EFFECT OF PROCESS PARAMETERS IN CNC DRILLING OF ALUMINIUM MATRIX COMPOSITE BY USING GRA AND ANOVA

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ABSTRACT

In aluminum matrix composites presence of hard particles inside the matrix which causes tool wear, poor surface finish and high cutting forces while machining. This paper discusses the influence of graphite particles and cutting parameters on drilling characteristics of hybrid aluminum matrix composites (AMCs)-Al6063/Alo3 and Al6063/12% SiC/4% Graphite. The composites were fabricated using stir casting method. Experiments were conducted with TiN coated carbide tools and commercial carbide tools at various cutting speeds, feeds and work pieces. MRR and surface roughness of the drilled hole was investigated with special attention paid to the effects of graphite particles.

It is also find the optimal process parameters to achieve economical manufacturing of MMC by using GRA and ANOVA.

Key words: *CNC drilling, GRA, ANOVA*

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1. Introduction

In present era of globalization manufacturers are facing the challenges producing metal matrix composites to provide required properties for different applications. The manufacturers are facing the problem of machining of metal matrix composites because of their hardness. Because of their higher hardness the cutting tool must be harder than that of metal matrix composites. To avoid this problem, to increase material removal rate (MRR), to reduce the surface roughness and to increase the tool life. And most important consideration in present day manufacturing systems is to provide economy of machining. To avoid above problems mentioned above are rectified by applying different advanced solutions to the manufacturing systems that are may be optimizing input parameter, insertion of soft materials in metal matrix composites and some other, to ensure overall machining economy

II. MATERIALS, CUTTING CONDITIONS AND EXPERIMENTAL DESIGN

Aluminum is one of the lightest engineering metals, having strength to weight ratio superior to steel. By utilizing various combinations of its advantageous properties such as strength, lightness, corrosion resistance, recyclability and formability, aluminum is being employed in an ever-increasing number of applications.

Table 1.1 Different Aluminum alloys and their applications

Aluminum Alloy	**Common Use**
1050/1200	Food and Chemical Industry
2014	Airframes
5251/5052	Vehicle paneling, Structures exposed to marine atmospheres, mine cages.
6063	Architectural extrusions (internal and external) window frames, Irrigation pipes.
6061/6082	Stressed Structural Members, Bridge cranes, roof trusses, beer barrels.
7075	Armored vehicles, military bridges, motor cycle and bicycle frames.

There are different types of aluminum series; in our project I considered the material is Al 6063 materials.

Aluminum alloy 6063 is a medium strength alloy commonly referred to as an architectural alloy. It is normally used in intricate extrusions. Most commonly available as T6 temper, in the T4 condition it has good formability.

Table 1.2 Chemical composition of AL-6063 T6

Chemical element	**% Present**
Manganese (Mn)	0.0 - 0.10
Iron (Fe)	0.0 – 0.35
Magnesium (Mg)	0.45 – 0.90
Silicon (Si)	0.20 – 0.60
Zinc (Zn)	0.0 – 0.10
Titanium (Ti)	0.0 – 0.10
Chromium (Cr)	0.0 – 0.10
Copper (Cu)	0.0 – 0.10
Aluminium (Al)	Balance

Table 1.3 General properties of AL-6063 T6

Chemical element	% Present
Manganese (Mn)	0.0 - 0.10
Iron (Fe)	0.0 – 0.35
Magnesium (Mg)	0.45 – 0.90
Silicon (Si)	0.20 – 0.60
Zinc (Zn)	0.0 – 0.10
Titanium (Ti)	0.0 – 0.10
Chromium (Cr)	0.0 – 0.10
Copper (Cu)	0.0 – 0.10
Aluminium (Al)	Balance

Table 1.4 Mechanical properties of AL-6063 T6

Mechanical Property	Value
Proof stress	170 Min Mpa
Tensile Strength	215 Min Mpa
Hardness Brinell	75 Typical HB
Elongation	8 Min %

Table 1.5 properties of aluminum oxide.

Mechanical	Units of measure	SI/Metric	value
Density	Gm/cc	3.89	(242.8)
Porosity	%	0	(0)
Color	-	IV0RY	-
Flexural strength	Mpa	379	(55)
Elastic modulus	Gpa	375	(54.4)
Shear modulus	Gpa	152	(22)
Bulk modulus	Gpa	228	(33)
Poisson’s ratio	-	0.22	(0.22)
Compressive strength	Mpa	2600	(377)
Hardness	Kg/mm^2	1440	-
Fracture toughness	$MPa*m^{1/2}$	4	-
Max. use temperature	^oC	1750	(3180)

1.6. 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 material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Structural and wear applications are constantly developing. Silicon carbide is composed of tetra-hydra of carbon and silicon atoms with strong bonds in the crystal lattice. This produces a very hard and strong material. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C. In air, SiC forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal conductivity coupled with low thermal expansion and high strength give this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600°C with no strength loss.

Table 1.6 properties of silicon carbide.

Mechanical	**Units of measure**	**SI/Metric**	**value**
Density	Gm/cc	3.1	(193.5)
Porosity	%	0	(0)
Color	-	Black	-
Flexural strength	Mpa	550	(80)
Elastic modulus	Gpa	410	(59.5)
Shear modulus	Gpa	-	-
Bulk modulus	Gpa	-	-
Poisson’s ratio	-	0.14	(0.14)
Compressive strength	Mpa	3900	(566)
Hardness	Kg/mm^2	2800	-
Fracture toughness	$MPa*m^{1/2}$	4.6	-
Max. use temperature	^oC	1650	(3000)

1.7 Graphite :

Graphite archaically referred to as Plumbago, is a crystalline form of carbon, a semimetal, a native element mineral, and one of the allotropes of carbon. Graphite is the most stable form of carbon under standard conditions. Therefore, it is used in thermo chemistry as the standard state for defining the heat of formation of carbon compounds. Graphite may be considered the highest grade of coal, just above anthracite and alternatively called meta-anthracite, although it is not normally used as fuel because it is difficult to ignite.

Table 1.7 properties of graphite.

Property	**Units**	**Value**
Density	Gm/cc	1.72-1.9
Porosity	%	9-12

Hardness	Kg/mm^2	12-18
Thermal conductivity	w/mk	70-130
Flexural strength	MPa	0.8-1.7
Compressive strength	MPa	4.4-22
Fracture toughness	$MPa*m^{1/2}$	<1
ultimate tensile strength	Mpa	0.9-1.7

III. EXPERIMENTAL RESULTS AND ANALYSIS

Table 4.2: Machining Parameters and Their Levels

Parameters	Units	Level-1	Level-2
Speed	Rpm	750	1200
Feed rate	mm/min	30	50
Work pieces		$Al6063/AlO_3$	Al6063/12%SiC/4%Gr
Tool type		Uncoated carbide tool	TiN coated carbide tool

Taguchi's orthogonal array of L_{16} ($\mathbf{2^4}$) is most suitable for this experiment. Because, speed,feed, work piece and tool with Three levels each and then 2×2×2×2=16 runs were required in the experiments for four independent variables. The L_9 orthogonal array is presented in Table- 4.3

Table 4.3: L_9 (3^4) orthogonal array

S.No	Speed	Feed rate	Work piece	Tool
1	1	1	1	1
2	1	1	1	2
3	1	1	2	1
4	1	1	2	2
5	1	2	1	1
6	1	2	1	2
7	1	2	2	1
8	1	2	2	2
9	2	1	1	1
10	2	1	1	2
11	2	1	2	1
12	2	1	2	2
13	2	2	1	1
14	2	2	1	2
15	2	2	2	1
16	2	2	2	2

In the above Table-4.3, 1, 2, 3and 4 in columns represents the levels of factors corresponding to the particular variable presented in the column. For the above coded values of machining parameters, actual setting values are presented in Table- 4.4.

Table 4.4: Actual Setting Values for the Coded Values

s.no	Speed	Feed rate	Ghaphite	Tool
1	750	30	Al/AlO_3	Uncoated
2	750	30	Al/AlO_3	Coated
3	750	30	Al/12%SiC/ 4%Gr	Uncoated
4	750	30	Al/12%SiC/4%Gr	Coated
5	750	50	Al/AlO_3	Uncoated
6	750	50	Al/AlO_3	Coated
7	750	50	Al/12%SiC/4%Gr	Uncoated
8	750	50	Al/12%SiC/4%Gr	Coated
9	1200	30	Al/AlO_3	Uncoated
10	1200	30	Al/AlO_3	Coated
11	1200	30	Al/12%SiC/4%Gr	Uncoated
12	1200	30	Al/12%SiC/4%Gr	Coated
13	1200	50	Al/AlO_3	Uncoated
14	1200	50	Al/AlO_3	Coated
15	1200	50	Al/12%SiC/4%Gr	Uncoated
16	1200	50	Al/12%SiC/4%Gr	Coated

The surface roughness was measured by using stylus type instrument i.e., Talysurf Surface Roughness meter.

Table5.2: Experimental results for R_a and MRR

S.No	Speed	Feed rate	Workpiece	Tool	M.R.R	R.A
1	750	30	Al/AlO_3	Uncoated	27.31	1.1433
2	750	30	Al/AlO_3	Coated	28.34	0.8400
3	750	30	Al/12%SiC/4%Gr	Uncoated	28.55	0.4033
4	750	30	Al/12%SiC/4%Gr	Coated	29.91	0.5800

5	750	50	Al/AlO_3	Uncoated	34.90	0.5466
6	750	50	Al/AlO_3	Coated	37.32	1.3300
7	750	50	Al/12%SiC/4%Gr	Uncoated	36.95	0.4266
8	750	50	Al/12%SiC/4%Gr	Coated	41.88	0.5166
9	1200	30	Al/AlO_3	Uncoated	29.91	0.6733
10	1200	30	Al/AlO_3	Coated	31.41	0.4133
11	1200	30	Al/12%SiC/4%Gr	Uncoated	38.26	0.3300
12	1200	30	Al/12%SiC/4%Gr	Coated	44.87	0.2466
13	1200	50	Al/AlO_3	Uncoated	39.26	0.2433
14	1200	50	Al/AlO_3	Coated	41.38	0.3100
15	1200	50	Al/12%SiC/4%Gr	Uncoated	48.33	0.3266
16	1200	50	Al/12%SiC/4%Gr	Coated	52.35	0.2833

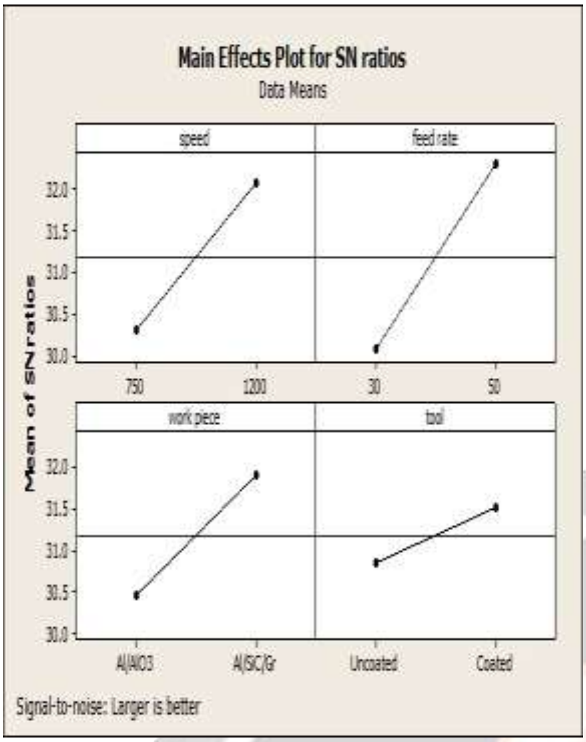
Here MRR was calculated by using below formula and surface roughness was measured by taly surf meter.

$$MRR = \frac{\text{Initial mass} - \text{Final mass}}{\text{density of material} * \text{machining time}} \quad mm^3/min \qquad \text{Eq. (5.1)}$$

These responses were given to the taguchi optimization technique software to generate optimum input parameters and to find out which parameter influencing more among all. Responses from taguchi are shown below.

Table 5.3 Response Table for Signal to Noise Ratios (Larger is better)

Level	Speed	Feed rate	Work piece	Tool
1	30.31	30.07	30.47	30.85
2	32.05	32.30	31.90	31.52
Delta	1.72	2.23	1.43	0.67
Rank	2	1	3	4



CONCLUSION

A Taguchi method was proposed to study the optimization of CNC drilling process parameters. Surface roughness, material removal rate are selected as quality targets. Sixteen experimental runs based on orthogonal arrays were performed.

GRA optimization technique was applied to find optimum experimental run and most influencing parameters on machining of MMC's. From GRA optimum experimental run was sixteenth experiment and most influencing parameters are cutting speed, work piece, feed, tool respectively.

The contributions of input parameters on individual response are identified by ANOVA. From ANOVA surface finish and material removal rate, are mostly affected by cutting speeds, depth of cut.

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