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**EXPERIMENTAL ANALYSIS OF CUTTING FORCES, TOOL LIFE AND SURFACE  
ROUGHNESS OF SINGLE POINT CUTTING TOOL DURING TURNING PROCESS**

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**ABSTRACT**

In any metal cutting operation the features of tools, input work materials, machine parameter settings will influence the process efficiency and output quality characteristics. For turning process, the cutting conditions i.e. Speed, Feed and Depth of cut plays an important role in the efficient use of a machine tool. HSS is one among the major machining operations in manufacturing industry; the revelation made in this research would significantly contribute to the cutting parameters optimization.

In this study, tool chip interface temperature was determined in cutting of medium carbon steel workpiece with HSS as the tool. The effects of different parameters like cutting speed, feed rate and depth of cut are taken into account so as to predict their effects on tool life and surface roughness are studied in experimental analysis. The results have shown that change in cutting speed and feed rate has the maximum effect on cutting force, tool life and surface roughness.

**KEYWORDS:** cutting parameters, temperature distribution, tool-work thermocouple, tool life.

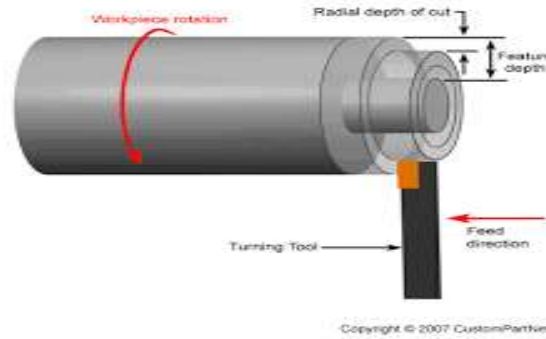
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**INTRODUCTION**

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material as shown in Figure 1.1. The turning process requires a turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desire shape.

An orthogonal metal cutting process for a controlled contact tool is depicted in Figure 1 with labels illustrating the nomenclature used in this paper. An Eulerian reference co-ordinate is used to describe the steady state motion of the workpiece relative to a stationary cutting tool. This cutting method is a common and time favoured metal removal process which produces finished surfaces with high quality. Its general use in all industries may give an impression that it is a perfected art. Yet, tool failure and product quality deterioration account for frequent and costly downtime for all cutting machines. Optimization of the process and accurate estimate of tool life become indispensable in this age of automation.

The various parameters involved in metal turning process are feed rate, depth of cut, cutting speed, rake angle, tool and workpiece materials and tool nose radius.

**Fig 1. Turning process**

Tool life is defined as the time elapsed between the two successive grindings of the tool. During this time the tool cuts the material effectively and efficiently. The tool life of a cutting tool must be higher.

## LITERATURE REVIEW

**Maheshwari N Patil and Sarange S [1]** Finite element analysis based techniques are available to analyse the effect of temperature and cutting forces (Horizontal force, vertical force) on the tip of tool using three dimensional model of an single point cutting tool in ANSYS software and simulate cutting processes and offer several advantages including prediction of temperatures, distribution of von misses stresses and deformation of tip of single point cutting tool using tool forces, estimation of tool wear and residual stresses on machined surfaces. The conclusions obtained in the analysis of single point cutting tool are as follows as depth of cut increases, the von-misses stresses developed in the tool increases and also the temperature generated in the tool at the tool tip also increases which causes the failure of the tool.

**Kapil Sharma et al [2]** The parameters like rake angle, depth of cut, feed rate, temperature and cutting speed are taken in to account so as to predict their effects on tool life. The cutting force decreases as the tool rake angle increases. With increase in feed rate, this tends increase in cutting force. The increase in absolute value of negative tool rake angle and cutting speed these results in the decrement of tool chip friction. The tool tip temperature increases with an increase in cutting speed. With the increased in positive rake angle, the cutting forces are decreased which means that less force/power is required.

**T T M Kannan et al [3]** CBN tool insert are considered to be one of the most suitable material for machining hardened steel because of their high hardness, wear resistance and chemical inertness. In this experimental investigation regarding about heat partition, tool life and develop Merchant circle and tool wear of CBN cutting tool and analyzed while turning of AISI316 steel rods. CBN cutting tool insert has been damaged in moderate cutting velocities and produce fairly good machinability. It also mentioned higher cutting temperature decreases the yield strength of produce white layer formation. However CBN cutting tool insert was suitable for turning of Austenite stainless steel (AISI316) and produce better performance.

**P. Albertelli [4]** in this paper an experimental study regarding the effects of Spindle Speed Variation technique on tool wear in steel turning is presented. The experimental tool wear tests were arranged and performed following a full factorial design: the cutting speed and the cutting speed modulation were the main investigated factors. The flank wear width was the main considered process response and it was monitored continuously during wear tests up to the end of the tool life.

**Sushil D. Ghodam [5]** proposed that by applying coating on the tool the life of the tool was increased. The tool work thermocouple was used for the experimental analysis of the tool life because it was inexpensive. The comparisons were made between the temperature distribution for coated and uncoated tool. These showed that with coatings the temperatures generated within the tool were decreases so the tool life was increased.

**Evaluation of Cutting Force, Tool Life and Surface Roughness by Experiments**

The experiment is conducted on the HSS tool operating on medium carbon steel workpiece in turning. These machining tests were carried out in a conventional lathe. The workpiece material used in the experiment was medium carbon steel in the form of cylindrical bar having a diameter of 30mm and a length of 300mm.

A Lathe machine with a spindle speed range from 230 to 514rpm was used for the machining trial. The machining center was driven by 5.5kW electric motor. The experiment was done under dry machining environment. A tape rule model Fat Max Blade Armor 35` was used to measure the total cutting length a tool will cut effectively. Tool life was determined by dividing the total length of effective cut by the product of feed rate and spindle speed of machining. The same machine was used for all experimental work. The tool life data were collected for each of the cutting conditions. Table 1 presents the cutting parameters.

**Table 1. The cutting parameters and their level**

Symbol	PARAMETERS	Levels		
		1	2	3
A	Spindle speed N, rev/min	230	340	514
B	Feed rate f, mm/rev	0.35	0.7	1.4
C	Depth of cut d, mm	0.5	1	1.5

The influence of cutting parameters on cutting force, tool life and surface finish are evaluated and tabulated in below shown table 2.

**Table 2. Cutting forces, tool life and surface finish for medium carbon steel**

S.No	Factors			Parameters			Cutting force $F_c$ N	Tool life (seconds)	$R_a$ ( $\mu$ m)
	A	B	C	N rev/min	f mm/rev	d mm			
	N	f	D						
1	1	1	1	230	0.35	0.5	315	178.88	6.12
2	2	2	2	340	0.7	1.4	1695.4	60.50	8.35
3	3	3	3	514	1.4	1.5	3360	20.01	13.26
4	3	1	1	514	0.35	0.5	315	80.04	8.19
5	1	2	2	230	0.7	1	1211	89.44	13.14
6	2	3	3	340	1.4	1.5	3360	30.252	13.08
7	2	1	1	340	0.35	0.5	315	121.00	8.16
8	3	2	2	514	0.7	1	1211	40.02	11.67
9	1	3	3	230	1.4	1.5	3360	44.72	11.92

The formulae involved in present work are

$$\text{Cutting force } F_c = K_c \times \text{DOC} \times f$$

Where  $K_c$  = specific cutting energy coefficient ( $\text{N}/\text{mm}^2$ )

DOC = depth of cut (mm)

F = feed rate (mm/rev)

$$\text{Tool life } T = L \times 60/f$$

L = length of effective cut (mm)

F = feed rate (mm/min)

$$\text{Surface roughness } R_a = 0.0321f^2/r$$

Where f = feed rate (mm/rev)

r = cutter nose radius (mm)

$R_a$  = surface roughness ( $\mu$ m)

**RESULTS AND DISCUSSION**

Cutting force increases linearly with the increase in depth of cut from 0.5mm to 1.5mm. The Tool life is more when the speed is moderate, depth of cut is minimum and the feed rate is moderate. When there is a higher feed rate then

there is a significant effect on cutting force, tool life and surface roughness. The speed and depth of cut have insignificant effect on cutting force, tool life and surface roughness.

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