium alloy in the respective percentages (3%,4.5%,6%,9%) has shown an appreciable increase in its mechanical properties. The hardness and tensile strength were increased with respect to the addition of weight percentage of quartz particles. Wear rate is minimum at 9% composition of quartz compared to other samples The SEM result reveal the distribution of quartz in aluminium matrix was fairly homogeneous From this study it reveals that addition of quartz in aluminium alloy result in better hardness and increase in wear resistance.

References

[1] David Raja Selvam. J, Robinson Smart. D.S. Dinaharan.(2013) I. “Synthesis and characterization of Al6061-Fly Ashp-SiCpcomposites by stir casting and compocasting methods”, Energy Procedia 34 637 – 646.

[2] A. Ruteckaa, Z. L. Kowalewskia, , K. Pietrzakb, L. Dietricha, K. Makowskab, J. Woniakc, M. Kosteckic, W. Bochniakc and A. Olszynac.(2011) “Damage development of Al/SiC metal matrix compositeunder fatigue, creep and monotonic loading conditions”, Procedia Engineering 10 1420–1425.

[3] C.Dhavamani, T.alwarsamy.(2012) “optimization of machining parameters for aluminium and silican carbide composite using genetic algorithm”, Procedia Engineering 38 1994 – 2004.

[4] T.S.Mahesbabu, S.aldrinsugin,Dr.N.Muthukrishnan. (2012) “investigation on the characterization of surface quality on machining of hybrid metal matrix composite(Al-SiC-B_4C)”, Procedia Engineering 38 2617 – 2624,1877-7058.

[5] J.Jabeenmoses, I.Dinaharan, S.Josephsekhar.(2014) “Characterizatio.n of silicon carbide particulate reinforced AA6061aluminium alloy composites produced via stir casting”, procedia material science 5 106-112.

[6] Hamid Reza Ezatpour , SeyedAbolkarimSajjadi , Mohsen Haddad Sabzevar , Yizhong Huang.(2014) “Investigation of microstructure and mechanical properties of Al6061-nanocomposite fabricated by stir casting”, Materials and Design 55 921–928.

[7] K. Kalaiselvan , N. Murugan , Siva Parameswaran.(2011),“Production and characterization of AA6061–B4C stir cast composite”, Materials and Design 32 4004–4009

[8] Himanshu Kala, K.K.S Mer, Sandeep Kumar.(2014)“A Review on Mechanical and Tribological Behaviors of Stir CastAluminum Matrix Composites”. Procedia Materials Science 6 1951 – 1960.

[9] Ashok Kumar Sahoo, SwastikPradhan.(2013) “Modeling and optimization of Al/SiCp MMC machining usingTaguchi approach”, Measurement 46 3064–3072.

[10] K. Palanikumar , A. Muniaraj.(2014) “Experimental investigation and analysis of thrust forcein drilling cast hybrid metal matrix (Al–15%SiC–4%graphite) Composites”, Measurement 53 240–250.

[11] K.K. Alaneme, A.O. Aluko.(2012) “Fracture toughness (K1C) and tensile properties of as-cast andage-hardened aluminium (6063)–silicon carbideparticulate composites”, ScientiaIranica A 19 (4), 992–996.

[12] S. Gopalakrishnan , N. Murugan.(2012) “Production and wear characterisation of AA 6061 matrix titanium carbideparticulate reinforced composite by enhanced stir casting method”, Composites: Part B 43 302–308.

[13] G. Elango, B.K.Raghunath. (2013) “Tribological Behavior of Hybrid (LM25Al + SiC+ TiO2) MetalMatrix Composites”,Procedia Engineering 64 671 – 680

[14] S. Suresh, N. ShenbagaVinayagaMoorthi. (2013) “Process development in stir casting and investigation onmicrostructures and wear behavior of TiB2 on Al6061 MMC”, Procedia Engineering 64 1183 – 1190.

[15] Ravindra Singh Rana, Rajesh Purohit, Anil kumar Sharma, SaraswatiRana.(2014) “Optimization of Wear Performance of Aa 5083/10 Wt. % SicpComposites Using Taguchi Method”, Procedia Materials Science 6 503 –511.