OPTIMIZATION IN SELECTION OF TOOL FOR TURNING OF MATRIX COMPOSITE USING COATED AND UNCOATED CUTTING TOOLS.

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Abstract: **Industries always work aiming the profit, it ranges from materials, equipment's, and in deep cutting tools, work material etc, and such of its kind satisfying the requirement is Metal matrix composite. Metal Matrix composite are finding increased applications in many areas and are now gaining their usage in aerospace and automotive industries, because of their low cost. But machining of Metal matrix composite materials is difficult to carry out due to the anisotropic and non-homogeneous structure of composites and to the high abrasiveness of their reinforcing constituents. This typically results in damage being introduced into the work piece and also in very rapid wear development in the cutting tool but even then these industries are forced to move with MMC. Cutting tool is considered to be the main factor while machining MMC, a proper cutting tool which does not break during MMC operation will definitely yield good results and also the vast usage in all areas. The wear rate of the cutting tool decreased rapidly with increasing the cutting parameters such as cutting speed, feed and depth of cut, however cutting speed is shown to be more effective. Sudden breakage of tool inserts occurred at high cutting speeds. Coated carbide tools have significantly improved the tool life. Coated tools show better results compared to uncoated tools. Therefore this paper brings out an important aspect in such as optimization and design Break even analysis of tool during turning operation of Metal matrix composites by using coated and uncoated tools, which is analysed using a Minitab software while comparing the graph the material removal rate in MMC depends upon the depth of cut, so as the tool wear depends upon the depth of cut perfectly. Also coated tools show less tool wear than the uncoated tools also will yield in good surface finish.**

***Keywords*—Metal Matrix composite, Coated, Uncoated, Minitab Technique**

1) METAL MATRIX COMPOSITE

Metal Matrix composite nowadays find increased usage in variety of applications space shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs, and others. The term metal matrix composite covers various types of systems and also a wide range of scales and microstructures. MMC types are commonly subdivided according to whether the reinforcement is in the form of a) Particles, which are at least approximately equiaxed, b) Short fibers (With or without a degree of alignment) or c) Long aligned fiber matrix and reinforcement. Compared to monolithic metals, MMCs have higher strength to density ratio, better fatigue resistance, better elevated temperature properties (such as high strength and low creep rate) lower coefficients of thermal expansion, high thermal conductivity, good damping characteristics, excellent wear properties and flexibility in design attributes. However, the utilization of the MMC in different industries is not as generalized as expected due to difficulties encountered with the machining if MMC Materials. Cost effective machining of MMC has not yet been proven; of what this paper try's to bring out the cost effective machining of MMC. Studies of advancements in the materials show promise for machinability .The same holds true for tooling. New coatings for cutting tools show great promise for advancing the machinability of this class of material have not been investigated in detail. The past test results show the influences of reinforcement materials on tool wear and the surface integrity of MMC, but have not proven the optimum condition of tooling while machining the MMC material. When the work piece was machined with worn cutting tools the reinforcements are fractured. Studies prove that the Coated PCD tools are best for machining MMC. The type of the cutting depends upon the type of coating provided over the cutting tool. Studies proving that the coating is the best method for machining a MMC it is very important to study the optimum performance of cutting tool or the point where the cutting tool breaks while machining the optimum cutting condition, the type of coating to be used can be clearly pointed out by Taguchi Method for the type of tool used. This experiment mainly validates the usage of cutting tool and surface finish or any other criteria on work piece is not analyzed.

A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An MMC is complementary to a cermets'. Metal composite materials have found application in many areas of daily life for quite some time. Often it is not realized that the application makes use of composite materials. These materials are produced *in situ* from the conventional production and processing of metals. Here, the Dalmatian sword with its meander structure, which results from welding two types of steel by repeated forging, can be mentioned. Materials like cast iron with graphite or steel with high carbide content, as well as tungsten carbides, consisting of carbides and metallic binders, also belong to this group of composite materials. For many researchers the term metal matrix composites is often equated with the term light metal matrix composites (MMCs). 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. In traffic engineering, especially in the automotive industry, MMCs have been used commercially in fiber reinforced pistons and aluminium crank cases with strengthened cylinder surfaces as well as particle-strengthened brake disks. 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. From this potential, metal matrix composites fulfill all the desired conceptions of the designer. This material group becomes interesting for use as constructional and functional materials, if the property profile of conventional materials either does not reach the increased standards of specific demands, or is the solution of the problem. However, the technology of MMCs is in competition with other modern material technologies, for example powder metallurgy. 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.

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminium matrix to synthesize composites showing low Density and high strength. However, carbon reacts with aluminum to generate a brittle and water-soluble compound Al_4C_3 on the surface of the fiber. To prevent this reaction, the carbon fibers are coated with nickel or titanium boride. The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminium, magnesium, or titanium, and provides a compliant support for the reinforcement. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common

1.2 PROBLEM STATEMENT

There are many factors that affect the machining of the Metal Matrix composite using a standard tool such as cutting speed, depth of cut, feed rate etc. Also lot of efforts and researches have been made to decide the performance by comparing the type of tools such as coated and uncoated tools, which is been clear from A.Fathy et al. moreover from A. Fathy et al, in addition to Tool coatings, no optimization has been on presentation of tool to the material. The main problem when machining MMC is the extensive tools wear caused by the very hard and abrasive reinforcements. The results obtained from the above mentioned investigations indicate there is more need to study the effect of cutting tool when it makes contact with work piece. Here I try to investigate the optimum parameters for a cutting tool for machining, using both coated and uncoated cutting tools. Coated tools can perform better than uncoated tool in terms of flank wear but uncoated tools give better surface finish. This paper brings out the optimum cutting tool performance by conducting break even analysis for machining a Metal Matrix composite the performance of coated Tool and Uncoated Tool is compared

1.3 PERFORMANCE OF COATED AND UNCOATED TOOLS

Coated tools now are used in 40 to 80% of all machining operation, particularly in turning, milling and drilling. To increase the life of carbide tools, and they are sometimes coated. Four such coatings are TiN (titanium nitride), TiC (titanium carbide), Ti(C)N (titanium carbide-nitride), and TiAlN (titanium aluminium nitride). (Newer coatings, known as DLC (Diamond-like carbon) are beginning to surface, enabling the cutting power of diamond without the unwanted chemical reaction between real diamond and iron.) Most coatings generally increase a tool's hardness and/or lubricity. A coating allows the cutting edge of a tool to cleanly pass through the material without having the material gall (stick) to it. The coating also helps to decrease the temperature associated with the cutting process and increase the life of the tool. The coating is usually deposited via thermal CVD and, for certain applications, with the mechanical PVD method. However if the deposition is performed at too high temperature, an *eta phase* of a Co_6W_6C tertiary carbide forms at the interface between the carbide and the cobalt phase, facilitating adhesion failure of the coating. From

A.Fathy et al and M.Wieland et al it is clear that the coated tools arebetter and coated tools can increase tool life with more than 3.3 times of uncoated tools. Further coated tools prove better cutting than uncoated tools however uncoated tools give better surface finish over coated tools. Coated and uncoated carbide tools are widely use in metal working industry. This study is to investigate the performance of coated and uncoated carbide tool while dry machining MMC in term of surface roughness. There are many factors that affect the performance of cutting tool especially when dry machining. Nowadays, there are many type of cutting tools invented by manufacture engineers to overcome the problem. As an example the coated and uncoated carbide cutting tools. This two cutting tools have their advantages and disadvantages. We try to investigate the best cutting tool whether coated or uncoated carbide cutting tool for dry machining Aluminium Metal matrix composite. Coated Tool VS Uncoated Tool flak wear ratio studied from A.Fathy et.al is mentioned below as graph drawn using MS word bar option

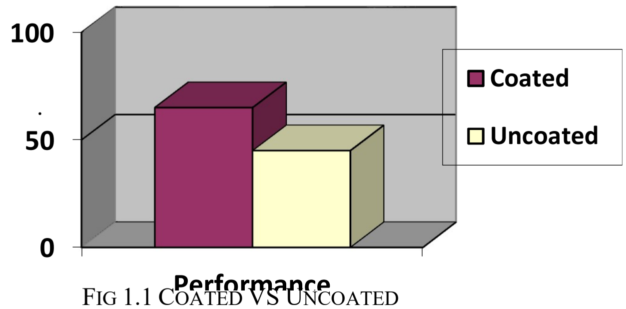

FIG 1.1 COATED VS UNCOATED

TAGUCHI METHOD

4₁) THE PURPOSE OF EXPERIMENTATION

The purpose of product or process development is to improve the performance characteristics of the product or process relative to customer needs and expectations. The purpose of experimentation should be to understand how to reduce and control variation of a product or process; subsequently, decisions must be made concerning which parameters affect the performance of a product or process. A matrix experiment consists of a set of experiments where the settings of several product or process parameters to be studied are changed from one experiment to another. Matrix experiments are also called design experiments, parameters are also called factors, and the parameter settings are also called levels. There are two methods in conducting experiments.

Full factorial experimental design .(Design of Experiments technique)

Fractional factorial experimental design .(Taguchi technique)

4.1 TOOL COATING

A.Fathy et.al [(1)] makes clear that Coating can be provided by Physical vapour deposition of chemical vapour deposition coatings can improve the tool life the cost effective coating of a tool is yet to be proven for MMC. Here the coating selected is CVD AC 630 M coated tool. Super FF coat is been provided in the coated tool. It is the combination of Ti Compound and Al substrate. The coating is applied through CVD technique.

Table 1.1 COATING SPECIFICATIONS

Hardness	TRS (Gpa)	Coating Thickness
89.5	2.7	5

EXPERIMENTAL WORK

1.1 FABRICATION OF COMPOSITE

Metal matrix composite materials can be produced by many different techniques. The work material selected for the study was A356-SiC (15p) metal matrix composite of cylindrical bars (diameter 32 mm and 175 mm long) and are fabricated using stir casting method. It is highly used in aeronautical and automobile industries because of their high strength to weight ratio, mechanical and physical properties compared to monolithic material. Table- 5.1 shows the physical and mechanical properties of Al-SiC-MMC. The chemical composition of Al-Sic is 6.247% of sic 0.030%of chromium.1.092% of Iron, 1.588% of copper, 0.152% of manganese,0.019% of magnesium, 3.959% of Zinc,0.070% of Tin, 0.159% of Nickel, 0.025% of Titanium, 0.435% lead, 86.199% Aluminium. Metal matrix composites including various weight fractions of Al2O3 particles were produced by powder metallurgy techniques followed by extrusions

CUTTING INSERTS

A Cylindrical bar 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 carbide insert as cutting tool. Parameters selected for carrying out the experimental work is as:

Table 2 Cutting Tools used in the Experiments

Type of tool	Cutting tool Designation	Cutting fluid	Cutting speeds	Depth of Cut	Feed Rate
Carbide tool	ECLNL 2525	Dry	Starting from 500	0.1 - 0.2	0.2
Coating tool	AC 630 M	Dry	Starting from 500	0.1 - 0.2	0.2

5.3 EXPERIMENTAL PROCEDURE

The experimental work was carried out on CNC lathe of spindle power 35-3000rpm. Two machining parameters were considered as controlling factors (cutting speed, feed rate and depth of cut) and each parameter has three levels. Cutting parameters and their levels are listed in Table 2 the response measured is the breaking point of tool in coated and uncoated tools

Table 3 Process Parameters and their Levels

Factors	Process Parameters	unit	Level 1	Level 2	Level 3
A	Cutting speed	m/min	500	700	1000
B	Feed Rate	mm/rev	0.2	0.2	0.2
C	Depth of Cut	mm	0.1	0.15	0.2

RESULTS AND DISCUSSIONS

The objective of this study is to predict the effects of machining parameters on coated and Uncoated cutting tools, the Material removal rate which depends upon time had a major effect on the cutting parameters other than the cutting speed or feed rate. The Feed rate is kept constant and depth of cut is varied unlike other experiments carried out by earlier authors. Use of coated tools is expanding for improved tool life and higher cutting speeds. In my work I have concentrated the effect of depth of cut in terms of material removal rate also with feed rate and cutting speed. Results of Initial depth of cut showed the material removal rate is less and it gives good surface finish so therefore the feed rate is made constant for all experiments altering only the depth of cut for various cutting speeds. Here the speed range of 500, 700, 1000 is been used for constant feed rate of 0.2 and depth of cut 0.1, 0.15 and 0.2. Here we are comparing the effect on tool wear as well as material removal rate.

6.1 EFFECT ON UNCOATED TOOLS

Figure 6.1 shows the effect of tool wear in terms of cutting speed, feed and depth of cut for uncoated tools, tool wear is in the terms of micron

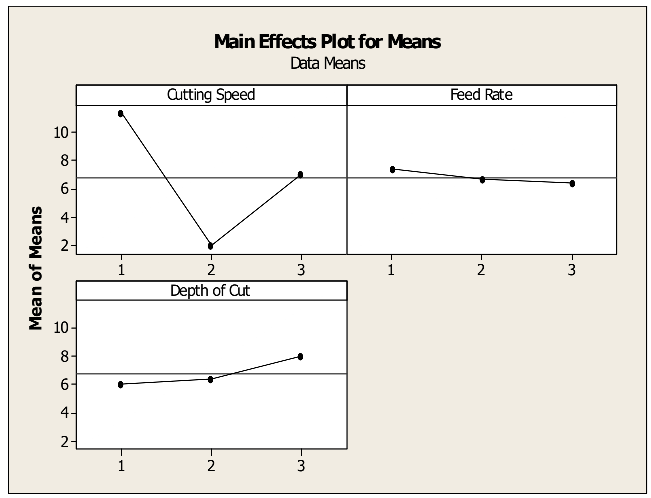

Fig 6.1 Tool Wear VS Cutting Speed, Depth of Cut and FeedRate

From the graph it is clear that the tool wear increases as cutting speed proceeds it results in the increasing levels of wear in cutting tools as compared to depth of cut and feed rate but when comparing the graph at one stage the wear is too low, but in feed rate more or less the tool wear is constant and for depth of cut tool wear is more or less equal on comparing three cutting speed has more impact on Tool wear.

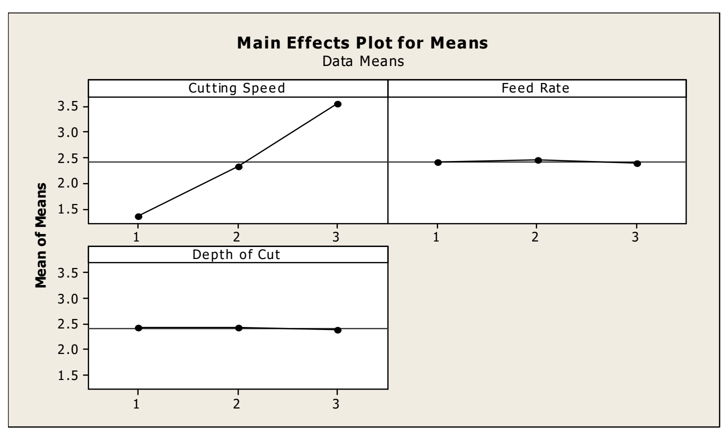

Fig 6.2 MRR VS Cutting speed, Depth of Cut, and Feed Rate

The break in period is followed by the steady state region, in which wear occurs at fairly uniform rate. Here figures are quoted as linear functions of time. Finally wear reaches a level at which wear accelerates. This marks the beginning of failure region. However, in production it is often a disadvantage to use the tool until failure region occurs because of tool resharpening and problem of work quality. In feed rate or depth of cut failure region was not seen since time required to each the same level of tool wear. The material removal rate also has direct impact on cutting speed. So good feed rate and depth of cut will yield for good material removal rate.

EFFECT ON COATED TOOLS

A minimum of two levels are required to evaluate a factors effect on a giving quality characteristic. In the beginning round more number of factors can be included with reduced levels so that the size of the experiments will be minimized. After finding the influential factors through the first round, levels can be increased to optimize the response.

The selection of parameters of inserts was based on some preliminary experiments and from literature survey. The selected parameters with their levels are listed in table

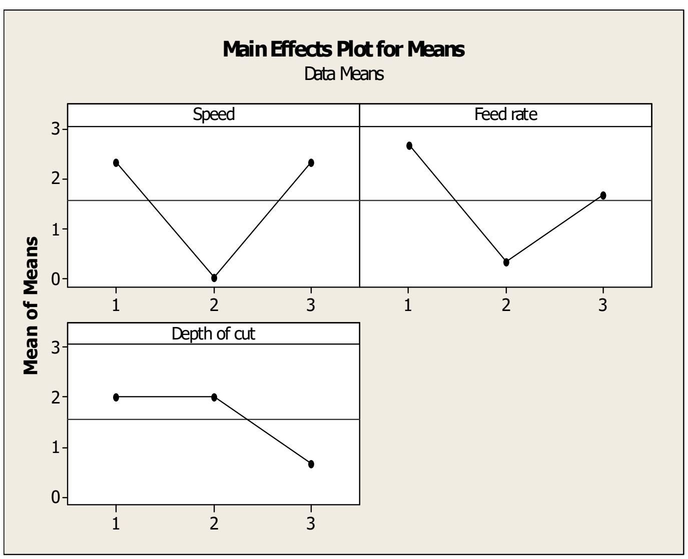

Fig6.3 Tool wear VS Depth of cut, cutting speed and feed rate

As compared to the uncoated tools the tool wear in coated is less. From graph coated carbide tool has shown better performance in decreasing wear rate than that of the uncoated one. The time required to reach the same level of tool wear in coated was 3 minutes compared to 1.2 minutes in case of uncoated carbide inserts. The coated tools with coating such as TiN or TiC have generally higher cutting-edge strength, lower friction lower tendency to form built up edge and good bonding to the substrate.

CONCLUSIONS

This research has described the use of design of experiments (DOE) for conducting experiments. In summary of machining tests to MMCs, using carbide inserts as cutting tools with and without coating, the following results were obtained during simple lathe turning tests.

- The wear rate increased rapidly with increasing the cutting parameters: cutting speed, feed and depth of cut, however cutting speed is shown to be more effective
- Coated Tools can increase tool life coated tools produced less wear than Uncoated tools.
- In terms of material removal rate cutting speed influences the same based on the cutting speed the material removal rate.
- On comparing the results keeping the feed rate constant and changing the depth of contact will yield good results.
- Compared to any other experiments conducted by previous authors now the material removal rate is low which yields better output.
- Therefore keeping the feed rate constant and by changing the depth of cut a smooth machining of MMC is made possible.
- Moreover carbide inserts is proven a very good alternative to PCD cutting tool.
- Coated carbide inserts shows better performance than uncoated carbide inserts.

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References

[1] E.Fathy Effect of manufacturing Parameters of Ai Sic metal matrix composites.

[2] Y. Sahin, M. Kok, and H. Celik, “Tool wear and surface roughness of Al2O3 particle-reinforced aluminium alloy composites,”*Journal of Materials Processing Technology*, vol. 128, no. 1–3, pp.280–291, 2002.

[3] Y. Sahin and G. Sur, “The effect of Al2O3, TiN and Ti (C,N) based CVD coatings on tool wear in machining metal matrix composites,” *Surface and Coatings Technology*, vol. 179, no. 2-3, pp. 349–355, 2004.

[4] L. A. Looney, J.M.Monaghan, P. O’Reilly, and D. M. R. Taplin, “The turning of an Al/SiC metal-matrix composite,” *Journal ofMaterials Processing Tech.*, vol. 33, no. 4, pp. 453–468, 1992.

[5] J. T. Lin, D. Bhattacharyya, and C. Lane, “Machinability of a silicon carbide reinforced aluminium metal matrix composite,” *Wear* vol. 181–183, no. 2, pp. 883–888, 1995.

[6] Y. Sahin, “Preparation and some properties of SiC particle reinforced aluminium alloy composites,” *Materials and Design*, vol. 24, no. 8, pp. 671–679, 2003.

[7] M. El-Gallab and M. Sklad, “Machining of Al/SiC particulate metal-matrix composites Part I: tool performance,” *Journal ofMaterials Processing Technology*, vol. 83, no. 1–3, pp. 151–158,1998.

[8] K. H. W. Seah, X. Li, and K. S. Lee, “The effect of applying coolant on tool wear in metal machining,” *Journal of Materials Processing Tech.*, vol. 48, no. 1–4, pp. 495–501, 1995.

[9] I. Ciftci, M. Turker, and U. Seker, “Evaluation of tool wear when machining SiCp-reinforced Al-2014 alloy matrix composites,”*Materials and Design*, vol. 25, no. 3, pp. 251–255, 20

[10] Paulo Davim J: (2002) Diamond tool performance in machining metal matrix composites, *J.Mater. Process.Tech,* Vol.128, pp.100-105.

[11] Ravirajshetty; (2009) Taguchi’s techniques in machining of metal matrix composites, *J. of the Braz .society ofMech.Science. & Eng.* Vol.16, No.1, pp.12-20.

[12] K. Palanikumar, R. Karthikeyan (2007), “Assessment of factors influencing surface roughness on the machining of Al/SiC particulate composites”, Mater Des 28:1584–1591

[13] Rajesh Kumar Bhushan&Sudhir Kumar & S. Das, (2010) “Effect of machining parameters on surface roughness and tool wear for 7075 Al alloy SiC composite”, Int J Adv Manufacturing Technology (2010) 50:459–469

[14] N. Muthukrishanan, & P.J. Davim, (2008) “Optimization of machining parameters of Al/SiC- MMC with ANOVA and ANN analysis”, Journal of materials processing technology.