# Effect of Machining Input Parameter on the Surface Roughness Quality

**Amninder Singh, Ashwani Kumar**

***Abstract:** Past few years 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 has been seen which have 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. In this research work the effect of different back rake angle along with cutting parameters and speed has been investigated while machining AISI H11 steel with single coated carbide tools.*

***Index Terms:** Machining, Surface roughness, Feed, Rake angle, Speed, Coating.*

## I. INTRODUCTION

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. Across world, machining operations such as turning, milling and shaping involves a large amount of money annually [1-4]. Out of these machining processes, turning still remains the most important operation. Because in turning, the conditions of operation can be varied. Increasing productivity and reducing manufacturing cost are the requirement of the manufacturing industries. Machining is the process in which tool removes material from the surface of the workpiece in the form of chips [5-8]. 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 [9-14].

These traditional machining operations are mostly used to remove excess material from the work piece. Out of these machining processes, turning is very important operation used to shape metals in almost all manufacturing industries. Although the work piece can be effectively shaped by a large number of other manufacturing processes, yet the process of turning plays an important role, being one of the most versatile processes of manufacturing [15-18]. Its versatility can be attributed to so many factors, some of which are

1. Machine tools do not require elaborate tooling.
2. The process of machining can be employed to almost all engineering materials.
3. The wear of tools is not costly, if it is kept within limits.
4. A large number of parameters which come into play during machining can be suitably controlled in order to overcome technological and economical difficulties.

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work part dimensional accuracy and surface finish, high production rate and cost saving [19-20]. Researchers made experiment studies to investigate the effect of various factor effecting surface quality of the product but few studies have been reported, the combined effect of carbide tool with single and multilayer coated, cutting parameters along with rake angle.

## II. LITERATURE SURVEY

Singh et al. (2016) In this paper focuses on determining optimized parameters for minimum surface roughness in CNC end milling. Design of experiments based on response surface methodology with three independent factors (cutting speed, feed rate and depth of cut) and one category factor (nose radius), five level central composite rotatable designs has been used to develop relationships for predicting surface roughness. Model adequacy tests were conducted using ANOVA table and the effects of various parameters were investigated and presented in the form of contour plots and 3D surface graphs. Numerical optimization was carried out considering all the input parameters within range so as to minimize the surface roughness [1].

Payal et al. (2016) H11 die steel is widely used in forging dies, aircraft landing gears and shafts. Electric discharge machining (EDM) is one of the most suitable processes to shape this material. This work demonstrates the effect of pulse-on-time (Ton) on surface roughness during EDM of H11 tool steel by taking three different tool electrode materials. Experiments have been conducted by varying Tonin four steps (10 µs, 20 µs, 30 µs, 40µs) while keeping the values of other variables fixed. On the basis of experimental results, it is concluded that tool properties of electrode play a vital role in machining characteristics of die-sinking EDM process. The results demonstrate that Copper-tungsten electrode offers the best surface finish followed by graphite and copper electrode in EDM of H11 too steel [2].

**Revised Version Manuscript Received on July 14, 2017.**

**Amninder Singh,** Department of Mechanical Engineering, Sri SAI College of Engineering and Technology, Badhani, Pathankot, India, E-mail: sandhu.a22@gmail.com

**Asst. Prof. Ashwani Kumar,** Department of Mechanical Engineering, Sri SAI College of Engineering and Technology, Badhani, Pathankot, India.

Mathew et al. (2015) In this paper an effort has been made to compare the usefulness of electrode made through Powder Metallurgy (PM) in comparison with conventional copper electrode during electric discharge machining. Experimental results are presented on electric discharge machining of H11 steel in standard EDM oil with copper tungsten (75% Cu and 25%W) tool electrode made through powder metallurgy technique and Copper electrode (99%Cu). An L18 orthogonal array of Taguchi Methodology was used to identify the effect of process input parameters (viz. electrode type, peak current, voltage and duty cycle) on the output factor (viz. Tool wear rate). It was found that copper tungsten (CuW) made through powder metallurgy gives better TWR as compared to conventional electrode (Cu) and the best parametric setting for minimum TWR is with CuW powder metallurgy tool electrode, 4 ampere current, 40 volts gap voltage, 0.72 duty cycle [3].

Pathak et al. (2015) In the present study an attempt has been made to investigate the effect of cutting parameters (cutting speed, feed rate, and depth of cut) on surface roughness and material removal rate (MRR) during dry turning operation of AISI H11 tool steel as per Taguchi's experimental design technique using an L9 orthogonal array. Signal to noise ratio (S/N) results and Analysis of Variance (ANOVA) were employed in order to investigate the optimal and significant cutting characteristics of H11 tool steel respectively. This paper focuses on optimizing the cutting parameters for minimum surface roughness and maximum MRR of H11 tool steel using high speed steel (HSS) as the cutting tool during turning. The results indicated that feed has a significant influence on surface finish and depth of cut on MRR when turning operation was carried out with HSS cutting tool. An artificial neural network model and regression equations were also developed to obtain minimum surface roughness and maximum MRR at different cutting conditions [4].

## III. MATERIAL AND METHOD

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. Full factorial design of experimentation method is one of the best methods, which further simplified and standardized the design of experiment. In present research work, selected input machining parameters with their designation are listed in Table 1 and Table 2 enlists levels of machining parameters and assigned values of machining parameters at these levels for experimentation work.

**Table 1Assigned values of input machining parameters at different level**

| Factors | Cutting parameters | `Levels | | |
|---|---|---|---|---|
| | | Level 1 | Level 2 | Level 3 |
| A | Rake angle | +5 | -5 | 0 |
| B | Insert shape with coated | Round insert single coated carbide | Round insert multi coated carbide | ------------ |
| C | Speed (m/min) | 90 | 115 | 135 |
| D | Feed rate (mm/rev) | 0.1 | 0.2 | 0.3 |
| E | Depth of cut | 0.2 | -------- | -------- |

**Table 2 Experimental design on full factorial method**

| S. No | Tool material | Feed (mm/rev) | Speed (m/min) | Rake angle |
|---|---|---|---|---|
| 1 | Single coated | 0.1 | 90 | 0 |
| 2 | Single coated | 0.2 | 90 | 0 |
| 3 | Single coated | 0.3 | 90 | 0 |
| 4 | Single coated | 0.1 | 115 | 0 |
| 5 | Single coated | 0.2 | 115 | 0 |
| 6 | Single coated | 0.3 | 115 | 0 |
| 7 | Single coated | 0.1 | 135 | 0 |
| 8 | Single coated | 0.2 | 135 | 0 |
| 9 | Single coated | 0.3 | 135 | 0 |
| 19 | Single coated | 0.1 | 90 | -5 |
| 20 | Single coated | 0.2 | 90 | -5 |
| 21 | Single coated | 0.3 | 90 | -5 |
| 22 | Single coated | 0.1 | 115 | -5 |
| 23 | Single coated | 0.2 | 115 | -5 |
| 24 | Single coated | 0.3 | 115 | -5 |
| 25 | Single coated | 0.1 | 135 | -5 |
| 26 | Single coated | 0.2 | 135 | -5 |
| 27 | Single coated | 0.3 | 135 | -5 |
| 37 | Single coated | 0.1 | 90 | 5 |
| 38 | Single coated | 0.2 | 90 | 5 |
| 39 | Single coated | 0.3 | 90 | 5 |
| 40 | Single coated | 0.1 | 115 | 5 |
| 41 | Single coated | 0.2 | 115 | 5 |
| 42 | Single coated | 0.3 | 115 | 5 |
| 43 | Single coated | 0.1 | 135 | 5 |
| 44 | Single coated | 0.2 | 135 | 5 |
| 45 | Single coated | 0.3 | 135 | 5 |

## IV. RESULTS AND DISCUSSION

In this experiment five input parameters (cutting speed, depth of cut, feed rate, and rake angles) were used in machining of AISI H11 steel. All these parameters were varied at three levels. The output response parameters investigated are surface roughness,

tool wear & chip thickness ratio. The variation of surface roughness with cutting speed, feed rate, coated carbide inserts and rake angle were investigated at constant depth of cut 0.2 mm. The variations of the surface roughness with process variables are shown in Table 3, Table 4and Table 5.

**Table 3 Machining with single coated and multi coated insert under zero ($0^\circ$) rake angle.**

| Tool material | Cutting speed (v) m/min | Feed (f) mm/rev | Ra(µm) |
|---|---|---|---|
| Single coating | 90 | 0.1 | 3.83 |
| Single coating | 90 | 0.2 | 5.93 |
| Single coating | 90 | 0.3 | 10.57 |
| Single coating | 115 | 0.1 | 3.77 |
| Single coating | 115 | 0.2 | 5.77 |
| Single coating | 115 | 0.3 | 9.93 |
| Single coating | 135 | 0.1 | 3.33 |
| Single coating | 135 | 0.2 | 4.00 |
| Single coating | 135 | 0.3 | 9.21 |

**Table 4 Machining with single coated and multi coated insert under zero ($-5^\circ$) rake angle.**

| Tool material | Cutting speed (v) m/min | Feed (f) mm/rev | Ra(µm) |
|---|---|---|---|
| Single coating | 90 | 0.1 | 3.69 |
| Single coating | 90 | 0.2 | 4.71 |
| Single coating | 90 | 0.3 | 9.91 |
| Single coating | 115 | 0.1 | 3.49 |
| Single coating | 115 | 0.2 | 4.51 |
| Single coating | 115 | 0.3 | 7.09 |
| Single coating | 135 | 0.1 | 2.90 |
| Single coating | 135 | 0.2 | 3.75 |
| Single coating | 135 | 0.3 | 6.11 |

**Table 5 Machining with single coated and multi coated insert under zero ($5^\circ$) rake angle.**

| Tool material | Cutting speed (v) m/min | Feed(f) mm/rev | Ra(µm) |
|---|---|---|---|
| Single coating | 90 | 0.1 | 2.07 |
| Single coating | 90 | 0.2 | 3.37 |
| Single coating | 90 | 0.3 | 9.68 |
| Single coating | 115 | 0.1 | 2.09 |
| Single coating | 115 | 0.2 | 3.97 |
| Single coating | 115 | 0.3 | 6.90 |
| Single coating | 135 | 0.1 | 1.06 |
| Single coating | 135 | 0.2 | 3.10 |
| Single coating | 135 | 0.3 | 5.94 |

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 Fig. 1. Interaction plots for mean surface roughness are shown in the Fig. 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.

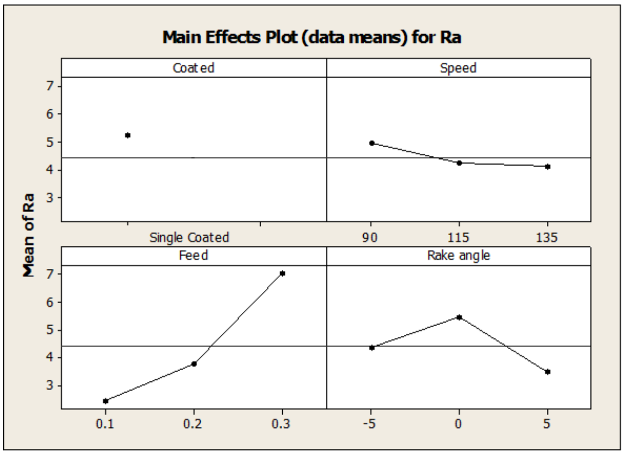


**Figure 1 Main effects plot of surface roughness.**

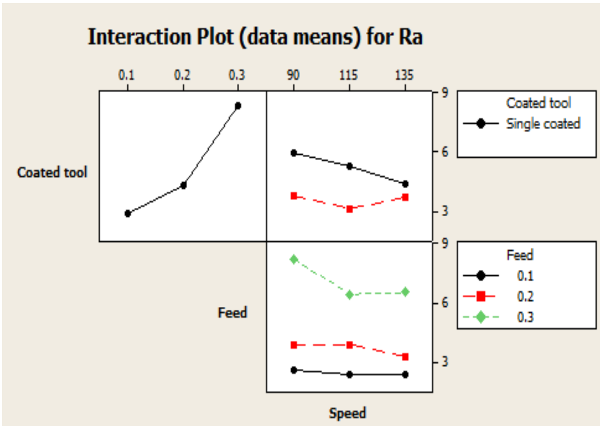


**Figure 2 Interaction plot of surface roughness.**

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. Statistically F-test has been applied to find the significance of the process parameters. In performing the F test, the mean of square deviation (MS) due to each design parameter needs to be calculated. The MS is equal the sum of square deviation (SS) divided by the number of degree 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 95% confidence interval are given in Table 6.

From the above Figure 3 we can observe that feed rate (65%) has more effect on the surface roughness. The surface roughness increases with increase in feed rate.

Because 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 cutting tool and thus increases surface roughness. In this experiment result, it is concluded that rake angle& coated carbide inserts plays a vital role on surface roughness and its contribution on surface roughness was 11% and 12%.

**Table 6**

| Source | DF | Seq SS | Adj SS | Adj MS | F | P | %C |
|---|---|---|---|---|---|---|---|
| Rake angle (α) | 2 | 34.11 | 34.11 | 17.05 | 52.11 | 0 | 10.6 |
| Cutting tool (T) | 1 | 37.50 | 37.50 | 37.50 | 114.5 5 | 0 | 11.7 4 |
| Cutting Speed (S) | 2 | 7.37 | 7.37 | 3.68 | 11.26 | 0 | 2.30 |
| Feed (F) | 2 | 208.3 | 208.3 | 104.1 | 318.2 | 0 | 65.2 |
| T×S | 2 | 6.42 | 6.42 | 3.21 | 9.81 | 0 | 2.01 |
| T×F | 2 | 6.47 | 6.47 | 3.23 | 9.88 | 0 | 2.02 |
| S×F | 4 | 6.52 | 6.52 | 1.63 | 4.98 | 0.002 | 2.04 |
| Error | 38 | 12.44 | 12.44 | 0.32 | | | 3.89 |
| Total | 53 | 319.1 | 319.1 | | | | 99.9 |
| S = 0.601972 R-Sq = 96.82% R-Sq (adj) = 93.98% | | | | | | | |

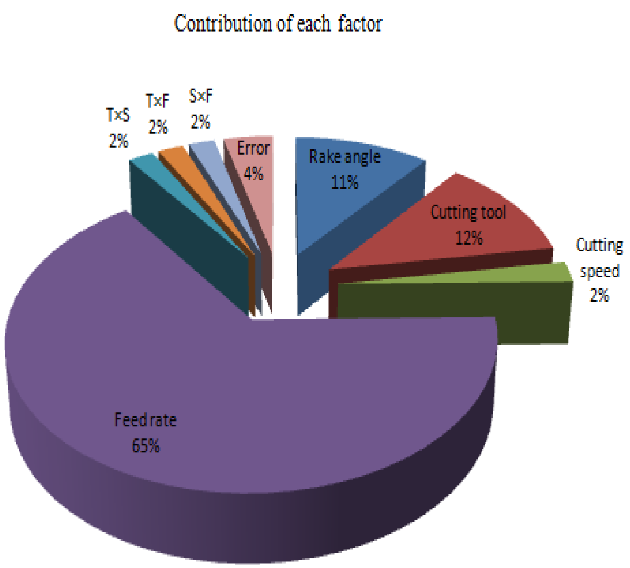


**Figure 2 Pie chart Showing Contribution of each factor on the surface roughness.**

## V. 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 50rake angle.

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