Proceedings of the International Conferenceon Applied Mechanical Engineering Research(IC-AMER2019)
NIT Warangal, India – May 02-05, 2019
Paper No. XXX (The number assigned when the papaer is accepted)

SYNTHESIS AND MACHINING CHARACTERISATION OF SiC REINFORCED ALUMINIUM COMPOSITES

N.MK Sarath Kumar[a*],E.Ramu[b], A. Vamsi Krishna[c], A. Sandeep Reddy[d]

[a,b,c,d]*Department of Mechanical Engineering, Vignan's Lara Institute of Technology & Science, Vadlamudi, Guntur 522 213 Andhra Pradesh, India*

*Corresponding author Email: sarath.kumarnmk@gmail.com

Current work aims to produce silicone carbide composites in aluminum metal matrix using the stir casting technique, which is a 40 micron particle with a 5 percent weight. Mostly because of its castability, A356 alloy is famous as a matrix material for its composite. Also the lower density of silicon Carbide, a popular A356 alloy reinforcement agent. These are therefore chosen for composite preparation in this work. They are tested for machinability studies on successful synthesis of specimens. Due to the hardening of the composite, cutting forces showed an increasing trend to a speed of 50mm / min and then reduced at a high speed as a result of softening the material. MRR and surface roughness have demonstrated an increasing speed trend. The tool has to deal with a higher material volume due to an increase in the depth of the cut, which eventually increases the cutting force and power consumption. Increasing trends in cutting depth have been shown by MRR while surface roughness has dropped from 0.95 to 0.75 μm and then grew to high cutting depth.

***Keywords*:** Depth of Cut, Feed, Material Removal Rate.

1. Introduction

In many applications today, the metal matrix composites (MMCs), due to their superior properties such as high strength to weight, hardness, rigidity and corrosion resistance replaces the conventional materials. Reinforced aluminum-based MMCs of silicon carbide (SiC) are among the common MMCs available on the market and have an economical manufacturing potential. [1] Furthermore, developments in the particular form of stir casting route have reduced its costs to an adequate level in comparison with those in powder metallurgy and spray casting. The rigidity and the strength-to-weight ratio of the cast MMCs are increased, however ductility is significantly reduced. AMC production methods include solid condition, liquid condition, vapour deposition and in-situ deposition. Liquid processing is an easy proposal and is widely accepted for the production of AMC. The present study attempts the development of a new composite in situ from a waste (colliary shale) made by the treatment of the plasma reactor / vacuum furnace when coal is mined from the underground mine. [2]

2. Materials

2.1. Matrix Material (A356):

System-based mechanical properties were studied in preformed A356 alloys with thixotropic structure (designated SSM-A356) with the goal of establishing a database for further forming and thermal treatment research. The heat treatment conditions of the SSM-A356 were examined by means of microstructure observations and micro hardness measurements due to the special microstructure and characteristics. In the heat treatment study, eutectical silicone was refined and spheroided, which is unlikely for traditional treatment, were observed. The mechanical test results indicated thatSSM-A356 's output and ultimate tensile resistance were approximately 115% and 34% higher than that of conventional A356 and that the elongation was two-three times higher respectively. The breakage propagation in the manner of a trans-granular is a typical type of ductile fracture, according to the analysis in fractured method by fatigue test. Therefore, a good ductility was expected for SSM-A356. From the test results the superior mechanical conduct of SSM-A356 could be concluded that the microstructure is essentially refined and eutectical silicone was periodized. [3]

Fig.2.1 A356 Ingots

2.2 .Reinforcement material –SiC:

Silicone carbide is the single chemical compound consisting carbon and silicone, also known as carborundum, produced in bulk since 1893 for use as abrasive. The chemical formula of silicon carbide is SiC, [4] it is a simple compound with the carbon atom attached to silicon by means of a triple bond leaving both atoms with a positive and a negative charge. An intensive high-temperature for the electro-chemical response of silicon and carbon. Acheson method is used to industrialise silicon carbide by mixing pure silica sand (SiO_2) and finely ground coke (carbon), and heating them to quite high temperatures in an electric furnace.

Pure SiC with a density of 3,21 grams / ml, an extremely high melting temperature of 2,730 ° C is produced like a colourless crystal. This is most commonly found by small quantities of iron or other industrial production as a bluish-black, iridescent crystalline solid. Silicon carbide (SiC) particles attributes high thermal conductivity, extremely high stability, high purity, good wear resistance and a reduced co-efficient of thermal expansion. These high-temperature particles are resistant to oxidation. An important point concerning storage is that moisture, heat and stress are to be avoided.

3. Stir casting method

The aluminum alloy was loaded into the crucible and heated above 700 C until the entire metal was melted. The reinforcement part SiC was preheated to 700-800oC for 1 hour before moisture was incorporated into the melt. The degassing tablet (coveral powder) was added after the molten metal was completely melted to reduce porosity. The stirrer consisting of ceramic stainless steel was slowly reduced for molding the molten metal at 700 rpm for melting. On the furnace, the velocity of the burning machine can be controlled. The pre-heated SiC particles were added to the molten metal repeatedly during stirring. Stirring was continued for a further 5-10 minutes even after particulate feeding. An interesting new development is a two-stage mixing process. The fluid composite material is then cast using conventional casting methods, with conventional metal forming methods being used for processing. [6]

Fig.3.3 A356+SiCComposite

4. Experimental method

The experiments were performed on an automatic lathe using HSS tool bits. Machining was carried out with a constant feeding rate of 0.2 mm / rev and depth of cut (t) 1 mm in dry environments with three cutting speedings (Vc) of 202, 303 and 455 m / min. Cutting forces at the Vignans Foundation for Science, Technology and Research in Guntur were measured on the lathe dynamometer facility. At the same time, the values of the temperature and the surface are measured under different feed and cutting conditions.

Fig.4.3 Lathe tool dynamometer setup

5. Experimental conditions:

5.1 Input Parameters:

Different cutting speeds, depth of cuts and feed rates as input parameters are used to calculate various machining characteristics.

Table.5.1 Experimental condition of machine

S. no	Speed (m/min.,)	Depth of cut(mm)	Feed (mm/rev)
1	30	0.5	Constant (0.4)
2	50	0.75	Constant (0.4)
3	70	1	Constant (0.4)

5.2 Responses measured:

During machining, cutting forces and temperatures are take from lathe tool dynamometer and by using these values power and material removal rate are calculated.
Axial force (F_x) in(N), Cutting force (F_y) in(N), Radial force (F_z) in(N), Temperature (Tt) in(^{O}C), Metal removal rate (MRR) in(mm^3/min.,), Power in(kw), Surface roughness in (μm)

6. Results and discussion

After loading the component on the lathe machine plane turning operation has performed and specimen is divided into six divisions to perform six operations by varying speed and depth of cut parameters. Feed is kept constant in every time.

6.1 Effect of speed:

Under this situation turning operation is carried out at different cutting speeds like 202, 303 and 455 rpms at the same time feed and depth of cut are kept constant. Cutting forces values are taken from lathe tool dynamometer.

Table.6.1 Cutting forces values at different cutting speeds

Cutting speed (m/min)	F_x(N)	F_y(N)	F_z(N)
30	39.24	147.15	176.58
50	78.48	235.44	225.63
70	78.48	196.2	206.01

By noticing the above values we can find that by gradually increasing the speed, cutting forces induced between the tool and work piece are increased.

6.2 Effect of depth of cut:

Under this situation turning operation is carried out by giving different depth of cuts like 0.5, 0.75 and 1 mm. while cutting speed and feed are constant. Again cutting forces values are taken from lathe tool dynamometer.

Table.6.2 Cutting forces values at different depth of cuts

Depth of cut (mm)	F_x(N)	F_y(N)	F_z(N)
0.5	88.29	206.01	215.82
0.75	88.29	196.2	196.2
1.0	147.15	294.3	274.68

6.3 Machining results

By using the values collected from lathe tool dynamometer we calculated power and material removal rate and by using surf test instrument we checked surface roughness of machining specimen.

6.3.1 Effect of speed

Power, material removal rate and surface roughness values under different cutting speeds are as follows

Table.6.3 Power, MRR and surface roughness values at different cutting speeds

Cutting speed (m/min)	Power (kw)	MRR(mm^3/min)	Surface roughness(μm)
30	4.29	8.75	17.02

50	10.3	13.92	19.01
70	12.9	18.19	29.09

6.3.2 Effect of depth of cut

Power, material removal rate and surface roughness values under different depth of cut are as follows

Table.6.4 Power, MRR and surface roughness values at different depth of cuts

Depth of cut (mm)	Power (kw)	MRR(mm^3/min)	Surface roughness(μm)
0.5	6.01	8.75	14.08
0.75	8.58	13.92	13.67
1.0	19.35	16.15	20.40

7 CONCLUSION

With the stir casting technique, A356-SiC composite was successfully prepared. Cutting forces showed an increasing trend to speed due to composite hardness and then decreased at high speed due to material softness. Increasing trends in speed are shown by MRR and surface roughness. As the cutting depth increases, the tool is responsible for higher material removal, which ultimately leads to increased energy consumption and force. The trend towards cut depth has been steadily increasing, whereas surface ruggedness has decreased and increased at a high cutting depth.

References

1. J. Surappa, M.K. and Rohatgi, R.K., Journal of Material Science, Vol. 61,983- 993(1981)

2. Monaghan.J.M., P.O" Reilly. "The drilling of an Al /SiC journal of material ProcessTechnol".(1992)

3. Amol Mali, S. A. Sonawane, Sachin Dombale, Effect of Hybrid Reinforcement on Mechanical Behavior of Aluminium Matrix Composite, International Journal of Engineering Research & Technology (IJERT), Vol. 4 Issue 01,130-133(2015)

4. J. Hashim, L. Looney, M.S.J. Hashmi, Metal matrix composites: production by the stir casting method, Journal of Materials Processing Technology,92-93 (1999).

5. S. G. Kulkarni, J. V.Meghnani, AchchheLal, Effect of Fly Ash Hybrid Reinforcement on Mechanical Property and Density of Aluminium 356 Alloy, International Conference on Advances in Manufacturing and Materials Engineering AMME, (2014)Procedia Materials Science 5, pp.746-754

6. Pardeep Sharma, GulshanChauhan, Neeraj Sharma, Production of AMC by stir casting – An Overview, International Journal of Contemporary Practices, Vol.2, Issue1pp.23-46 , (2008).