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EFFECT OF SINGLE AND MULTILAYER CARBIDE COATED TOLL ON CHIP THICKENS RATIO OF AISI H11 STEEL

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Abstract— **Machining is the most widespread metal shaping process in the manufacturing industry. It is a process in which the material is removed from the work piece in the form of chips with the cutting tool. The output of the machining processes is measured in terms of surface quality, tool wear, cutting forces and metallurgical properties. The productivity during manufacturing can be enhanced by reducing machining cost and selecting appropriate machining parameters. The performance of machining process is depends on various parameters like tool geometry parameters, cutting parameters, tool materials, work piece materials. But geometrical parameters like nose radius, side cutting edge angle, end cutting edge angle, relief angle and rake angle have considerable effect. The effect of back rake angle along with cutting parameters when machining with single and multiple layer coated carbide tool during machining of AISI H11 steel are needed to be investigated. AISI H11 steel has ultimate tensile strength (1990 Mpa), good fatigue strength, excellent wear resistance, good thermal shock resistance. It has wide range of application in such as pressure die casting tools, extrusion tools, forging dies, extrusion mandrels, die and mould industry. Therefore in this research work the effect of different back rake angle along with cutting parameters has been investigated while machining AISI H11 steel with single and multilayer coated carbide tools.**

Keywords— **Watermarking, Haar Wavelet, DWT, PSNR**

I. INTRODUCTION

In the manufacturing industry, increasing productivity and reducing manufacturing cost have always been the important area of interest, in turning, higher values of cutting parameters offer opportunities for increasing productivity. Turning is a very important machining process in which a single point cutting tool removes material from the surface of a cylindrical work piece [1-2]. The material removed, known as chip slide on the rake face of the tool, subjecting to a high coefficient of friction during chip formation. The effects of work piece hardness, cutting edge geometry, feed rate and cutting speed on the surface roughness are statistically significant [1]. High cutting temperature adversely affects tool life, surface finish and dimensional accuracy of the product [3-5]. The principal of the turning process is shown in Fig. 1.

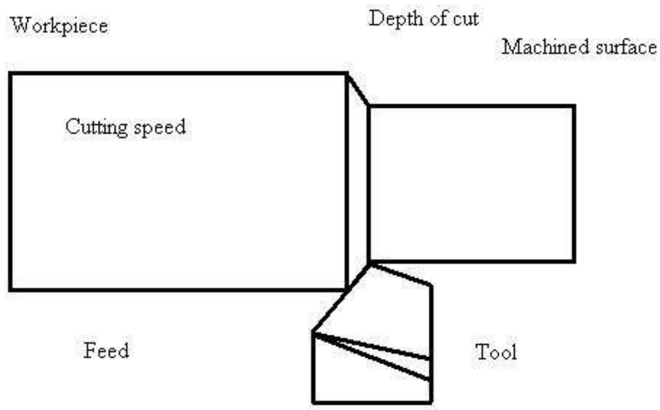

Fig. 1. Principal of Turning Process.

In turning process, heat generated as aresult of the plastic deformation of the layer being cut and overcoming friction on the tool-chip and tool-work interfaces. This heat is dissipated by thethree cutting zone in processing the material such as the cutting tool, the work piece and chip formed. The greater part of the heat passes into the chip, while a portion is conducted into the tool and material.As shown in figure 1.2 the heat is produced in the three different zones namely primary deformation zone, secondary deformation zone and tertiary deformation zone respectively. In the primary deformation zone or shear zone, heat is generated due to the plastic deformation of the work piece material. In the secondary deformation zone or at the tool-chip interface, heat is produced due to the friction between the chip and rake face of the tool. In the tertiary deformation zone, heat is generated due to the friction between work piece and flank of the tool [6-10].

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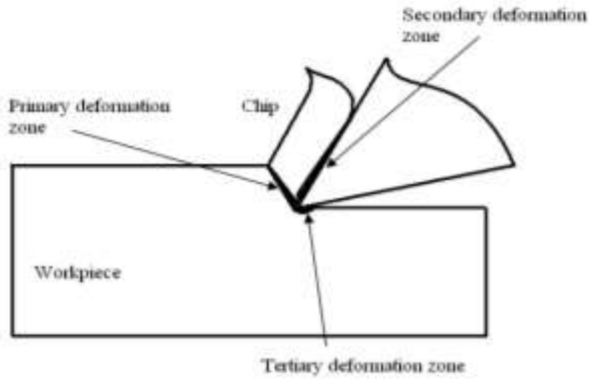

Fig. 2. Dissipation of heat among tool, chip and work piece.

The maximum amount of heat is carried away by the flowing chips and some heat is absorbed by the tool and remaining heat is an absorbed by the work piece. The sharing of the heat depends upon the configuration, size and thermal conductivity of the tool-work material and the cutting conditions. Cutting temperature depends upon several factors like work piece and tool material, cutting conditions and tool geometry. If a material has high tensile strength and hardness, more energy is required for chip formation and more heat is generated. If thermal conductivity is high then temperature evolved will be lower [11-14].

The three primary factors in any basic turning operation are cutting speed, feed rate and depth of cut. Other factors such as kind of material, type of tool and geometrical parameters have a large influence on the machining. Cutting speed- The cutting speed can be defined as the relative surface speed between the tool and the work piece. The cutting speed is the work piece surface relative to the edge of the cutting tool during a cut, the selection of proper speed is desirable in machining. If the speed is too high, the tool gets overheated which leads to generate rough surface. If the speed is to low, too much time is consumed in machining and full capacities of the tool and machine are not utilized.

$$V = \frac{\pi DN}{1000} m \min^{-1}$$

where V is the cutting speed in turning, D is the initial diameter of the work piece in mm and N is the spindle speed in rpm.

Feed rate – The speed of the cutting tool's movement relatives to the work piece as the tool makes a cut. The feed rate is measured in rev per minute. Large feed rate was the major reason for the surface roughness. Feed always refers to the cutting tool, and it is the rate at which the tool advances along in cutting path. On most power-fed lathes, the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle), or mm/rev.

Depth of cut- The depth of the tool along the radius of the work piece as it makes a cut as in a turning or boring operation. A large depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life.

$$dcut = D - \frac{d}{2} mm$$

where dcut represent depth of cut, D and d represent initial and final diameter (in mm) of the job respectively [15-16].

II. GEOMETRICAL PARAMETER

A. Rake angle: The angle between the rake surface and the normal is called rake angle. Rake angle is a parameter used in various cutting and machining processes, describing the angle of the cutting face relative to the work. Rake angle is one of the geometry which has a great affect on the cutting forces, Surface quality and tool wear. Increasing and decreasing or keeping the rake angle negative and positive the cutting force and power thereby increases and decreases respectively. When the negative rake angle is used, the shear strain is more, but for practical range, the negative rake angle has lower cutting force than positive rake angle.The two rake angles, namely the back rake angle and side rake angle, both of which help to guide chip flow. There are three types of rake angles: positive, negative, and zero [17-18].

Generally, positive rake angles:

- Make the tool more sharp and pointed. This reduces the strength of the tool, as the small included angle in the tip may cause it to chip away.
- Reduce cutting forces and power requirements.
- Helps in the formation of continuous chips in ductile materials.
- Can help avoid the formation of a built-up edge.

Negative rake angles, by contrast:

- Make the tool more blunt, increasing the strength of the cutting edge.
- Increase the cutting forces.
- Increase friction resulting in higher temperature.

. The class of cutting tool materials currently in use for machining operation are high speed steel, tool steel, cemented carbides, ceramic, polycrystalline cubic boron nitride and polycrystalline diamond. Different machining applications require different cutting tool materials.

The ideal cutting tool material should have following characteristics:

1. Harder than the work to be machined
2. High temperature stability
3. Wear resistance and thermal shock
4. Impact resistant

5. Chemically inert to the work material and cutting fluid

Butin manufacturing industries, carbide tool are preferred for material removal due to its low cost.

It is important in evaluating the heat and degree of deformation during turning process. It is measure of efficiency of chip formation. The chip thickness ration can be calculated using depth of cut and final deformed chip thickness. The type of chip produced during metal cutting depends on the material being machined and the cutting conditions used.

Chip thickness ration (r) = Depth of cut/Chip thickness (tc) (1.3)

Chip thickness can be measured by vernier caliper or micrometer.

Chip thickness ratio depends on many other factors (cutting tool geometry, material properties etc). Sometimes the chip will be thicker or thinner than depth of cut, due to deformation of chip as it is removed.

Tool wear in machining is defined as the amount of volume loss of tool material on the contact surface due to the interactions between the tool and work piece. Specifically, tool wear is described by wear rate (volume loss per unit area per unit time) and is strongly determined by temperature, stresses, and relative sliding velocity generated at the contact interface. Metal cutting tools are subjected to extremely high surface loads. Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to metal contact between the chip and work piece. Under conditions of very high stress at high temperature, the situation is further aggravated (worsened) due to the existence of extreme stress and temperature gradients near the surface of the tool. During machining, cutting tools remove material from the component to achieve the required shape, dimensions and surface roughness (finish).

The major tool failure are due to the flank wear on the main and auxiliary cutting edge, creater wear on the rake face and built up edge formation occur around this zone of the tool. Flank wear is mainly caused by abrasion of the flank face by the hard constituents of the work piece. Creater wear is caused by chemical interactions the rake face of the tool and the hot metal chip flowing over the tool [19-20].

III. EXPERIMENT AND RESULT

AISI H11 steel has ultimate tensile strength (1990 Mpa), good fatigue strength, excellent wear resistance, good thermal shock resistance. It has wide range of application in such as pressure die casting tools, extrusion tools, forging dies, extrusion mandrels, die and mould industry. Therefore in this research work the effect of different back rake angle along with cutting parameters has been investigated while machining AISI H11 steel with single and multilayer coated carbide tools. For getting good results from this experiments there is a need of proper planning of the research work to be done. There are four machining input parameters and surface roughness, tool wear as output parameters were selected for the present study which are discussed below:

Table 1 Input machining parameters

Variables	Units	Set-up
Rake angle	-	00,+50,-50
Cutting speed	m/min	90-135
Feed	mm/rev	0.1-0.3
Coated carbide insert	-	Round shape insert withsingle and multi layer coated carbide inserts
Length of cut	mm	20

For the present study AISI H11 steel was selected as work material. Work piece of length 400mm and diameter 60mm was used. The work piece material was hardened 40-45HRC before machining. The material used in the present study has been used to forging die, pressure die casting, die and mould industry.

As per the problem formulated the surface roughness, tool wear was investigated with round shape single coated carbide insert and multi coated carbide inserts. The coated carbide inserts of Seco Company, RCMT0803M0-F2Single coated carbide has diameter 8 mm and height 3.5 mm with clearance angle 70 and RPHW12040-6-MD05 Multi coated carbide has diameter 12mm with clearance angle 110 was used in this experiment study. A seco SRSCR2525M8JET tool holder with zero degree rake angle was used.

The one inclined strip was made for Rake angle. The one side of strip inclined50 and other side of strip inclined -50. The strip was placed under tool post below the tool holder for adjusting the rake angle. The 50inclined side of strip was used which means that is a positive five degree (+50) rake angle. Also the -50 inclined side of strip was used which means that is negative five degree (-50) rake angle. The photographic view of coated insert, tool holder and rake angle adjustment strip are given below.

In this experiment five input parameters (cutting speed, depth of cut, feed rate, coated carbide inserts& rake angles) were used in machining of AISI H11 steel. All these parameters were varied at three levels. The output response parameter investigated is chip thickness ratio. The Full factorial design methodology was employed to design the

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experiment using MINITAB 16 software. The results obtained from a series of experiment are as follows.

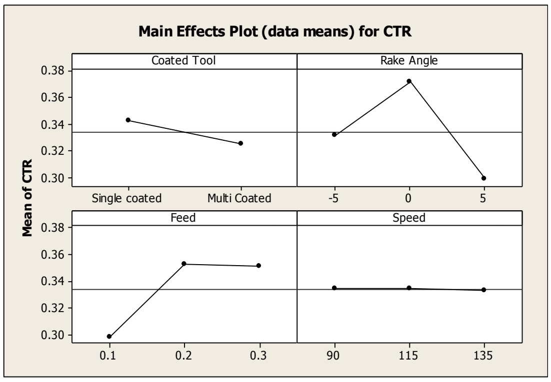

Fig. 3. Main Effect plot for Chip thickness ratio

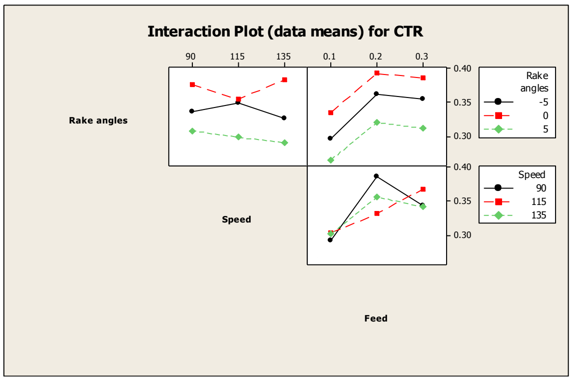

Fig. 4. Interaction plot for Chip thickness ratio.

The Chip Thickness Ratio values obtained corresponding to each trial is given in Table 2. The photograph of chip obtained during trial is shown in Appendix 1. The input parameters like cutting tool insert, cutting speed, feed rate and rake angle have considerable effect on Chip Thickness Ratio as shown in main effects plot for means of Chip Thickness Ratio in figure 5.16. Interaction plots for mean chip thickness ratio is in the figure 5.17. From the main effect plots for mean chip thickness ratio, it is observed that Chip Thickness Ratio increases frequently with increase in feed and it decreases frequently with increase in cutting speed. More is the feed more is the chip thickness ratio. Theoretically this is due to increase in contact area between chip and tool, leads to increase in amount of heat transfer to chip, thus leading to high chip deformation. From the Fig. 3 and Fig. 4 we can also observer Chip Thickness Ratio coming out to be less with the with multi coated carbide inserts as compared to single coated carbide insert this is basically due to the reason that in case of multi coated carbide insert provide strength to the material and Multi coated tool alsoreduce the friction between tool and work piece material and act as self- lubricant. More over the Chip Thickness Ratio is coming out to be minimum for the +50 Rake angle as compared to -50, 00rake angle under same working condition. Because with positive rake angle the edge of the cutting tool remain sharp, so cutting force and power is reduced and heat is not taken away by chip because cutting force reduce under 50 rake angle.

Table 2 Analysis of variance for means of chip thickness ratio

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% C
Rake angle	2	0.0477444	0.0477444	0.0238722	72.90	0.000	40.50
Coated tool (T)	1	0.0028167	0.0028167	0.0028167	8.60	0.006	2.38
Cutting Speed (S)	2	0.0005444	0.0005444	0.0002722	0.83	0.443	0.46
Feed rate (F)	2	0.0378778	0.0378778	0.0189389	57.83	0.000	32.13
α×S	4	0.0047444	0.0047444	0.011861	3.62	0.013	4.02
S×F	4	0.0117111	0.0117111	0.0029278	8.94	0.000	9.93
Error	38	0.0124444	0.0124444	0.0003275			10.55
Total	53	0.1178833					99.97
S = 0.0180966 R-Sq = 89.44% R-Sq(adj) = 85.28%							

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The purpose of ANOVA was to investigate which of the process parameters significantly effect the performance characteristics. For find the result of ANOVA full factorial method was used. Modified ANOVA was prepared by removing some in significant terms. Statically there is a F test to see which design parameters have a significant effect on the quality characteristic. In performing the F test, the mean of squared deviations (MS) due to each design parameters needs to be calculated. The MS is equal to the sum of squared deviations (SS) divided by the number of degrees of freedom associated with the design parameter. Then the F value for each design parameter is simply the ratio of MS to the mean of squared error. The analysis of variance results for surface roughness at confidence interval are given in Table 5.9.ANOVA result shows that tool, speed, feed and rake angle have significant effect on the Chip thickness ratio. When F value increases the significance of the parameter also increases. ANOVA table shows the percentage contribution of each parameter. The rake angle and feed both have contribution for the Chip Thickness Ratio, followed by speed.

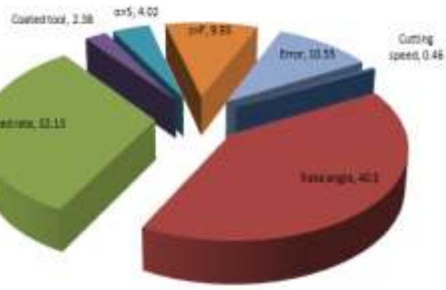

Fig. 5.Pie chart showing contribution of each factor on chip thickness ratio

Rake angle plays a significant role on the production ofchip thickness formation. As the heat between tool and work piece material will be reduced, the formation of chip thickness also will be reduced. In this experiment result, it is concluded that rake angle plays a vital role on chip formation and its contribution about 41%. After rake angle feed is considered as effect on chip thickness ratio. More feed effects large chip formation and contribution in this experiment was 32%. Speed has effect on chip thickness formation about 0.46%.

IV. CONCLUSION

The present study was carried out to study the effect of input parameters on the surface roughness, tool wear and chip thickness ratio. There are many factors which affect the surface finish of the work piece during machining, but one of the chief factors was Rake angle. Chip thickness coefficient found best with 5^0 Rake angle. Chip thickness ratio has lower value with multi coated carbide insert. As the cutting speed increased the chip thickness ratio was decreased due to the reason work piece and tool comes in contact with each other for less time. With the increase of feed chip thickness ratio also increased.

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