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STUDY THE EFFECT OF CARBIDE AND HSS DRILLING ON SURFACE ROUGHNESS OF Al/SiC-MMC

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Abstract - This paper presents an experimental investigation of the influence of drilling conditions on surface finish of hole during drilling of Al/SiC-MMC. Taguchi method and Analysis of variance (ANOVA) is employed to investigate the influence of spindle speed, feed rate and drill bit material (Carbide and HSS) on surface finish of hole. Through various graphical representations it can be concluded that lower spindle speed and lower feed rate are the suitable parameters for better surface finish for carbide drill. Higher spindle speed and higher feed rate are suitable parameters for HSS drill.

Keywords - Al/SiC-MMC, Stir Casting, Taguchi Method, ANOVA Method, Drilling of MMC, Surface Finish.

I. INTRODUCTION

A composite material is a combination of two or more chemically distinct, having different properties, distinct boundaries; and insoluble phases. Its properties and structural performance are superior to those of its constituents if separate. A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal as matrix material. The other material may be a different metal or another material, such as a ceramic or organic compound as reinforced. Carbide drills are often made from a tough cobalt matrix with hard tungsten carbide particles inside is example of MMC.

Aluminium alloys are widely used in the automotive industry because of their high strength to weight ratio as well as high thermal conductivity. It is used particularly in automobile engines as cylinder liners as well as other rotating and reciprocating parts, such as the piston, drive shafts, brake rotors and in other applications in automotive and aerospace industries. Ceramic particles such as SiC are commonly added as a second reinforcement material in MMC hybrid composite to an increase in wear resistance, elastic modulus; and decrease in the thermal expansion coefficient for contact sliding application, i.e. brake disk rotors.

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring. Stir Casting is the simplest and the most cost effective method of liquid state fabrication. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies. Advance composite materials like Al/SiC metal matrix composite is gradually becoming very important materials for their scope of uses in modern industries e.g. aerospace, automotive and automobile industries due to their superior properties.

The production of through and blind holes, grooves, slots and odd shaped complex contours with high dimensional accuracy in the Al/SiC composite parts have also been difficult to obtain with traditional casting process. Hence, these Al/SiC-MMC parts are required to finish with subsequent machining processes. One of the major machining operations that are carried out on Al/SiC-MMC owing to the need for components assembly in mechanical structures is, drilling. It is most commonly used machining processes in various industries such as automotive, aircraft and aerospace, Dies/Molds, Home Appliance, Medical and Electronic equipment industries. Tight geometric tolerance requirements in design demand that drilled hole precision must be increased in production. For example, over 100,000 holes are made for a small single engine aircraft: in a large transport aircraft millions of holes are made mostly for fasteners like rivets and bolts. The quality of the drilled hole can be critical to the life of the joints for which the holes are used. However, few special drills will be used to investigate the effect of various parameters of drilling of Al/SiC-MMC. For overcoming the Al/SiC-MMC machining problems, the continuous research is going on in the area of machining of such composites.

Burn, Lee and Gorsler (1985) studied on the machinability of Al/40 vol % SiC using PCD, PCBN, Al2O3-TiC coated tools without use of coolant. They concluded that all the cutting tools worn out rapidly and only PCD tool provided somewhat useful tool life. A. Manna.; and B. Bhattacharaya (2002) performed a series of turning tests on Al/SiC MMC using different tooling systems. The tooling systems used was fixed rhombic tooling (FRT), fixed circular tooling (FCT), rotary circular tooling (RCT). They concluded that self propelled rotary circular tool have more life than fixed circular tool even if used in intermittent machining of Al/SiC MMC. J.P. Lucas, J.J. Stephens and F.A. Greulich (1991) studied on the microstructural characterization of cast Al-7Si particulate reinforced metal matrix composites, which included extensive examination of particulate-matrix interfacial precipitation reactions. They concluded that the type of reinforcements have a profound effect on the interfacial precipitation and microstructures of the matrix. M. Gupta and S. Qin (1997) studied the interfacial behavior in a SiC reinforced 6061 Al alloy synthesized using the conventional casting route. S. Basavarajappa et al. (2008) presented the influence of cutting parameters on thrust force, surface finish, and burr formation in drilling Al2219/15SiCp and Al2219/15SiCp-3Gr composites. A. Riaz Ahamed et al. (2010) reported on the drilling of Al-5%SiCp-5% B4Cp hybrid composite with high-speed steel (HSS), not expensive PCD, or carbide drills in an attempt to explore the viability of the process. Drilling of Al-5%SiC-5%B4C composites with HSS drills is possible with lower speed and feed combination.

II. EXPERIMENTAL PROCEDURE

Al/SiC Metal Matrix Composite materials are to be used as work-piece materials. It is essential to select proper machining parameters for effective drilling of Al/SiC-MMC's. Stir casting technique will be used to prepare the work-piece samples. These work-piece samples Al/SiC-MMC will be utilized for drilling through hole 10mm depth on drill machine. Different drilling tests were performed on Al/SiC-MMC using automatic feed HMT Radial Drilling Machine. Table-1 shows the details about the machine tools, work-piece and different drill bits used for experimentation.

Table 1 Details of experimental conditions for drilling

Drill Type	Diameters of Drill
HSS drill	5 mm
Pure carbide drill	5 mm

Table-2 shows the different parameters and their levels considered for the experimental investigation. For measuring the drilled hole surface roughness, each test sample was cut into two pieces along the centre line of the each drilled hole with necessary precaution so that inner surface does not get damaged. Surfcom 130A surface measuring instrument was used to measure the drilled hole surface roughness. For each half-hole surface, three readings were taken in different locations, i.e. at entry of the drilled hole, middle of the drilled hole and at exit of the drilled hole along the direction of drilling. The deviation of drilled hole diameters were measured using digital telescopic gauge of least count 0.01 mm.

Table -2 Drilling parameters and their levels for experimentations

Parameters, units	Parametric Levels		
	1	2	3
Spindle Speed (rev/min)	260	450	770
Feed rate (mm/rev)	0.12	0.25	0.50

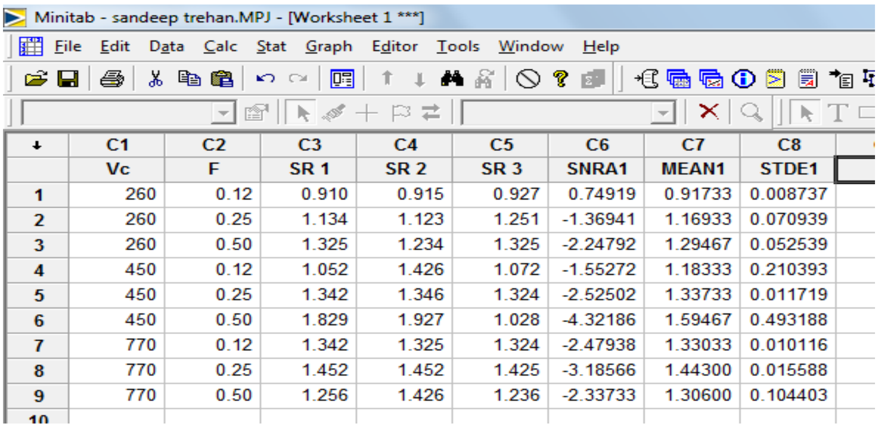
III. RESULTS AND DISCUSSION

Various graphs have been plotted to analyze the effect of spindle speed and feed rate on the drilling characteristics such as drilled hole surface roughness height.

3.1 Results of Carbide Drill

Table-3 Experimental results for surface roughness height Ra (μm) for Carbide Drill

Experiment No.	Cutting Velocity (Vc)	Feed (F)	Surface roughness		
			SR_1	SR_2	SR_3
1.	260	0.12	0.91	0.915	0.927
2.	260	0.25	1.134	1.123	1.251
3.	260	0.5	1.325	1.234	1.325
4.	450	0.12	1.052	1.426	1.072
5.	450	0.25	1.342	1.346	1.324
6.	450	0.5	1.829	1.927	1.028
7.	770	0.12	1.342	1.325	1.324
8.	770	0.25	1.452	1.452	1.425
9.	770	0.5	1.256	1.426	1.236



Minitab - sandeep trehan.MPJ - [Worksheet 1 ***]

	C1	C2	C3	C4	C5	C6	C7	C8
	Vc	F	SR 1	SR 2	SR 3	SNRA1	MEAN1	STDE1
1	260	0.12	0.910	0.915	0.927	0.74919	0.91733	0.008737
2	260	0.25	1.134	1.123	1.251	-1.36941	1.16933	0.070939
3	260	0.50	1.325	1.234	1.325	-2.24792	1.29467	0.052539
4	450	0.12	1.052	1.426	1.072	-1.55272	1.18333	0.210393
5	450	0.25	1.342	1.346	1.324	-2.52502	1.33733	0.011719
6	450	0.50	1.829	1.927	1.028	-4.32186	1.59467	0.493188
7	770	0.12	1.342	1.325	1.324	-2.47938	1.33033	0.010116
8	770	0.25	1.452	1.452	1.425	-3.18566	1.44300	0.015588
9	770	0.50	1.256	1.426	1.236	-2.33733	1.30600	0.104403

Fig 1: Results of Mean, S/N ratios, and Standard Deviations

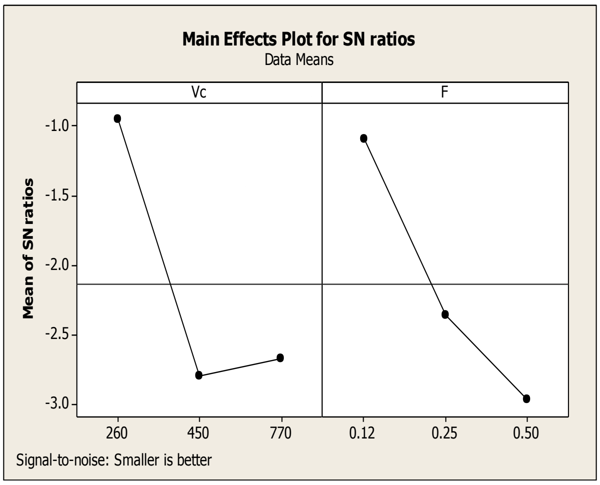


Fig 2: S/N Ratio Graph of Surface Roughness for Carbide Drill

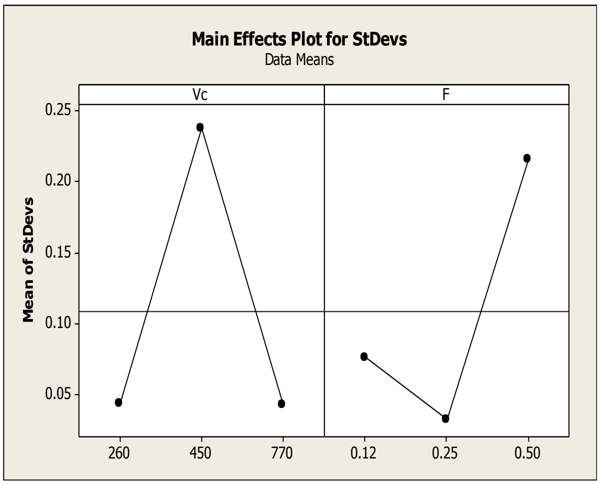


Fig 3: Standard Deviation Graph of Surface Roughness for Carbide Drill

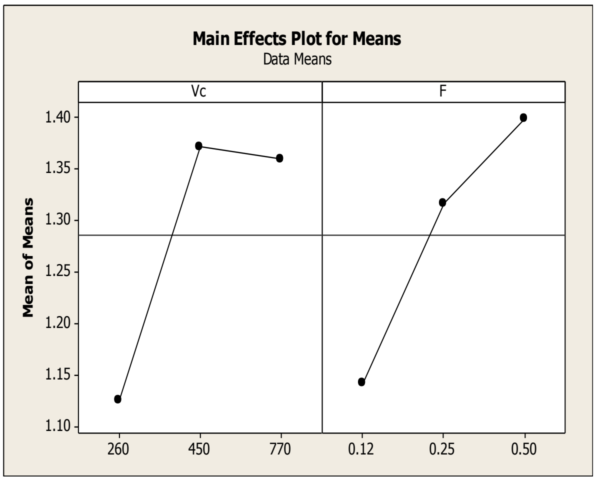


Fig 4: Means of Surface Roughness Height for Carbide Drill

3.2 Results of HSS Drill

Table 4: Experimental results for surface roughness height Ra (μm) for HSS Drill

Experiment No.	Cutting Velocity (Vc)	Feed (F)	Surface roughness		
			SR_1	SR_2	SR_3
10.	260	0.12	3.527	3.738	3.562

11.	260	0.25	3.829	3.762	3.785
12.	260	0.5	1.324	1.625	1.624
13.	450	0.12	2.346	2.643	2.537
14.	450	0.25	3.453	3.345	3.365
15.	450	0.5	3.556	3.466	3.547
16.	770	0.12	3.457	3.427	3.426
17.	770	0.25	1.527	1.638	1.538
18.	770	0.5	2.438	2.537	2.531

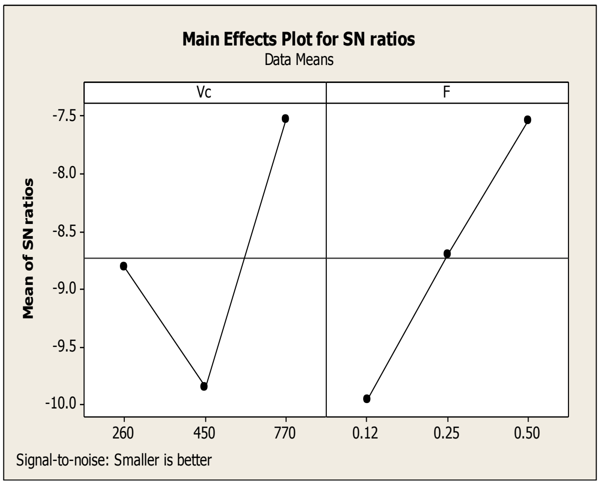


Fig 5: S/N Ratio Graph of Surface Roughness for HSS Drill

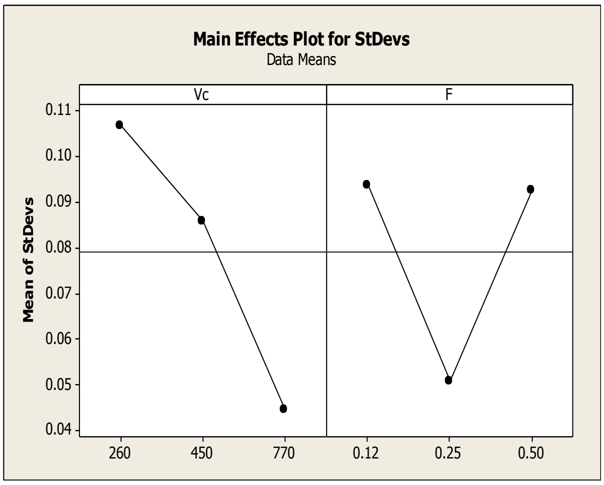


Fig 6: Standard Deviation Graph of Surface Roughness for HSS Drill

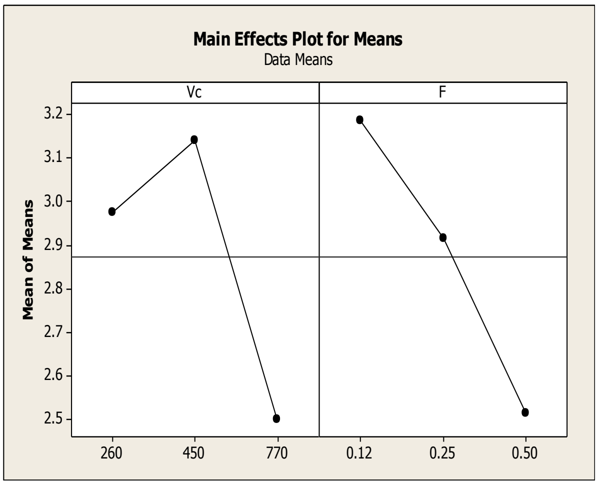


Fig 7: Means of Surface Roughness Height for HSS Drill

IV. CONCLUSIONS

Based on the experimental results and discussions the following conclusions are drawn for drilling of Al/SiC Metal Matrix Composites Materials as listed below:

- The lowest surface height is noted at lowest spindle speed 260rpm and lowest feed rate 0.12 mm/rev for carbide drill.
- For HSS drill, the lowest surface height is noted at lowest spindle speed 260rpm and 0.5 mm feed rate.
- S/N ratio is smaller for 260 rpm and 0.12 mm/rev, after that it is increasing by increasing the value of speed and as well as feed for carbide drill. It is concluded that by increasing spindle speed and feed rate the surface roughness is increase for carbide drill.
- S/N ratio is smaller for 770 rpm and 0.5 mm/rev of feed rate for HSS drill. It is concluded that by increasing the spindle speed the surface roughness is decrease.

- For carbide drill the lower spindle speed and lower feed rate is recommended for drilling of Al/SiC MMC. For HSS drill the higher spindle speed and higher feed rate is recommended for drilling of Al/SiC MMC.

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