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Machining Response in Turning Aluminium Composite LM13 With 15% SiC

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Abstract: - In this paper, an attempt has been made to experimental investigation the machinability of aluminum metal matrix composite (LM13/SiC/15p) during continuous turning of composite rods using carbide inserts. Base matrix material is Aluminium LM13 reinforced with 15 % weight by volume of Silicon carbide particles of mean diameter 20 µm to 40 µm is used. The main focus of investigation is to determine surface roughness. Experiments were conducted in the CNC lathe by using carbide insert at various cutting conditions and parameters such as cutting speed, feed and depth of cut and surface roughness was found at different levels. The effect of machining parameters, e.g. cutting speed and depth of cut on the surface roughness investigated during experimentation.

Key words: Metal matrix composite, Surface roughness (SR), CNC turning center.

I. INTRODUCTION

Metal matrix composites are formed by combination of metal matrix and stiff and hard reinforcing phase. Incorporation of silicon carbide particles enhances the properties like adhesive, abrasive, wear resistance, thermal properties, hardness, and stiffness (Houyem Abderrazak and Emna Selmane Bel Hadj Hmida 1996). For many researchers the term metal matrix composites (MMCs) is often equated with the term light metal matrix composites (LMCs) because of their high strength to weight ratio (low density high tensile strength). Substantial progress in the development of light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications. These innovative materials open up unlimited possibilities for modern material science and development. The characteristics of MMCs can be designed into the material, custom-made, dependent on the application. The advantages of the composite materials are only realized when there is a reasonable cost – performance relationship in the component production. The use of a composite material is obligatory if a special property profile can only be achieved by application of these materials.

In engineering, especially in the automotive industry, LMCs have been used commercially in fiber reinforced pistons and aluminum crank cases with strengthened cylinder surfaces as well as particle-strengthened brake disks [1]. As they are harder comparatively they are generally difficult to machine. These types of materials can be machined with carbide tools [2]. Tool tip temperature increases with increase in cutting speed. At high speeds, surface finish is least affected. Surface finish deteriorates at high feed rates; hence to obtain good surface finish, feed rate may be kept low. At low speeds cutting force are high & tendency of work material to form a built up edge is also stronger. At lower speeds, surface roughness increases with increasing feed but at higher speeds surface roughness is less dependent on feed.

The machinability 2024Al/Al2O3 particle composite was investigated in terms of tool wear, tool life and surface roughness by turning specimens with TiN (K10) coated and uncoated carbide tools in different cutting conditions. The test results showed that tool life decreased with increasing cutting speed for both cutting tools [3].

N. Muthukrishnan presents the study of the tool wear mechanism in machining the metal matrix composites (MMC) and its dependence on the percentage of reinforcing with MMC. Aluminum alloy (A356 - SiC) silicon carbide metal matrix composite having 10 and 20% silicon carbide particles by weight are fabricated and experiments were conducted using polycrystalline diamond (PCD) insert. The result showed that the tool flank wears was maximum while machining 20% of the SiC reinforcing MMC when compared with 10% of the SiC reinforcing MMC [4].

LM 25 aluminum alloy reinforced with green bonded silicon carbide particles of size 25 µm with different volume fractions was used for experimentation. The machining experiments were conducted on the lathe using tungsten carbide tool inserts (K10). It was concluded that feed rate has the greater influence on surface roughness, followed by cutting speed and percent volume fraction of SiC [5].

LM6 Mg15 SiC-Al-metal matrix composite, as casted with average particle size 23 µm, was used as composite material. Different sets of experiments were performed on a combination turret lathe. Uncoated tungsten carbide (WC; HW-K10) insert was used for turning. Results

indicated that cutting speed, feed rate, and depth of cut are having equal influence on the surface roughness characteristics, i.e., Ra and Rt. High speed, low feed rate, and low depth of cut was recommended for achieving better surface finish during turning of Al/SiC-MMC using tungsten carbide insert [6]. Rods of Al Si 7 Mg2 material reinforced with 5, 10, and 15 wt.% of SiC-p of particle size 30–60 μm were produced, 90 mm in diameter and 150 mm in length. TiN-coated WC (K10) tool was used for turning. Machinability of MMC was very different from traditional materials because of abrasive reinforcement element. This was because abrasive element causes more wear on cutting tools. Flank wear of cutting tool had also increased with increase in reinforcement ratio. Influence of feed rate was not as effective as cutting speed on tool wear, but as the feed rate increased, the wear of cutting tool also increased. In turning of AlSi7Mg2-MMC samples, surface quality improved when cutting speed decreased. Surface roughness increased due to increasing feed rate values. It was found that increase in particle ratio affects roughness negatively [7].
Sujit Das [8] attempts to study the machinability issues of aluminium-silicon carbide (Al-SiC) metal matrix composites (MMC) in turning using HSS cutting tool. SiCp-reinforced metal matrix composites (MMCs) containing SiC particles (5wt%-20wt %) of 400mesh size were prepared by powder metallurgy (P/M) route and used as work material for turning. Experiments were conducted at various cutting speeds and depth of cuts at constant feed rate and parameters, such as cutting forces and surface roughness were measured. It was found that higher weight percentage of SiCp reinforcement produced a higher surface roughness and needs high cutting forces during machining operation of MMCs. It was also observed that surface roughness and the cutting forces are also depending upon the depth of cut and the cutting speed at constant feed rate.

Material – LM13 [with 15% (wt.) SiC] composite

Chemical composition of matrix LM13 alloy by weight percentage

Mg	Si	Fe	Cu	Ti	Pb	Zn	Mn	Sn	Ni	Al
0.8–1.5	10–12	1.0	0.7–1.5	0.2	0.1	0.5	0.5	0.1	1.5	balance

The main objective of this experimental work is to study the effect of cutting speed, feed, and depth of cut for LM13-SiC composite in CNC turning for surface roughness. The main objective of this experimental work is to minimize the surface roughness during machining. To minimize the surface roughness, various parameters and levels selected for carrying out the work is as listed below:

Parameter and levels	**Reason for selection**
1. Insert	The HSS tools are inadequate; cemented carbide tools are preferred for rough machining operations. The cost of PCD tools increases the cost of production so it is necessary to carryout machinability studies to assess the suitability of carbide tools.
2. Feed rate (0.1, 0.2, 0.3, 0.4 and 0.5 mm/rev)	It is known from the fundamentals of metal cutting that feed rate influences pitch of the machined surface profile. Various researchers have observed the effect of feed rate on the surface roughness and tool wear during machining of composites. Thus, these feed rates are chosen based on the earlier findings in the literature.
3.Cutting speed (50, 100, 150, 200 and 250 m/min)	Previous studies have indicated that the surface roughness is influenced by the cutting speed. Therefore, to study the effect of cutting speed in detail, these values of cutting speed has been considered here.
4.Depth of cut (0.2, 0.4, 0.6, 0.8, and 1.0 mm)	The depth of cut influences the surface roughness, which in turn influences the tolerance and fit of the components.

II. EXPERIMENTAL DETAILS

This experiment was conducted using the hardware listed in Table I on CNC lathe machine as shown in Figure 1. A Cylindrical bar of LM 13 composite with 15% SiC (length 150 mm, diameter 30 mm) was used as work piece to carry out experiments on CNC lathe by a CNMG 120408 grade-6615 carbide insert as cutting tool. Parameters selected for carrying out the experimental work is as:

Cutting speed in m/min - 50, 100, 150, 200, 250
Feed rate in mm/rev - 0.2, 0.4, 0.6, 0.8, 1.0
Depth of cut in mm - 0.1, 0.2, 0.3, 0.4, 0.5
The CNC machine selected to carry out this project is 20 TC sprint series turning center.

Fig1- CNC Turning Center

Table I

S. No	Item no.	Specification
1	CNC turning center	Model- BATLIBOI, 20 TC Sprint series turning center X-axis - 150 mm Z-axis - 149 mm Turning length – 400mm Turning diameter – 275mm Swing over bed – 500mm Spindle speed – 30-4000rpm Main motor - 7.5 KW Tool in turret – 8 no. off Rapid traverse – 20m/min
2	Cutting tool Inserts	CNMG-120408EM grade - 6615
3	Surface roughness measurement device	Surface Roughness Tester- SRT 6210 Measures Ra, Rz, Rq in µm

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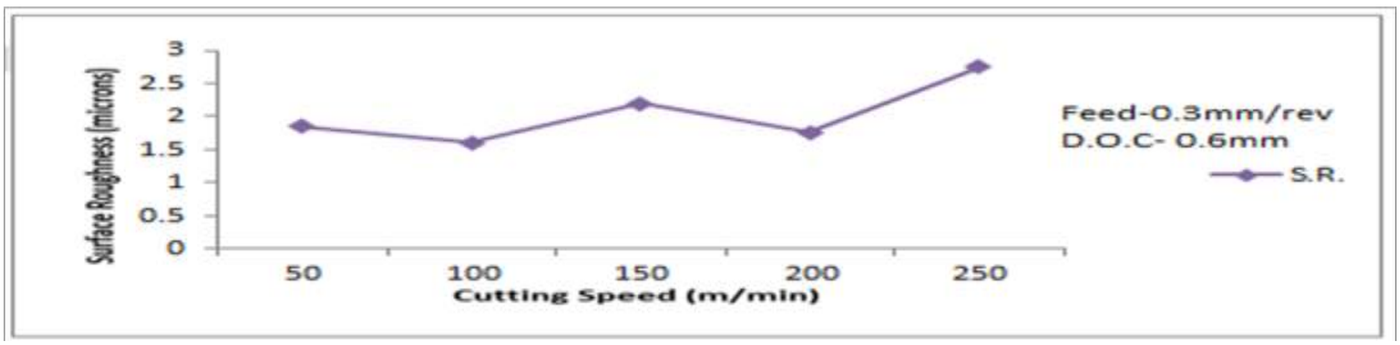
III. RESULTS & DISCUSSIONS

Work piece material LM13 composition is already shown above. It has got low thermal expansion and good wear resistance. It is observed that while machining LM13 work piece, discontinuous chips are formed. Experimental data related to surface roughness characteristics three graphs are plotted using MS-Word 2007 software application

For cutting speed (Speed varying)

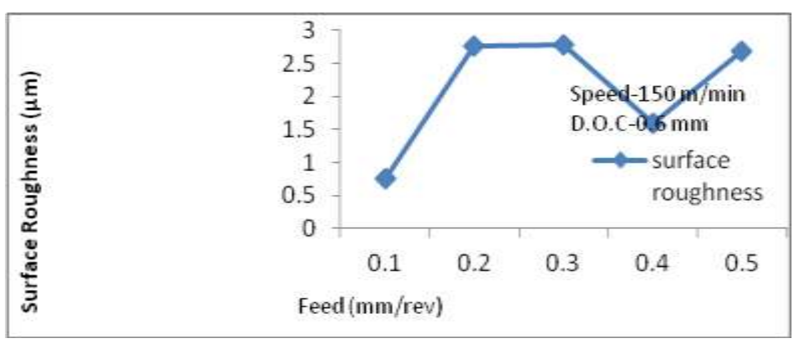
S.NO.	CUTTING SPEED (m/min)	FEED (mm/rev)	DOC (mm)	SR(R_a) µm
1	50	0.3	0.6	1.848
2	100	0.3	0.6	1.615
3	150	0.3	0.6	2.197
4	200	0.3	0.6	1.762
5	250	0.3	0.6	2.755



It is observed from the Graph of Ra Vs Speed at Feed=0.3 mm/rev & Depth of Cut=0.6 mm that when feed & depth of cut are kept constant & only speed is increased continuously after certain maximum value of 250 m/min then we can obtain a sudden increase in the surface roughness. This is not the usual case in case of Al composites but in this experimental work, surface roughness is minimum at cutting speed of 100 m/min and maximum at 250 m/min.

For Feed (Feed varying)

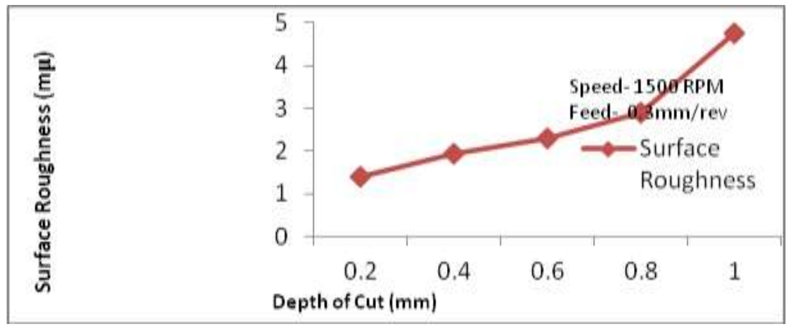
S.NO.	CUTTING SPEED(m/min)	FEED(mm/rev)	DOC(mm)	SR(R_a) µm
1	150	0.1	0.6	0.754
2	150	0.2	0.6	2.754
3	150	0.3	0.6	2.775
4	150	0.4	0.6	1.596
5	150	0.5	0.6	2.678



From the graph of Ra Vs Feed when Speed=150 m/min & Depth of Cut=0.6 mm it is observed that when speed & depth of cut are kept constant & only feed is increased continuously then surface roughness also increases continuously up to certain higher value of feed rate i.e. 0.3 mm/rev & after this as feed increases i.e. 0.4 mm/rev surface roughness decreases and again increases at 0.5 mm/rev.

For depth of cut (D.O.C varying)

S.NO.	CUTTING SPEED(m/min)	FEED(mm/rev)	DOC(mm)	SR(R_a) µm
1	150	0.3	0.2	1.383
2	150	0.3	0.4	1.942
3	150	0.3	0.6	2.301
4	150	0.3	0.8	2.881
5	150	0.3	1.0	4.751



From graph of R_a Vs. Depth of cut when speed = 150 m/min & feed = 0.3 mm/rev, it is observed that when speed & feed are kept constant & only depth of cut is increased continuously then surface roughness also increases continuously. Also spindle load increases continuously with cutting speed. Maximum value of spindle load occurs when value of depth of cut is high.

IV. CONCLUSIONS AND RECOMMENDATIONS

In this work, effects of SiC-p reinforcement to LM13 Al alloy on surface roughness during turning have been investigated in terms of selected parameters such as cutting speeds, feed rates, and depth of cuts. For optimum surface roughness in the workpiece, it is recommended that turning operation on Al alloy composite by carbide insert should be carried out at, cutting speed within the range of 100 to 200 m/min, feed rate within range of 0.4 mm/rev, and DOC within range of 0.4 to 0.6 mm.

Among all the cutting parameters affecting surface roughness of the Al composite (LM13/SiCp 15%), surface roughness shows increasing trend as the cutting speed increases. Cutting speed and depth of cut has maximum effect.

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