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Machining Of an Aluminum Metal Matrix Composite Using Tungsten Carbide Inserts

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ABSTRACT

This report presents an optimization of machining parameters in turning process of Aluminum metal matrix composite (MMC) using steel grade and aluminum grade tungsten carbide inserts. An MMC which is small variant of Duralumin alloy was decided upon to do the machining optimization. Aluminum is widely used in automotive industry, aerospace applications, architectural applications and others. The main objective of the research was to determine the effect of different parameters setting such as depth of cut, feed rate and cutting speed on surface roughness, cutting temperature and cutting forces using different inserts. The analysis revealed that cutting speed was the significant effect to the surface roughness followed by the feed rate while depth of cut was less effect. The best surface finish can be obtained with the combination of lowest cutting speed and feed rate.

KEYWORDS: - : *Surface Roughness, Cutting Temperature, Cutting Forces, MMC.*

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I. INTRODUCTION

In this competing world, industries around the world constantly experiment for economical solutions with reduced production time and better surface finish and good quality in order to maintain their competitiveness with their rivals. Automated and flexible manufacturing systems (FMS) are employed for that purpose along with computerized numerical control (CNC) machines that are capable of achieving very low processing time and high accuracy (Nalbant,2006).In the CNC machining, determining optimal cutting conditions or parameters under the given machining situation is a hard task.Traditional way for selecting these conditions such as cutting speed and feed rate has been based up on data from machining handbooks and or on the experience and knowledge on the part of programmer. As a result, the metal removal rate is low because of the use of such conservative machining parameters (Kyung and Soung, 1997).

The objective of this project is to optimize the machining parameters of an aluminum metal matrix composite by analyzing their effect on cutting forces, cutting temperature and surface roughness using different inserts. The machining parameters varied here are speed, feed and depth of cut.

The scope of this project lies with the material selected for the study. The material selected here is an aluminum metal matrix composite. The use of metal matrix composites is increasing day by day due to their characteristics of behavior with their high strength to weight ratio.

Aluminum composites and alloys have been used for many aeronautical and automobile applications due to their low weight to strength ratio. The MMC used here is a small variant of duralumin composition. The mechanical properties of the rare composite are tested and there as on for its selection are justified. The machining optimization of the MMC using different inserts will provide a standard cutting condition for the most effective way of machining the aluminum composite.

This study was to investigate the cutting temperature, surface roughness and cutting forces produced by different controllable parameter such as cutting speed, feed rate and depth of cut by turning Aluminum MMC with steel grade and aluminium grade inserts. By using the Taguchi method, it was easy to establish variable parameters in designing the experiment. Besides, the technique of the optimization was implemented for obtaining better cutting conditions.

II. EXPERIMENTAL SETUP

II.1. Composition of Aluminium Metal Matrix Composite

Duralumin is a strong, hard, light weight alloy of aluminum, widely used in aircraft construction, discovered in 1906 and patented in 1909 by Alfred Wilm, a German metallurgist; was originally made only at the company Dürener Metall werke at Düren , Germany.(The name is a contraction of Dürener and aluminum.) The original composition has been varied for particular applications; It may contain about 4 percent copper , 0.5–1 percent manganese, 0.5–1.5 percent magnesium, and, in some formulations, some silicon. After heat treatment and aging, these alloys are comparable to soft steel in strength.

Table 1. Aluminium Metal Matrix Composite composition

Constituents	Amount(Kg)	Percentage (%)
Aluminum	2.560	88
Copper	0.150	5
Magnesium	0.100	3.5
Manganese	0.100	3.5

II.2. Manufacturing of aluminium metal matrix composite

The experimental arrangement has been assembled by the coupling gear-box motor and mild steel four blade stirrer used. The melting of the aluminium (88%) ingot and constituent powder is carried out in the graphite crucible into the electric furnace. First the aluminum ingot was preheated for 3 to 4 hours at 450°C and other metal powder were also heated to 300°C. Then the ingot was transferred to the furnace so that it will melt at temperature of 800°C. The preheated metal powder is separately missed with a spatula. When the aluminum is fully melted the powder mixture is added to it. Then the stirrers turned on. The powder mixture is mixed thoroughly in the molten metal.

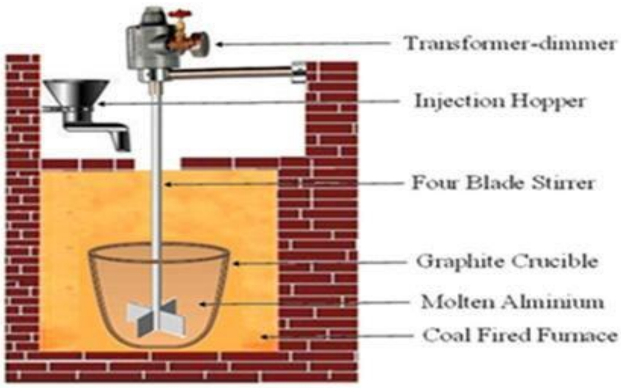

Figure 1: Stir casting apparatus

The furnace temperature was first increased above the composites completely to melt the scraps of aluminum and then cooled down just below the components temperature and keep it in a semi-solid state. At this stage the preheated metal powder mixture was added which were manually mixed with each other. It is very difficult to mix by machine or stirrer when metal-matrix composites are in semi molten state with manual mixing taking place. When the manual mixing is complete then automatic stirring will carried out for ten minutes with normal 400 rpm of stirring rate .The temperature rate of the coal-fired furnace should be controlled at 760±10°C in final mixing process. After complete the process the slurry has been taken into the sand mould with in thirty seconds allow it to solidify to a dimension of length 400 mm and diameter 40mm.Tests should be taken of solidified samples like hardness sand impact tests.

Figure 2: Stir cast specimen

II.3. Cutting inserts used in experiment

Machining was done by using steel grade and aluminium grade tungsten carbide cutting insert coded SNMG 120408. The code indicates that insert has dimensions of 12x12 mm with thickness 4mm and nose radius 8 mm.

Fig. 3: Aluminium grade and steel grade Tungsten carbide cutting inserts

II.4. Machining tests and optimization

The machining tests were performed on cylindrical molded bars with 40 mm diameter and 400 m length by using different grades of tungsten carbide insert tool. The cutting parameters selected for turning are: depth of cut(d), feed rate (f), and cutting speed (Vc).Nine trial numbers were defines as per the Taguchi orthogonal array and machining was done on the work piece according to the predefined set of cutting parameters. The values for cutting forces, cutting temperature and surface roughness were measured for each trial run. The main cutting force and the surface roughness parameter were measured for longitudinal turning. The cutting tests were conducted on a kirloskar lathe model turn master-35 without coolant and the cutting speed values were restricted by the work piece diameter and the speed of the lathe.

III. RESULTS AND DISCUSSIONS

III.1. Results

The following data represents observations of the machining analysis carried out.

III.1.1 Cutting temperature variation

Table 2: Cutting temperature variation

Trial No.	Speed (rpm)	Feed(mm/rev)	Depth of Cut (mm)	Feed Velocity(m/sec)	Volt(V)	Cutting temperature(˚c) T	
						Steel grade T_1	Aluminium grade T_2
1	500	0.05	0.6	25	16	33.1	30.01
2	500	0.075	0.8	37.5	22	32.2	28.9
3	500	0.1	1	50	28	31.42	30.3
4	600	0.05	0.8	30	18	27.7	27.52
5	600	0.075	1	45	25	29.33	28.35
6	600	0.1	0.6	60	32	30.3	27.65
7	700	0.05	1	35	33	31.25	28.35
8	700	0.075	0.6	52.5	37	31.9	27.7
9	700	0.1	0.8	70	28	33.2	28.9

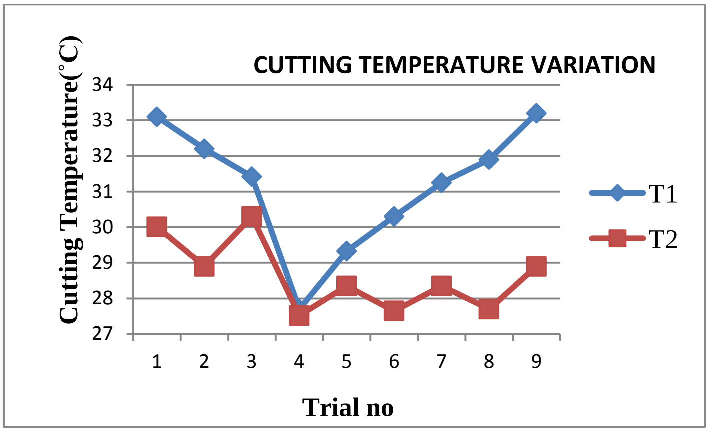

Fig. 4: Cutting temperature variation

III.1.2. Surface Roughness Variation

Table 3: Surface roughness variation

Trial No.	Speed(rpm)	Feed(mm/rev)	Depth of Cut(mm)	Feed Velocity(m/sec)	Volt(V)	Surface Roughness(µm) S	
						Steel grade S_1	Aluminium grade S_2
1	500	0.05	0.6	25	16	9.92	5.159
2	500	0.075	0.8	37.5	22	10.17	5.860
3	500	0.1	1	50	28	6.08	6.27
4	600	0.05	0.8	30	18	8.02	4.461
5	600	0.075	1	45	25	6.25	4.108
6	600	0.1	0.6	60	32	6.24	2.881
7	700	0.05	1	35	33	2.527	1.458
8	700	0.075	0.6	52.5	37	2.984	2.214
9	700	0.1	0.8	70	28	2.264	1.108

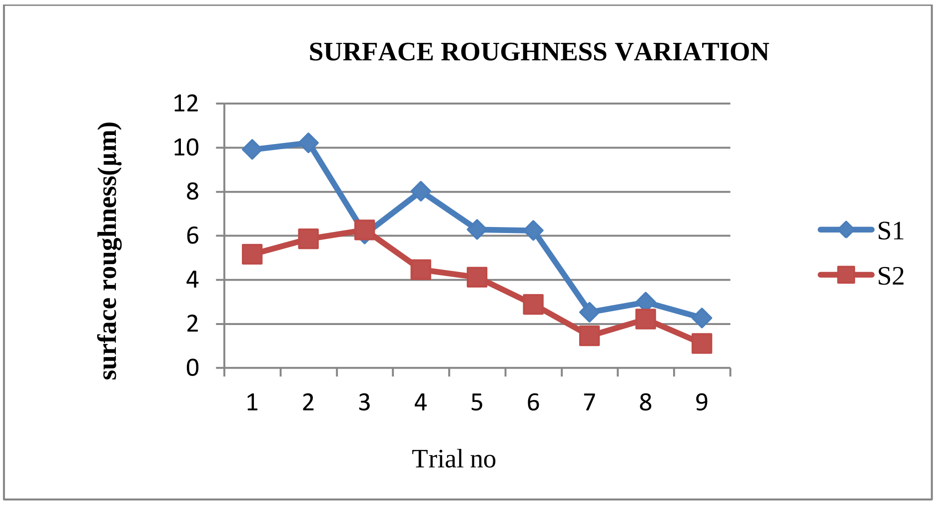

Fig. 5: Surface roughness variation

III.1.3CuttingForcesVariation

Table 4: Cutting force variation

Trial No.	Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Cutting Forces(N)					
				Steel grade			Aluminium grade		
				F_{x1}	F_{y1}	F_{z1}	F_{x2}	F_{y2}	F_{z2}
1	500	0.05	0.6	213.5	245.3	362.9	61.71	38.54	90.87
2	500	0.075	0.8	361	469.8	705.9	30.67	41.98	92.38
3	500	0.1	1	476	550	744.8	142.3	161.8	286.1
4	600	0.05	0.8	222.6	267.9	400.6	30.53	44.63	77.96
5	600	0.075	1	405.5	336.2	556.5	102.7	84.09	157.2
6	600	0.1	0.6	224.5	318.5	405.9	54.24	52.64	99.43
7	700	0.05	1	446.7	343.9	562.3	67.29	78.41	148.9
8	700	0.075	0.6	281.3	257.9	383.3	44.04	40.92	75.35
9	700	0.1	0.8	325	285	450.1	127.3	93.66	181.9

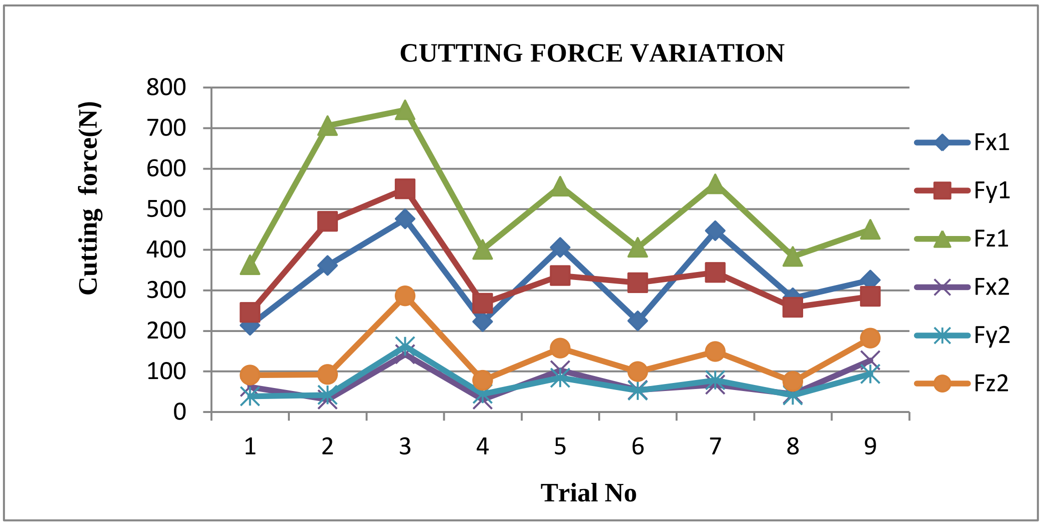

Fig6. Cutting forces variation

IV. CONCLUSIONS

Machining of aluminium MMC has immense significance as it is considered as a difficult task. Avery rare aluminium MMC was fabricated whose machining analysis has not been recorded before. Experiments were conducted to optimize various machining characteristics such as cutting forces, surface roughness.

It is observed that surface roughness is indirectly proportional to spindle speed. When feed rate increases surface roughness also increases. Surface roughness also increases with depth of cut. It is also observed that aluminium grade insert gives better surface finish and allows machining at a reduced temperature but steel grade insert offers better cutting force while machining the newly manufactured MMC.

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