IJSTE - International Journal of Science Technology & Engineering | Volume 4 | Issue 5 | November 2017
ISSN (online): 2349-784X

Influence of Machining Parameters on the Responses for Al/SiCp Composite

R. Suriyamurthy
Assistant Professor
Department of Mechanical Engineering
Kings College of Engineering, Punalkulam

Abstract

The manufacturing industries specially are focusing their attention on dimensional accuracy and surface finish. The important goal in the modern industries is to manufacture the products with lower cost and high quality in short span of time. There are two main practical problems that engineers face in a manufacturing process. The first is to determine the values of the process parameters that will yield the desired product quality, in other words attaining the technical requirements. And the second one is to maximize the manufacturing system performance using the available resource. For many researchers the term metal matrix composite (MMC) is often equated with the term light metal matrix (LMC) because of their strength to weight ratio. This paper presents the influence of process parameters like cutting speed, feed and depth of cut on surface roughness (Ra) in turning Al/SiCp metal matrix composites using carbide insert. The experiments have been conducted based on Taguchi's L9 orthogonal array. The optimal parametric combination for surface roughness was found. Mathematical models for surface roughness found to be statistically significant.
Keywords: Machining parameters, Aluminium, Silicon carbide, SEM, Optimization

I. INTRODUCTION

Metal matrix composites (MMCs) are newly developed materials in recent years having favourable mechanical properties like high strength, hardness, wear resistance and strength to weight ratio. It has a wide range of application in industrial sectors like automotive to aerospace [1]. As MMCs contain softer matrix reinforced with very hard particulate, machining of such material becomes difficult and put challenges in machining sectors. MMCs are basically manufactured by performing process to produce near net shape product. Machining is essentially required to obtain desired dimensional accuracy, form accuracy, surface finish to satisfy functional requirements [2]. This semi finishing and finishing operation is normally done by traditional machining processes like turning or milling etc. Machinability is termed as 'ease' with which a material can be machined. Machinability is difficult to quantify because of the large number of variables involved [3]. Generally, machinability characteristics of any combination of tool-work pair can be judged by (a) magnitude of cutting forces, (b) chip forms, (c) magnitude of cutting temperature (d) surface finish and (e) tool wear and tool life [4]. Machinability will be considered desirably high when cutting forces, temperature, surface roughness and tool wear are less, tool life is long and chips are ideally uniform and short enabling short chip-tool contact length and less friction. Traditional tool materials like high speed steel is not suitable for machining MMCs due to rapid growth of tool wear [5]. Experimentally investigated the machinability aspects of Al–SiC MMCs with PCD and coated tungsten carbide tools in context to tool wear, cutting forces and surface finish. PCD tool have shown 30 times higher tool life than carbides under similar cutting conditions. Abrasion was found to be the primary wear mechanism. It was found that the flank wear is the primary mode of tool failure in machining Al/SiC MMC with PCD tool. With increase of cutting speed and feed, flank wear was found to increase [6]. Discontinuous chip formation was observed due to the presence of uniformly dispersed Sic particles. Some of researchers investigated the comparative performance of PCD and Chemical Vapour Deposition (CVD) diamond coated carbide insert during machining MMCs. It was revealed that PCD inserts performed much better compared to CVD coated diamond inserts [7]. It was observed that PCD tool performed better compared to poly crystalline boron nitride (PCBN) tool in terms of tool life during machining MMCs. Built-up- edge formation and grooving wear was noticed in PCBN tools and eliminated by the use of coolant. Some of the researchers investigated the machining of Al/SiCp-MMC using PCD and conventional tungsten carbide tools. Adhesion was found to be dominant wear mechanism during machining. PCD tool offered greater benefit in the machining of MMCs [8]. Al-Si particle composite was produced using stir casting technique. Taguchi's L9 orthogonal array was used to investigate the process parameters. Experimental results indicate that multi-response characteristics such as density and hardness can be improved effectively through Taguchi analysis. Researchers observed that carbide inserts showed better surface finish as compared to ceramic insert during machining.

II. METHODS, MATERIAL SELECTION & PREPARATION OF COMPOSITES

A. Aluminium Alloy AA6063

Aluminium alloys can be developed from one or a combination of metal forming process. The mechanically worked after being cast and cannot be strengthened by precipitation hardening; they are hardened primarily by cold working. Working the material densities it, adding tensile strength but lowering malleability. Casting alloys are formed by a casting process that forms alloys either continuously or into set shapes. They include heat-treatable and non-heat treatable alloys, allowing more workability and higher amounts of alloying elements more workability and higher amounts of alloying elements to be added but decreasing the alloy. The representation of specimen is shown in figure 1.

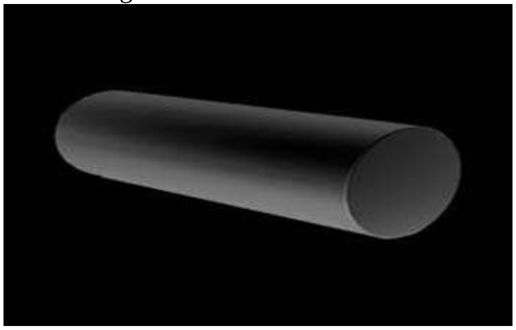

Fig. 1: Aluminium 6063 Grade specimen sample

B. Silicon Carbide

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications. The excellent properties of silicon carbide are, low density, high strength, low thermal expansion, high thermal conductivity, high hardness, high elastic modulus, excellent thermal shock resistance and superior chemical inertness. The SiC particle in powder form is shown in figure 2.

Fig. 2: Silicon carbide powder

C. Methodology of Stir Casting Technique

Stir casting is a liquid state method of composites materials fabrication, in which a dispersed phase (ceramic particles, short fibres) is mixed with a molten matrix metal by means of mechanical stirring. The simplest and the most cost effective method of liquid state fabrication is Stir Casting Technique. Stir casting involves adding particles into the melt in the crucible which is kept inside the furnace. The melt is transferred to permanent moulds after stirring, Modified stir casting involves directly transferring the melt into a permanent mould with a bottom pouring arrangement attached to the furnace.

D. Fabrication of Composites

Liquid metallurgy technique is used for fabrication of aluminium and silicon carbide combination. The cylindrical specimen of 30mm diameter and approximately 80mm in length is fabricated for test. The combination was heated above its melting temperature and stirred with zircon coated impeller. Zircon coating was done to prevent diffusion of ferrous material in to the combination during stirring. When the molten metal whirl is formed, to improve the wettability property pre heated SiC particles to about 4000C were introduced in to molten matrix. Magnesium is added in the small percentage which also improves the wettability. Continuous stirring of the mixture is enforced to facilitate the proper distribution and wetting of the particles. The stirred mixture is poured in to the permanent cast iron mould and required castings are obtained. Three compositions of SiCp are fabricated for current study and it includes 5%, 10% and 15% by weight. Microscopic study of composite was carried out by scanning electron microscopy. The specimen is polished for metallographic inspection. Polishing was carried out with different grades of emery papers and finally polished with Al_2O_3 paste and abrasive cloth. Suitable etching agent was applied to the surface for clear visualization of particle distribution. The typical SEM micrograph shows distribution of SiCp in the matrix and distribution was found to be uniform and at some portion clustering of SiCp was observed which is given in Figure 3.

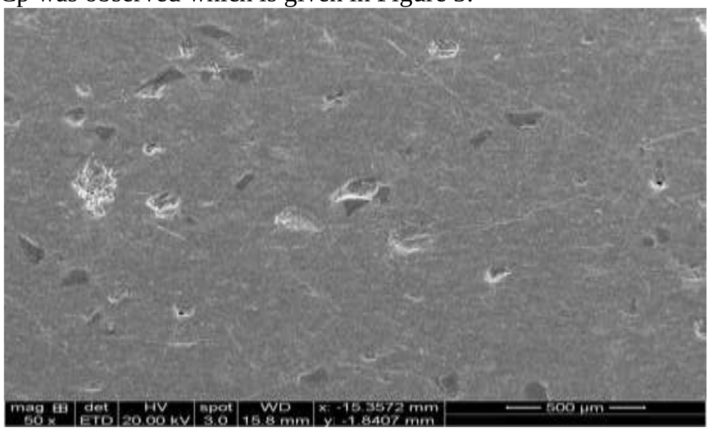

Fig. 3: SEM image of Aluminium and Silicon Carbide MMC

III. DESIGN OF EXPERIMENTS

Taguchi proposed an experimental plan in terms of orthogonal array that gives different combinations of parameters and their levels for each experiment. According to this technique, entire parameter space is studied with minimum number of experiments. This approach is based on the use of orthogonal arrays to conduct small, highly fractional factorial experiments up to larger, full factorial experiment. In this research there are three controllable variables or process parameters namely, cutting speed, feed and depth of cut? Three levels were specified for each of the factors. The orthogonal array chosen was L9, which has 9 rows corresponding to the number of parameter combinations. Three trials were performed for each combination resulting in a total of 27 trials which allows analysis of the variance of the results. The parameter and its levels are noted in table 1.

Table - 1
Factors and Levels

Parameters	*Designation & Units*	*Level 1*	*Level 2*	*Level 3*
Speed	*S (rpm)*	*250*	*400*	*550*
Feed	*F (mm/rev)*	*0.25*	*0.50*	*0.75*
Depth of Cut	*D (mm)*	*0.50*	*1*	*1.5*

The turning experiments were conducted under wet conditions on CNC super jobber 500 LM having height 1371.60mm, bed length 1066.80mm, bed width 177.80mm, bed to centre distance 127mm and motor 1hp. The 30mm diameter and 100mm length work piece were subjected to tuning on the CNC. After the turning operation has been performed the surface roughness was measured. The experimental values of roughness was denoted in table 2.

IV. RESULTS & DISCUSSION

Process performance characteristics surface roughness has been used to analyse the effect of process parameters. Parameter setting as per L9 mixed orthogonal array has been shown in table 2. Each trial has replicated for three times. In the Taguchi method, a loss function has been defined to gauge the deviation between the experimental and desired value of a performance characteristics.

Table - 2
Experimental inputs and response

Sl.No	*S (m/min)*	*F(mm/rev)*	*D (mm)*	*Ra (µ)*
1	*250*	*0.25*	*0.5*	*3.45*
2	*250*	*0.50*	*1.0*	*3.16*
3	*250*	*0.75*	*1.5*	*2.65*
4	*400*	*0.25*	*1.0*	*3.38*
5	*400*	*0.50*	*1.5*	*2.19*
6	*400*	*0.75*	*0.5*	*3.85*
7	*550*	*0.25*	*1.5*	*2.47*
8	*550*	*0.50*	*0.5*	*2.78*
9	*550*	*0.75*	*1.0*	*2.16*

The main effect has been studied by the level average response analysis of experimentally obtained data and the analysis has been done by averaging the experimentally obtained data at each level of each parameter and plotting the value in graphical form. The main effect plots for experimental obtained data for surface roughness have been shown in Figure 4.

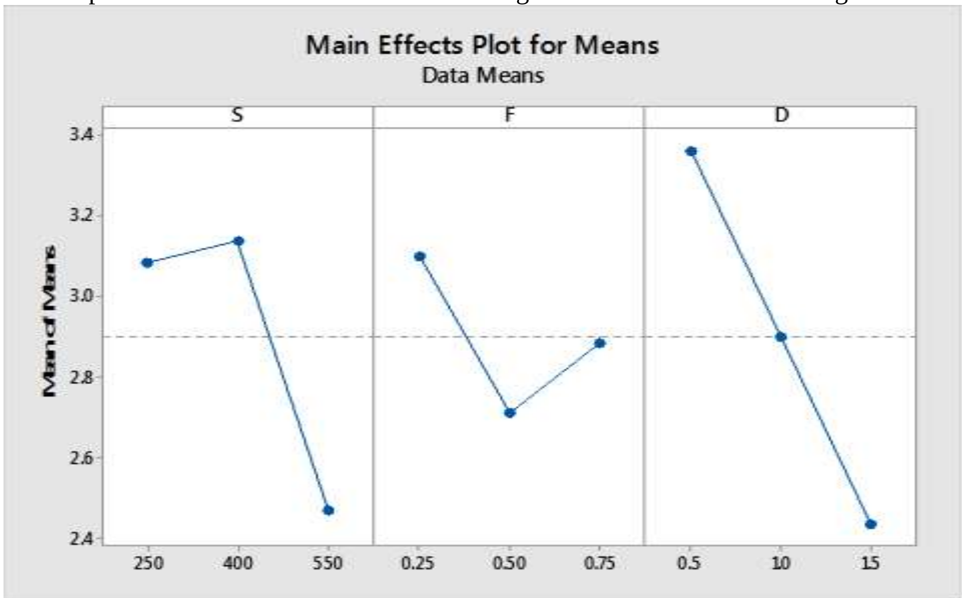

Fig. 4: Main Effect plot for the prediction of surface roughness

V. CONCLUSION

In this study the machinability of the silicon carbide reinforced aluminium composite material has examined. The effect of cutting parameter on surface roughness was measured. The following conclusions have been drawn

1) In this research work, the cutting parameters have been predicted to get desired surface roughness in minimum possible machining time using DOE technique. But machining is a complex phenomenon and so inclusion of many other machining parameters and constraints may enhance the result.
2) The objective of turning is to remove material from a work piece to obtain a specific shape and improve surface finish is studied in detail.
3) The optimal machining conditions are detailed as, at the speed 550 rpm, feed 0.50 mm/rev and depth of cut 1.5 mm is found to be optimal condition.

REFERENCES

[1] Balasubramaniyan and Mohanty (2012) ,"Boron Carbide Reinforced aluminium 1100 matrix composites Fabrication and properties" International journal on material science and engineering, pg no 42-52.
[2] Chowdhury et al, (2011), "The Effect of Sliding Speed and Normal Load on Friction and Wear Property of Aluminum" IJMME, vol 1, pg no. 45-49.
[3] Chen and Daniel Tao, (2010)," Modeling and optimization of high chromium alloy wear in phosphate laboratory grinding mill with fuzzy logic and particle swarm optimization technique" International Journal on Minerals engineering ,Pg no 713-719.
[4] Chen and Alpas,(2010) ," Wear of aluminium matrix composites reinforced with nickel-coated carbon fibres" International journal on wear pg 334-338.
[5] Dong Feng Diao et al , (2013)," Temperature dependence of sliding wear behavior in SiC whisker or SiC particulate reinforced 6061 aluminum alloy composite", International Journal on Wear, pg no 467-469.
[6] Devaraju et al, (2013)," Influence of reinforcements (SiC and Al2O3) and rotational speed on wear and mechanical properties of aluminum alloy 6061-T6 based.
[7] Ding yu Dong et al, (2012),"Thermal analysis for brake disks of Sic/6061 Al alloy co-continuous composite for CRH3 during emergency braking considering airflow cooling", pg 2783-2791.
[8] Goal Krishnan and Morgan (2012)," Production and wear characterization of AA 6061 matrix titanium carbide particulate reinforced composite by enhanced stir casting method", Composites part B, pg no 302-308.