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Experimental Investigation of Tool Life and Surface Roughness during CNC Turning Using Single Point Cutting Tool

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Abstract: Turning is one of the most important machining operation in industries. Turning is affected by many factors such as cutting speed, feed rate, depth of cut, geometry of cutting tool etc. Input parameters in this project work is cutting speed, feed rate and depth of cut. Output parameters are surface roughness and tool life. The objective of this paper is to evaluate the optimal setting of cutting parameters to have a maximum cutting tool life under wet machining environment. In this investigation HSS cutting tool with carbide insert is used. Mild steel and aluminium are workpiece material. The experiment are conducted under three different spindle speeds (600, 800, 1000), feed rates are (0.1, 0.15, 0.2) and depth of cut are (0.5, 1.0, 1.5). The relationship between cutting parameters and tool life obtained. This paper reviews the machining parameters affecting the performance of turning such as spindle speed, feed rate and depth of cut.
Keywords: CNC turning, tool life, surface roughness, carbide insert, cutting Parameters

I. INTRODUCTION

Material removal processes are a group of manufacturing process in which excess material is removed from the starting work piece so that the resulting shape is the desired geometry. The excess material is removed in the form of small fragments called chips and the process is referred to as machining.

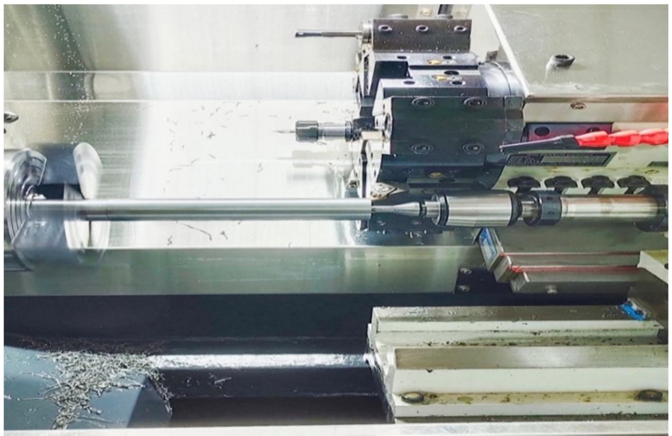
The body which removes the excess material through direct mechanical contact is called cutting tool and the machine which provides the necessary motions between the work piece and the tool is called machine tool. Since material is removed in the form of chips, therefore the machining of a finite area requires a continuous movement of the uncut portion towards the cutting at a suitable rate. The relative motion between the tool and the work responsible for the cutting action is called primary or cutting motion, and that responsible for gradually advancing the uncut portion is called secondary or feed motion. Machining can be defined as a process of removing materials from a workpiece in form of chip.

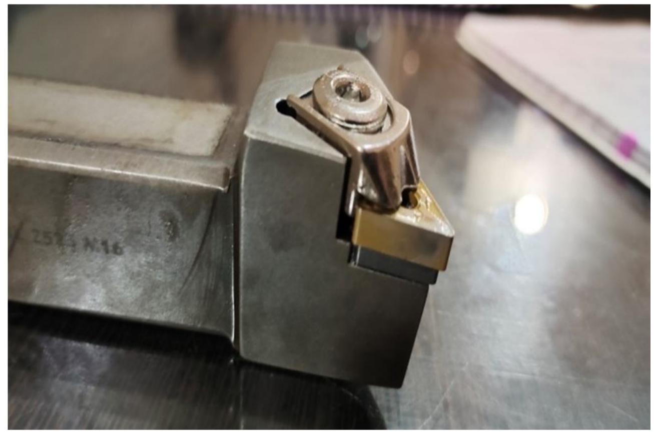
The excess material is removed in the form of small fragments is called as a chip and the process is referred to as a machining. Turning is one of the most basic and widely used metal cutting process. During turning process, the cutting tool remove materials from the rotating workpiece. Lathe machine is principle machine tool used in turning. Single point cutting tool is used to remove the materials from rotating workpiece. Objective of turning is to reduce the workpiece diameter to get the desired dimension. Turning can be done on both external surface and internal surface of the part. In turning the primary motion is provided by rotating the workpiece and feed motion is achieved by moving the cutting tool. The various process parameters involved in metal turning process are cutting speed, feed rate, depth of cut, tool and workpiece material.

II. EXPERIMENTAL PROCEDURE

Machining test was performed on a CNC machine. Cutting operation performed under various cutting condition like cutting speed, feed rate, depth of cut. In this experiment turning operation performed on mild steel and aluminium. Single point cutting tool with carbide insert used as a cutting tool for experimentation.

The dimension of the workpiece samples are 250 mm length and 40 mm diameter. Workpiece have been machined under different cutting speed, feed rate and depth of cut. The CNC machine with a spindle speed range 3500 RPM was used in machining. For experimentation Mild steel bar and aluminium bar clamped in the CNC machine. CNC machine was driven by 0.18kw electric motor. The experiment was done under dry machining operation. In this investigation Tool life is determined by Taylor’s equation and surface roughness determined by surface roughness tester.





III. PROPOSED WORK

A. Input Parameters

1) Speed

Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it tells their rotating speed. But the important feature for a particular turning operation is the surface speed, or the speed at which the work piece material is moving past the cutting tool. It is simply the product of the rotating speed times the circumference of the work piece before the cut is started. It is expressed in meter per minute (m/min), and it refers only to the work piece. Every different diameter on a work piece will have a different cutting speed, even though the rotating speed remains the same.

$$V = \pi * D * N/1000 \text{ m/min}$$

Here, 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.

2) Feed

Feed always refers to the cutting tool, and it is the rate at which the tool advances along its 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.

$$F = f * N \text{ mm/min}$$

Here, m F is the feed in mm per minute, f is the feed in mm/rev and N is the spindle speed in RPM.

3) Depth of Cut

Depth of cut is practically self explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm. It is important to note, though, that the diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work.

$$d = (D - d)/2 \text{ mm}$$

Here, D and d represent initial and final diameter (in mm) of the job respectively.

B. Output Parameters

1) *Tool Life:* Tool life generally indicates the amount of satisfactory performance or service rendered by a fresh tool or a cutting point till it is declared failed. Tool life is the time period between two consecutive resharpening, with which the tool cuts the material effectively. Tool life is important factor in production work since considerable time is most whenever a tool is re-sharpened and reset on the machine.

Taylor tool life Equation

$$VT^n = C$$

V = cutting speed, m/min
T = Tool life, min
n = Tool life index,
C = Machining index

2) *Surface Roughness:* Surface roughness is the measure of the finely spaced micro irregularities on the surface texture, which is composed of three components, namely roughness, waviness, and form. In this experiment surface roughness measured in micron (μm) and roughness measured in Ra value.
3) *Experimentation:* This experiment has been done on the CNC machine. In this experiment I have used aluminium and mild steel as a work material and carbide insert used as a tool material. In this work nine experiments are conducted for the different nine sets of parameters (speed, feed and depth of cut). surface roughness tester is used for measuring the Roughness of work piece. Taylor's tool life equation is used for finding the tool life.

IV. LITERATURE SURVEY

Dheeraj soni [1] Machining is the process of removing the excess material from the work piece or unwanted material from the work piece using a cutting tool. The surface finish and tool life obtain in machining process depends upon the various factors like work material, tool material , tool geometry, machine conditions, coolant and feed rate , speed , depth of cut etc. The focus of present study deals with finding optimal controlled process parameters to obtain good surface finish as well as here predicted tool life. It also shows the effect of the process parameters; cutting speed, feed rate and depth of cut on tool life. The most affecting factor on tool life are cutting speed and feed observed after the experimentation. Here it is also concluded that tool life decreases with increases of cutting speed and feed in machining process for CNMG tool and grey cast iron work material combination. Literature study is rich in terms of turning operation owing to its importance in metal cutting. The important cutting process parameters in this research are speed, feed and depth of cut. In addition, it also depends on the several other exogenous factors such as: work piece and tool material combinations and their mechanical properties, quality and type of the machine tool used, lubricant used, and vibrations created between the work piece, machine tool and cutting tool.

Nitin sharma [2] The purpose of this paper is to make an attempt to review the literature on optimization of input cutting parameters for improved surface finish by acquiring minimum surface roughness in turning process and to present various methodologies and practices that are being employed for the prediction of surface roughness. Surface roughness is one of the most commonly used criteria to determine quality of a turned surface. This literature review compiles different work presented on optimization of process parameters and concludes the most significant cutting parameters and most frequently used optimization techniques for improving surface finish The cutting parameters like Cutting speed, Feed rate, Depth of cut, Insert radius and Cutting fluid are taken into consideration. From the literature review it is observed that various methods are used to minimize surface roughness by optimizing cutting parameters like Cuttingspeed,Feedrate,Depthofcut,toolangle,nose radius,CuttingFluid,etc.

Abhinav Bhatnagar [3] These days one of the most important machining process in industries is turning. Turning is one of the most important machining operation in industries. Turning is affected by many factors such as the cutting velocity, feed rate, depth of cut and geometry of cutting tool etc., which are input parameters in this project work. The finished product with desired attributes of size, shape, and surface roughness and cutting forces developed are functions of these input parameters. The objective of this paper is to evaluate the optimal setting of cutting parameters such as cutting velocity (N), depth of cut(d), feed(f) to have a maximum cutting tool life under dry machining environment. In this project HSS cutting tool material and workpiece materials (mild steel and aluminium) are examined. The experiments are conducted under three different spindle speeds (190, 325, 520 rev/min) and feed rates (0.5, 0.75, 1.0 mm/rev). The values of depths of cut are recorded by the research work. The relationship between cutting parameters and tool life is obtained. HSS tool has the longest tool life with mild steel as a work piece material. The tool life is estimated from T = C/(V1/n × fn1/n × dn2/n)

S B Chikalthankar [4] This paper reviews the machining parameters affecting the performance of turning such as spindle speed, feed and depth of cut. Optimum performance in a turning operation is governed by selecting desired machining parameters. Selection of desired machining parameters by experience or using handbook does not ensure that the selected machining parameters are optimal for a particular machine or environment. In this study, Taguchi method is used for single characteristics optimization in order to establish a correlation between the input and output variables. Therefore, the experiments were performed according to a Taguchi design of experiments.

V. RESULT AND DISCUSSION

There are two different combination of design of experiment which are as follows:

	Tool Material	Workpiece material
Case 1	Carbide Insert	Mild Steel
Case 2	Carbide Insert	Aluminium

A. Case 1

In this case we have taken mild steel as workpiece material and carbide insert as tool material. Cutting speed, feed and depth of cut are taken as input parameters. Tool life and surface roughness are taken as output parameters. The relation between input and output parameters are shown in below table. The result are also shown in the table.

Sr No.	Spindle Speed (RPM)	Cutting Speed (m/min)	Feed rate (mm/rev)	D.O.C (mm)	Tool Life (min)	Surface Roughness (μm)
1	600	75	0.1	0.5	74	0.50
2	600	75	0.15	1.0	28.87	1.26
3	600	75	0.2	1.5	15.78	1.63
4	800	100	0.1	0.5	23.42	0.83
5	800	100	0.15	1.0	11.75	1.47
6	800	100	0.2	1.5	7.02	1.93
7	1000	125	0.1	0.5	9.59	1.12
8	1000	125	0.15	1.0	5.85	1.72
9	1000	125	0.2	1.5	4.26	1.33

B. Case 2

In this case we have taken Aluminum as workpiece material and carbide insert as tool material. Cutting speed, feed and depth of cut are taken as input parameters. Tool life and surface roughness are taken as output parameters. The relation between input and output parameters are shown in below table. The result are also shown in the table.

Sr No.	Spindle Speed (RPM)	Cutting Speed (m/min)	Feed rate (mm/rev)	D.O.C (mm)	Tool Life (min)	Surface Roughness (μm)
1	600	75	0.1	0.5	61.46	0.25
2	600	75	0.15	1.0	30.94	0.54
3	600	75	0.2	1.5	16.17	1.20
4	800	100	0.1	0.5	19.45	0.15
5	800	100	0.15	1.0	10.17	0.91
6	800	100	0.2	1.5	6.70	1.43
7	1000	125	0.1	0.5	7.96	0.76
8	1000	125	0.15	1.0	5.05	0.79
9	1000	125	0.2	1.5	3.78	0.55

VI. CONCLUSION

The following Conclusion can be drawn from the study:

The above work is experimentally investigated on the CNC machine. In this work mild steel and aluminium taken as a work material and carbide insert used as tool material. By varying the different parameters like cutting speed, feed rate and depth of cut at different condition the tool life and surface roughness are calculated. The results showed that the tool life is decreasing as the speed, feed and depth of cut increasing. The all parameters are inverse relation with tool life. A lot of work has been done in finding out optimum values of cutting parameters which provide best surface finish. The optimal combination of low feed rate and low depth of cut is beneficial for good surface finish.

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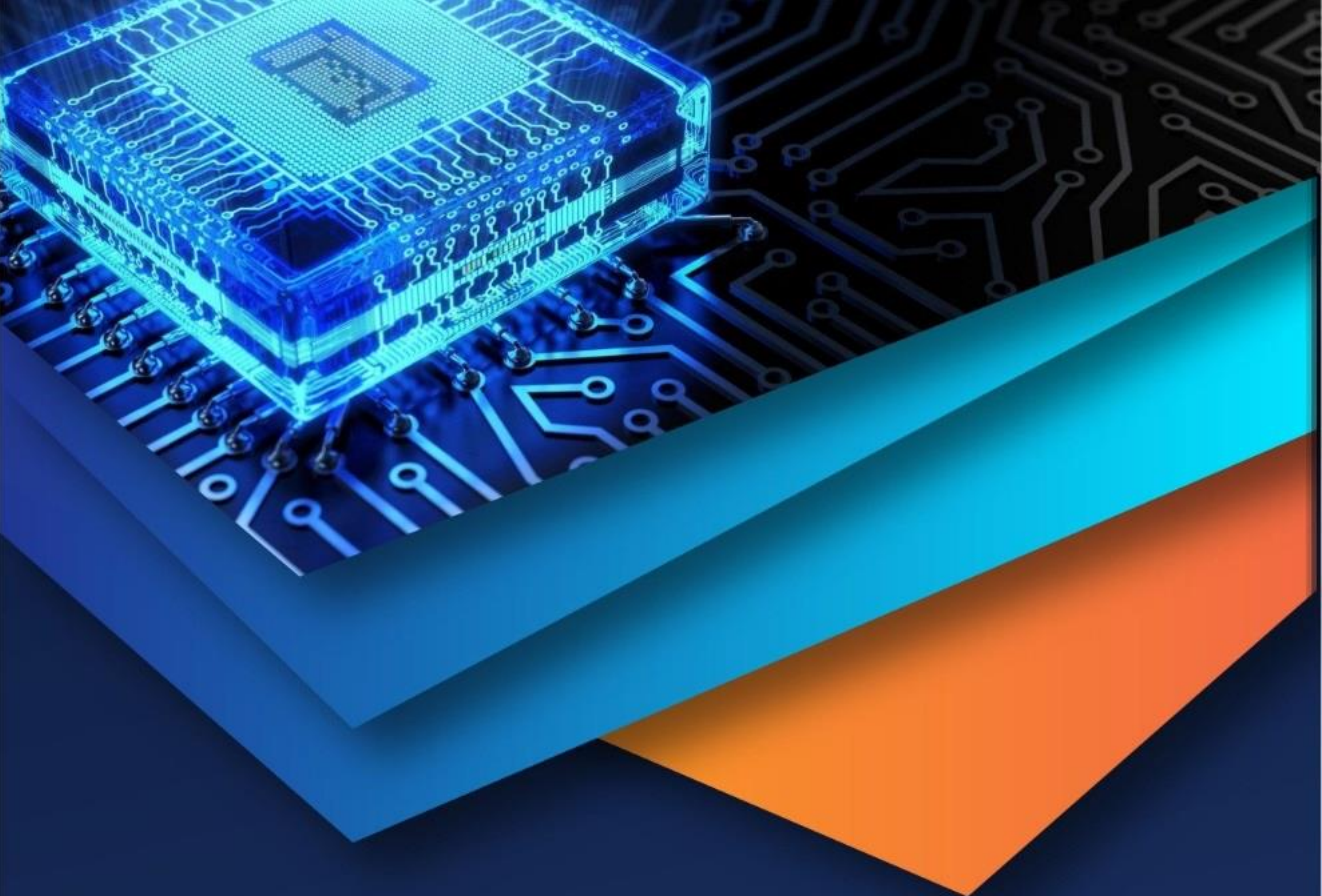

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