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Experimental Investigation of The Effect of Tool Geometry While Machining of AISIH13 Steel With Single and Multilayer Coated Carbide Tools

Govind Khullar, Chandan Gupta & Pankaj Sharma

Student in Sri Sai College of Engineering and Technology, Department of Mechanical Engineering, India.

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ABSTRACT

Machining is the process in which a tool removes material from the surface of work piece in the form of chips. Machining plays an important role in specifying the surface quality of the product which directly depends upon the tool geometry, types of tool used and parameters like feed rate, cutting speed and depth of cut. The surface quality is an important parameter to evaluate the productivity of machine tools as well as machined components. Hence achieving the desired surface quality is of great importance for the functional behavior of the machined parts. Surface quality is generally associated with surface roughness. The new cutting materials like high performance carbides and ceramics have improved machining of several engineering materials. So in present study the effect of rake angles (5^0,-5^0,0^0) with single coated carbide inserts and multi coated carbide inserts on surface roughness was investigated. It was analyzed that the cutting of work piece material under the presence of 5^0 rake angle provide much better surface finish as compared to -5^0, 0^0 rake angles. Moreover, it concluded that the multi coated carbide inserts performed better compared to the single coated carbide inserts. Therefore in this research work the effect of different back rake angle along with cutting parameters has been investigated while machining AISIH13 steel with single and multilayer coated carbide tools.

Keywords: Rake Angle, Coated carbide tool, Surface roughness.

1. INTRODUCTION

Machining is the process in which tool removes material from the surface of the work piece in the form of chips. Machining to high accuracy and finish essentially enables a product to fulfill its functional requirements, improve its performance and prolong its service. In machining the excess material in the form of chips can be removed by single point cutting tool, multi-point cutting tools and by abrasive operations. Single point tool operations are turning, boring, shaping and planning operations. Multi point tool operations include milling, drilling, tapping, reaming, hobbing, broaching and sawing operations. 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 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 effect 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. 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.

2. FORMULATION OF PROBLEM

From the literature review it has been observed that in the past few years have seen an increasing interest in the surface finish produced in turning operation to obtain a product of high quality, the new cutting tool materials like high performance ceramics, coated carbides, have been greatly improved machining of several engineering materials. 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. From the literature review it is observed that some work has been done during machining of AISIH13 steel using geometrical parameters. But still there is need to investigate the effect of back rake angle along with cutting parameters when machining with single and multiple layer coated carbide tool during machining of AISIH13 steel. AISIH13 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 AISIH13 steel with single and multilayer coated carbide tools.

3. EXPERIMENTAL SET-UP

3.1 Machine tool

Machine tool which holds the work between two rigid and strong supports called center. The chuck is mounted on the projected end of the machine spindle. The cutting tool is rigidly held and supported in a tool post and is fed against the revolving work. There are many types of machine tools available in the market but the required tool, which was used in the present study, was made HMT limited. The experiment set up used for conductivity by using carbide insert cutting tool on lathe.

FIG 3.1: Experimental setup

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3.2 Surface roughness tester

The surface quality of the machined surface has been measured using Mitutoyo surface roughness tester in metrology lab in BCET Gurdaspur, the tester consist of a flat table, tracer with drive unit and recorder. The machined flat surface to be tested was kept on the table by adjusting the tracer arm. The stylus traces the machined surface in the direction of feed motion. The stylus moves over the surface of work piece for a limited length 0.8 mm. The arithmetic mean deviation is recorded.

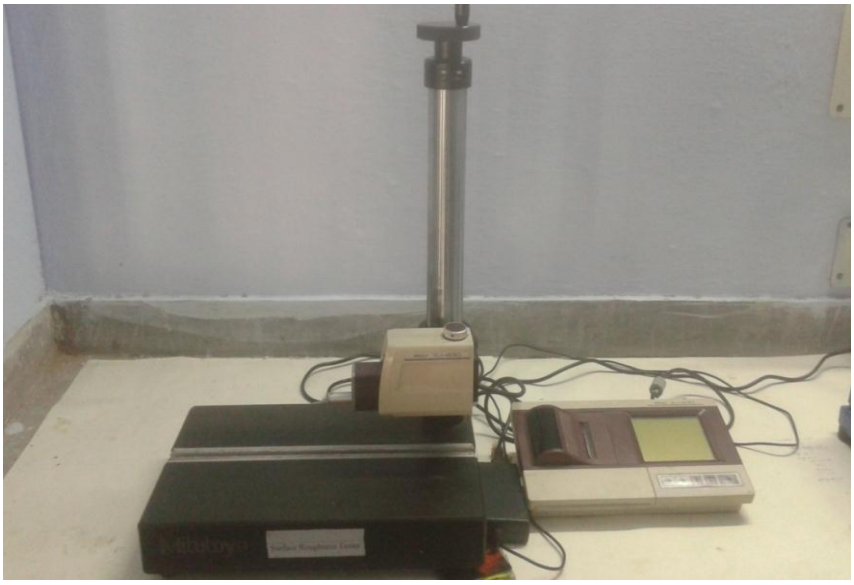

FIG 3.2: Surface roughness tester

4. WORK PIECE MATERIAL

For the present study AISIH13 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.

5. SET-UP AND EXPERIMENTAL PROCEDURE

In this experiment five input parameters (cutting speed, depth of cut, feed rate, coated carbide inserts& rake angles) were used in machining of AISIH13 steel. All these parameters were varied at three levels. The output response parameters investigated are surface roughness. The Full factorial design methodology was employed to design the experiment using MINITAB 16 software. The machining of AISIH13 involved five machining input parameters. These are cutting speed, feed rate, depth of cut, coated carbide inserts and rake angle ($+5^0$,-5^0,0^0). The parameters cutting speed feed rate and rake angle varied at all three levels and two levels of coated carbide inserts were taken single coated carbide inserts and multi coated carbide inserts. Depth of cut is kept constant throughout the experiment. The one inclined strip was made for Rake angle. The one side of strip inclined5^0 and other side of strip inclined -5^0. The strip was placed under tool post below the tool holder for adjusting the rake angle. The 5^0inclined side of strip was used which means that is a positive five degree ($+5^0$) rake angle. Also the -5^0 inclined side of strip was used which means that is negative five degree (-5^0) rake angle. The photographic view of coated insert, tool holder and rake angle adjustment strip are given below.

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FIG 5.1: Rake angle adjusting strip for ($+5^0$,-5^0)

Table 1 Input machining parameters

Variables	Units	Set-up
Rake angle	-	0^0,$+5^0$,-5^0
Cutting speed	m/min	90-135
Feed	mm/rev	0.1-0.3
Coated carbide insert	-	Round shape insert with single and multi layer coated carbide inserts
Length of cut	mm	20

6. EXPERIMENTAL OBSERVATIONS

Table 6.1 Machining with single coated and multi coated insert under zero (0^0) rake angle

Run No.	Tool material	Cutting speed (v) m/min	Feed (f) mm/rev	Ra (µm)
1.	Single coating	90	0.1	3.83
2.	Single coating	90	0.2	5.93
3.	Single coating	90	0.3	10.57
4.	Single coating	115	0.1	3.77
5.	Single coating	115	0.2	5.77
6.	Single coating	115	0.3	9.93
7.	Single coating	135	0.1	3.33

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8.	Single coating	135	0.2	4.00
9.	Single coating	135	0.3	9.21
10.	Multi coating	90	0.1	3.67
11.	Multi coating	90	0.2	4.29
12.	Multi coating	90	0.3	6.69
13.	Multi coating	115	0.1	3.23
14.	Multi coating	115	0.2	4.10
15.	Multi coating	115	0.3	6.27
16.	Multi coating	135	0.1	2.93
17.	Multi coating	135	0.2	3.45
18.	Multi coating	135	0.3	6.31

Table 6.2 Machining with single coated and multi coated insert under (-5^0) rake angle

Run No.	**Tool material**	**Cutting speed (v) m/min**	**Feed (f) mm/rev**	**Ra (µm)**
1	Single coating	90	0.1	3.69
2.	Single coating	90	0.2	4.71
3.	Single coating	90	0.3	9.91
4.	Single coating	115	0.1	3.49
5.	Single coating	115	0.2	4.51
6.	Single coating	115	0.3	7.09
7.	Single coating	135	0.1	2.90
8.	Single coating	135	0.2	3.75
9.	Single coating	135	0.3	6.11
10.	Multi coating	90	0.1	1.47
11.	Multi coating	90	0.2	2.52
12.	Multi coating	90	0.3	6.57
13.	Multi coating	115	0.1	0.90
14.	Multi coating	115	0.2	2.70
15.	Multi coating	115	0.3	4.47

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16.	Multi coating	135	0.1	2.73
17.	Multi coating	135	0.2	3.20
18.	Multi coating	135	0.3	5.93

Table 6.3 Machining with single coated and multi coated insert under (5^0) rake angle

Run No.	**Tool material**	**Cutting speed (v) m/min**	**Feed (f) mm/rev**	**Ra (µm)**
1.	Single coating	90	0.1	2.07
2.	Single coating	90	0.2	3.37
3.	Single coating	90	0.3	9.68
4.	Single coating	115	0.1	2.09
5.	Single coating	115	0.2	3.97
6.	Single coating	115	0.3	6.90
7.	Single coating	135	0.1	1.06
8.	Single coating	135	0.2	3.10
9.	Single coating	135	0.3	5.94
10.	Multi coating	90	0.1	0.93
11.	Multi coating	90	0.2	2.24
12.	Multi coating	90	0.3	5.87
13.	Multi coating	115	0.1	0.40
14.	Multi coating	115	0.2	2.25
15.	Multi coating	115	0.3	3.93
16.	Multi coating	135	0.1	0.93
17.	Multi coating	135	0.2	2.00
18.	Multi coating	135	0.3	5.70

7. RESULTS & DISCUSSION

7.1 Effect of surface roughness

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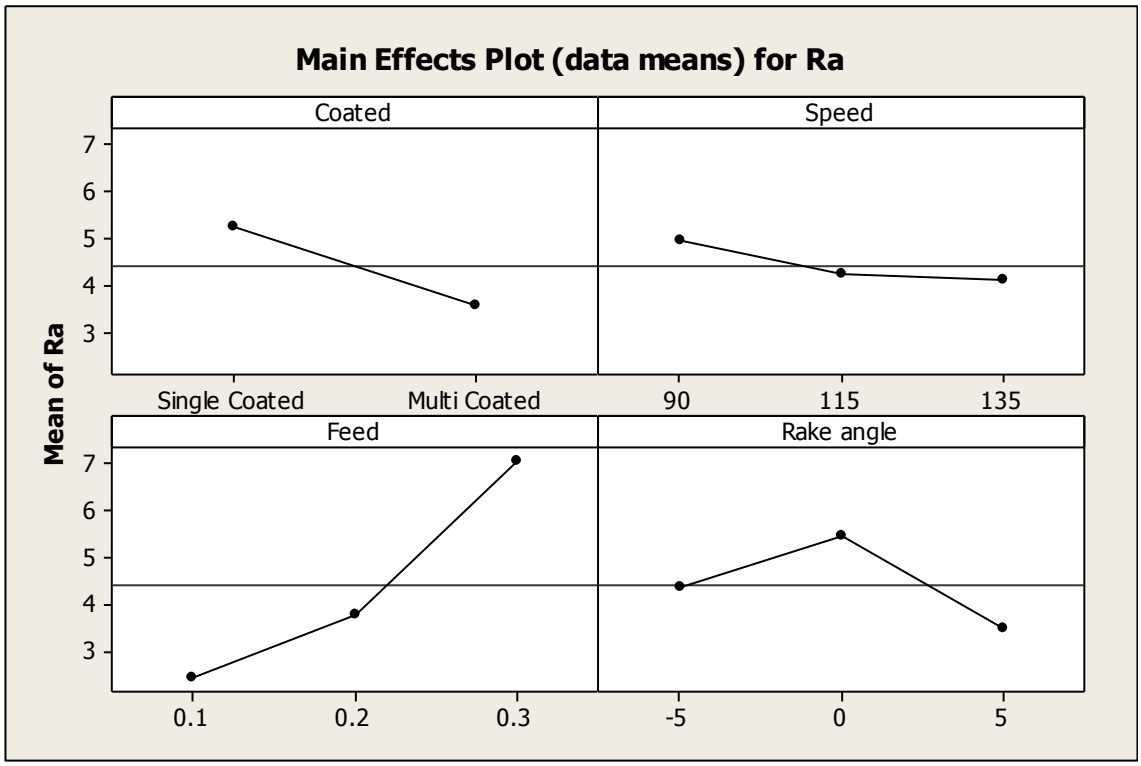

FIG 7.1: Main effects plot of surface roughness

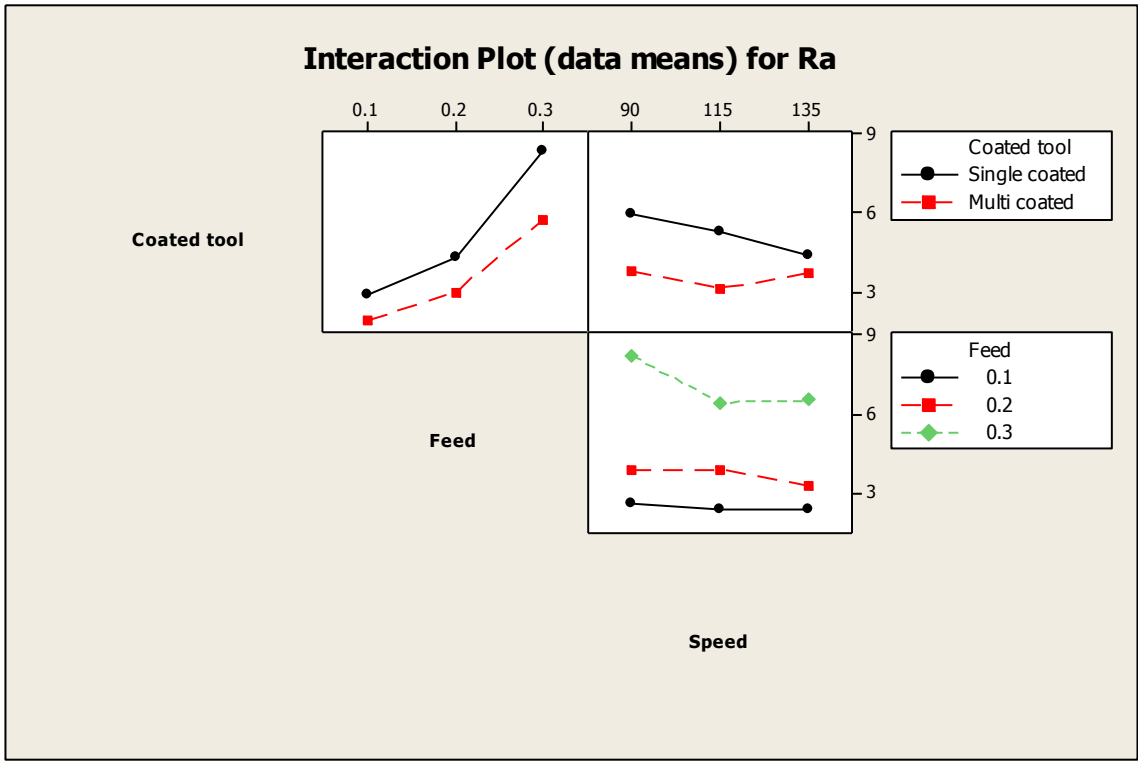

FIG 7.2: Interaction plot of surface roughness

The input parameters coated carbide inserts, cutting speed, feed rate and rake angle have considerable effect on surface roughness are shown in the main effects plot for mean of surface roughness in figure 7.1. Interaction plots

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for mean surface roughness are shown in the figure 7.2. From the main effect plots for mean surface roughness, it is observed that surface roughness increases frequently with increase in feed rate and it decreases with increase in speed. More is the cutting speed more is the surface finish. On the other hand increase in feed rate decreases is the surface finish. Moreover with increase in feed rate the cutting forces and area in contact between chip and tool increases, leading to increase in friction between material and tool and thus increases surface roughness. From the figure5.1 it can also be observed that surface roughness is less for the multi coated carbide inserts as compared to single coated carbide inserts. This is basically due to the reason that in case of multi coated carbide inserts less tool wear takes place. So multi coated carbide inserts provide good surface finish. The surface roughness is minimum 5^0 rake angle as compare to -5^0& 0^0 rake angle under same working condition.

8. CONCLUSION

The present study was carried out to study the effect of input parameters on the surface roughness, . There are many factors which affect the surface finish of the work piece during machining, but one of the chief factors was Rake angle. The following conclusions have been drawn from the study:

1. Surface roughness was found increased with as feed rate is increase. Feed rate has 64% contribution in surface roughness.

2. Surface finish increased with increase in cutting speed.

3. Surface finish was achieved best with multi coated carbide insert and under 5^0rake angle.

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