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Influence of Drilling Parameters on Surface Roughness in Drilling Of Al6061-Sic Composite

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Abstract— **Metal matrix composites find many applications in engineering field. They are used in engineering applications liken aerospace, marine, automobile and turbine compressor engineering applications, because of their light-weight, high strength, stiffness, and resistance to high temperature. In this experiment the thrust force and surface roughness is optimized for drill parameters (drill bit diameter, spindle speed and feed rates) in drilling Al6061-SiC metal matrix composite was experimentally investigated. The machining parameters considered were drill bit diameter (4mm, 6mm and 8mm), spindle speed (500 rpm, 1000 rpm, 1500 rpm), feed rates (20 mm/min, 30 mm/min, 40 mm/min). Using the above parameters thrust force and surface roughness in drilling Al6061-SiC metal matrix composite is experimentally investigated. The effect of drill parameters were analyzed using a L9 orthogonal array and signal-to-noise (S/N). Using Taguchi method, the interactions among factors are also investigated. In this experiment the obtained values for thrust force and surface roughness is optimized using signal-to-noise ratio (S/N) method and non-linear regression equation method. And it was found that optimization using non-linear regression equation method gives the better results than optimization using signal-to-noise ratio method. From the experiment the best result for surface roughness is obtained for the condition [1, 1, 3] in the L9 orthogonal array, that is diameter (4 mm), spindle speed (500 rpm), feed rate (40 mm/min).**

Keywords—**Surface roughness, Thrust force, Drilling, Taguchi, optimization.**

I. INTRODUCTION

Social Media recommendation is the mostwell-known Composite material is a combination of two or more materials. The physical and chemical properties are different for each material and they remain separate in the final structure. The main application of the material is in structural applications where high strength-to-weight and stiffness-to-weight ratio are required A composite materials consists of both matrix and reinforcement.. The physical and mechanical properties of reinforcement combine with the properties of matrix to produce composite material having superior properties than either matrix or reinforcement.

Because of their superior properties they are finding many applications in automobile, aerospace and petrochemical industry. Machining process associated with MMC's are costly, this is because the high hardness and abrasiveness of the ceramic reinforcing material which leads to high tool-wear rates. When using conventional high-speed steel tools, Consequently the effective machining methods will lead to the reduction in the overall cost of MMC components. This is one of the major challenges yet to be solved if a wider application of MMC materials is to be achieved.

This paper reports on a preliminary series of drilling tests performed on a Al-SiC composite to find the influence of the material and the operating conditions on torque and thrust force, and surface finish. They are developed specifically to meet the challenges of modern industry. The aluminum based composites are increasingly being used in the aerospace, transport, marine and automobile industry because of their improved strength, stiffness and wear resistance properties. Among all manufacturing processes, drilling operations are essential for the functionality of machined components. Drilling of such material is a difficult task to manufacturing engineers because of the differential machining properties.

II. OBJECTIVES

1. To fabricate Al-SiC metal matrix composite by stir casting method. With micron-sized SiC particles as reinforcement to fabricate Al6061-5 wt% SiC composite.
2. To conducted the drilling experiment on computer numerical control machining centre to study the influence of cutting parameters on drilling of Al-SiC metal matrix composites
3. To optimize the process parameters like Spindle

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speed, Feed rate and Diameter of the drill bit for minimum surface roughness.

III. WORK PIECE DETAILS

Al6061 is used as the metal matrix and the reinforcement is SiC with 5wt% with particle size 50μm. The composition of Al6061 aluminium alloy is given below

Material	Composition(%)
Mg	0.8 – 1.2
Si	0.4 – 0.8
Cu	0.15 – 0.40
Fe	0.7
Zn	0.25
Ti	0.15
Mn	0.15
Cr	0.04 – 0.35
Al	Balance

Table 1. Composition of Al6061 alloy

HSS twist drill bit is used for the the drilling of Al6061-SiC metal matrix composite.

IV. EXPERIMENTATION SET UP AND PROCEDURE

The Al-SiC composite is prepared by stir casting process. Stir casting is usually used for the fabrication of aluminum matrix composites. There are many parameters that effects the mechanical properties of the composite materials. In this study, micron-sized SiC particles were used as reinforcement to fabricate Al6061-5 wt% SiC composites.

The important component of stir casting machine are

1	Main furnace
2	Furnace casing
3	Stirrer unit
4	Control unit
5	Pre heating furnace
6	Carrying body

Fig. 1 Stir casting machine

The weights of Al6061 and SiC particles are measured as per the requirements. The specified amount of Al6061 is put into the crucible and placed inside the furnace for melting. The desired temperature range is selected from the control unit, i.e. 800ºC. The control unit cuts the supply off when the set point is reached. Al6061 starts melting after reaching a temperature about 690ºC. SiC particles are preheated in a preheating furnace. It takes about 50 min for the metal to melt completely.

Fig. 2 Casted specimen

The drilling experiment was performed on a (CNC) vertical machining centre. The experiments were performed at different feed rates, speeds and diameters, using L9 orthogonal array.

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PARAMETERS	VALUES
Drill bit type	HSS twist drill
Drill size	4mm, 6mm, 8mm
Spindle speed	500rpm, 1000rpm, 1500rpm
Feed rate	20mm/min, 30mm/min, 40mm/min

Table 2 Machining parameters

Drilling test was conducted using the above drilling parameters. Nine experiments was conducted using different diameters of drill bit, speed and feed rates. . The thrust forces during drilling were measured with a Piezoelectric-dynamometer mean while the signals of the thrust force from the dynamometer was amplified and fed through a data–acquisition system for electronic storage. The data-acquisition System is based on the dynaware software.

Fig. 3 Vertical machining centre (CNC)

The experiment was performed based on the variable factor levels using L9 orthogonal array. Machining is done using the above parameters and the nine different holes are made with variable diameters of drill bit, speed and feed rates. The cutting forces during machining was measured using piezo-electric (Kistler 9366AB) dynamometer. The charge amplifier converts the resulting charge signals, which are proportional to the force, to voltage and managed through the data acquisition system. Thus the torque and thrust force is obtained for different conditions, and Surface roughness of the nine different drilled holes was measured.

Exp.	Diameter(mm)	Speed(rpm)	Feed(mm/min)
1	4	500	20
2	4	1000	30
3	4	1500	40
4	6	500	30
5	6	1000	40
6	6	1500	20
7	8	500	40
8	8	1000	20
9	8	1500	30

Table 3 Variable factor levels (L9 orthogonal array)

Roughness includes the finest (shortest wavelength) irregularities of a surface. Roughness usually occours from a particular material condition or production process. Surface roughness heights are generally measured in micrometers or micro inches.

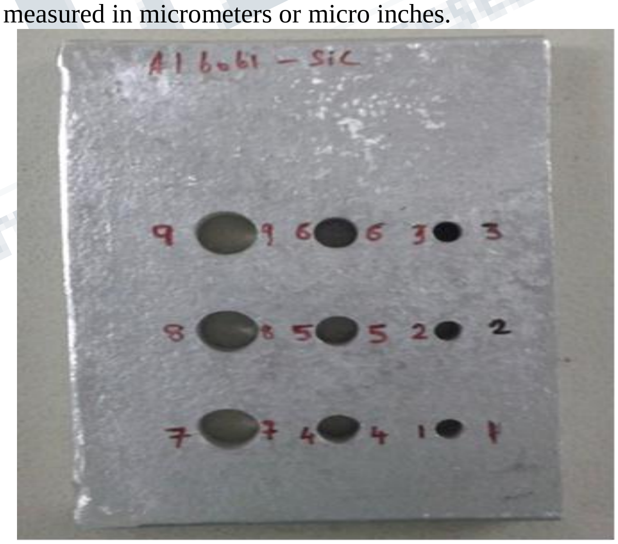

Fig. 4 specimen after machining

Nine different holes are drilled using variable factor levels. The torque and thrust force required for machining the prepared composite is tabulated. And the surface roughness (Ra) value of the drilled hole is also measured using surface roughness tester (Mitutoya SJ 410).

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EXP.	Thrust force(N)	Torque(Nm)
1	148.4	4.04
2	143.1	6.79
3	146.3	6.79
4	149.7	6.71
5	222.6	8.24
6	142.0	10.99
7	359.2	32.12
8	189.7	37.61
9	193.1	42.57

Table 4. Experimental readings

The surface roughness (Ra) of the hole was measured by surface roughness tester (Mitutoya SJ 410) with a sampling length of 0.4 mm.

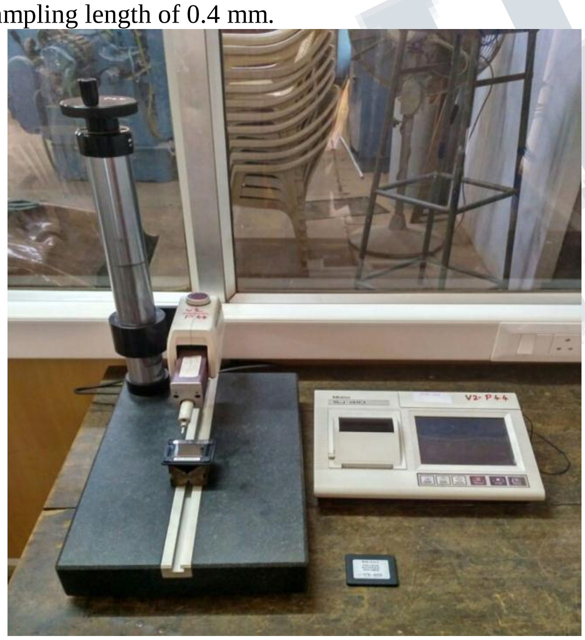

Fig. 5 Surface roughness tester

Using the surface roughness tester (Mitutoya SJ 410) the Ra value of the nine different drilled holes are obtained.

EXP.	Ra (μm)
1	6.687
2	6.554
3	4.762
4	7.333
5	8.096
6	8.306
7	8.163
8	5.974
9	7.652

Table 5 surface roughness obtained

V. RESULT AND DISCUSSIONS

Optimization-The surface roughness obtained from the experiment is optimized using Taguchi method and non-linear regression equation. The experiment was carried out for nine different process conditions. The design of experiment used is L9 orthogonal array with three parameters and three levels. The output parameter surface roughness is used to calculate the mean and signal to noise ratios for obtaining optimal roughness. The smaller the better criteria model is used. Since optimal value of roughness is minimum value of obtained.

LEVEL	A	B	C
1	6.001	7.394	6.989
2	7.912	6.875	7.180
3	7.263	6.907	7.007
Delta	1.911	0.520	0.191
Rank	1	2	3

Table. 6 Response table for mean

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LEVEL	A	B	C
1	-15.46	-17.35	-16.81
2	-17.95	-16.67	-17.10
3	-17.15	-16.54	-16.65
Delta	2.49	0.81	0.45
Rank	1	2	3

Table. 7 Response table for S/N ratio

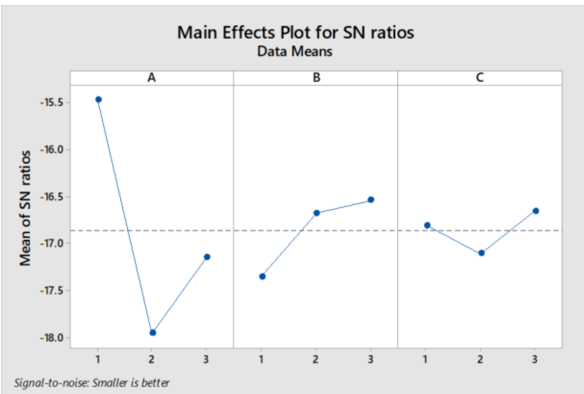

Fig. 6 Effect plot for S/N ratio

Main effects plot for mean and s/n ratio for surface roughness is shown in figure 6. It shows that better roughness was obtained at 6mm dia, 500rpm speed, and feed rate 40mm/min. And Ra value obtained is 7.333µm. When optimizing using non-linear regression equation, the equation is generated using the minitab software.

The equation generated is (Ra)= 3.602+2.839*A+3.173*B-2.273*C-1.280*A*A 0.5498*B*B-0.2797*C*C-0.1960*A*B+1.651*A*C.

where A, B and C is the three levels from the experiment. Here equation is solved for minimum Ra value. Here the optimum condition is obtained at 4mm dia, 500rpm and feed rate 40mm/min. Ra value obtained through non-linear regression equation method is 3.2049 µm.

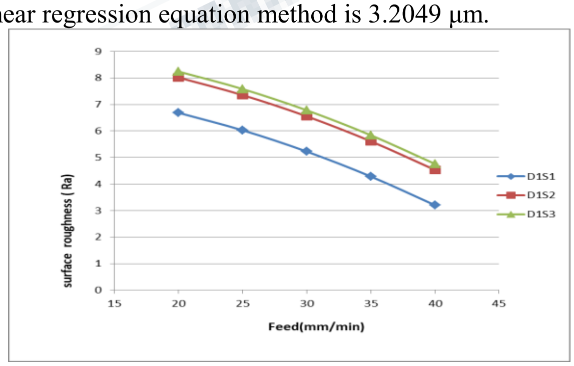

Fig. 7 Roughness vs Feed curve

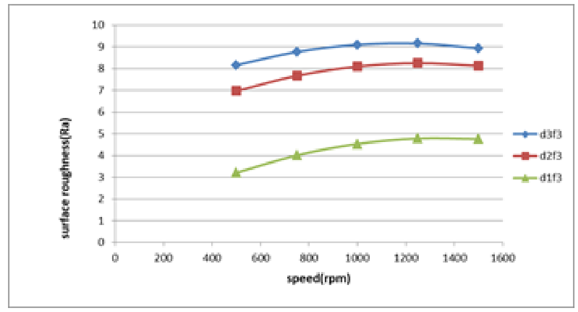

Fig 8 Roughness vs speed curve

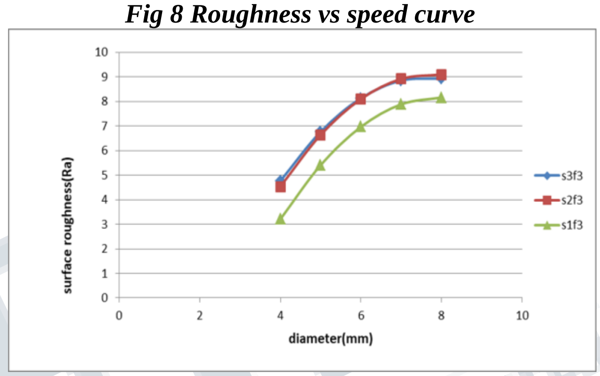

Fig 9 Roughness vs diameter curve

VI. CONCLUSION

Al6061- SiC composite was fabricated using stir casting method and machining was done using L9 array with varying drilling parameters. And the study was to optimize the process parameters like Spindle speed, Feed rate and Diameter of the drill bit for minimum surface roughness using two different optimizing techniques.

The optimum condition obtained using Taguchi method is [2, 1, 2], Ra = 7.333 µm. The optimum condition obtained using non-linear regression equation is for [1, 1, 3], Ra= 3.2049 µm. For [1, 1, 3] diameter is 4mm, speed is 500rpm and and feed rate is 40mm/min. Hence optimization using non-linear regression equation gives the better output.

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