Optimization of Cutting Parameters in Turning Operation

K. Venkataraman[1], K. Amrish[2], K. Hariprasad[3], R.P. Jithvin[4], S. Pranavamoorthi[5]

[1] Associate Professor, Department of Mechanical Engineering, KGiSL Institute of Technology, Coimbatore, India
[2,3,4,5] Students, Department of Mechanical Engineering, KGiSL Institute of Technology, Coimbatore, India

---***---

Abstract -Modern manufactures are seeking to remain competitive in the market by relying on their manufacturing engineers and production personnel effectively set up manufacturing processes for new products. The focus of our present experimental research deals with optimizing the process parameters to find which are effective for the tool. It considers the process cutting parameters such as (spindle speed, feed rate and depth of cut) in turning operation. Experiments are designed and conducted based on changing the various process parameters. And as a result of that, optimized factors are obtained to get effective improved tool life, minimized machining time, acceptable surface roughness, and increased material removal rate.

Key Words: **Cutting parameters, Surface roughness, Optimize, machining time, Turning, Tool life, and Material removal rate**

1. INTRODUCTION

Machining is one of the widest spread metal machining process in mechanical manufacturing industry. The goal of changing the geometry of raw material in order to form mechanical parts can be met by putting material together. Conventional machining is one most important material removal methods. Machining is a part of the manufacture all most all metal products. In turning, higher values of cutting parameter offered opportunities for increasing productivity but it also involves greater risk of deterioration in surface quality and tool life. Turning operation is very important material removal process in modern industry. At least one fifth of all applications in metal cutting are turning operations.

1.1Literature Review

The selection of machining parameters for a turning operation is a very important task in order to accomplish high performance. By high performance, we mean good machinability, better surface finish, lesser rate of tool wear, higher material removal rate, faster rate of production etc. [1] The surface finish of a product is usually measured in terms of a parameter known as surface roughness. It is considered as an index of product quality [2]

In order to achieve desired results, optimization is needed. Optimization is the science of getting most excellent results subjected to several resource constraints. In the present world scenario, optimization is of utmost importance for organizations and researchers to meet the growing demand for improved product quality along with lesser production costs and faster rates of production [3]Carbide tools find common use in the metal cutting industry due to their ability to machine at elevated temperatures and higher speeds Coated carbide tools are found to perform better than uncoated ones [4].Tool wear is an inherent occurrence in every conventional machining process. Bin Halim said that the tool wear is analogous to the gradual wear of the tip of a pencil [5].

1.2 TURNING OPERATION

Turning is one of the most common of metal cutting operations. In turning, a workpiece is rotated about its axis as single-point cutting tools are fed into it, shearing away unwanted material and creating the desired part. Turning can occur on both external and internal surfaces to produce an axially-symmetrical contoured part.

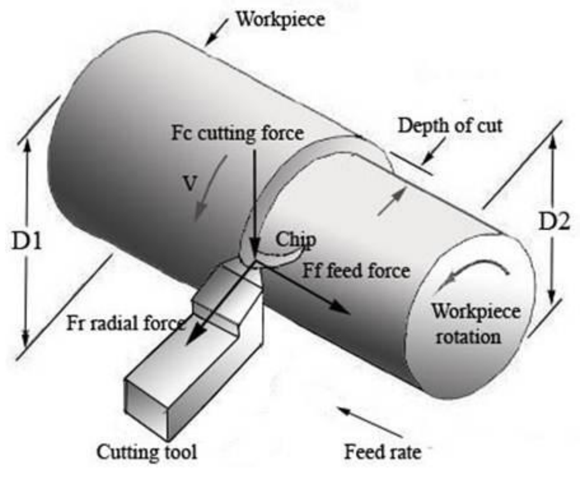

Fig -1: Turning operation

1.3 Cutting Parameters

In turning, the speed and motion of the cutting tool is specified through several parameters. These parameters are selected for each operation based upon the workpiece material, tool material, tool size, and more.

- **Cutting feed -** The distance that the cutting tool or workpiece advances during one revolution of the spindle, measured in inches per revolution (IPR). In some operations the tool feeds into the workpiece and in others the workpiece feeds into the tool. For a multi-point tool, the cutting feed is also equal to the feed per tooth, measured in inches per tooth (IPT), and multiplied by the number of teeth on the cutting tool.

- **Cutting speed** - The speed of the workpiece surface relative to the edge of the cutting tool during a cut, measured in surface feet per minute (SFM).
- **Spindle speed** - The rotational speed of the spindle and the workpiece in revolutions per minute (RPM). The spindle speed is equal to the cutting speed divided by the circumference of the workpiece where the cut is being made. In order to maintain a constant cutting speed, the spindle speed must vary based on the diameter of the cut. If the spindle speed is held constant, then the cutting speed will vary.
- **Feed rate** - The speed of the cutting tool's movement relative to the workpiece as the tool makes a cut. The feed rate is measured in inches per minute (IPM) and is the product of the cutting feed in inches per revolution (IPR) and the spindle speed in revolutions per minute (RPM).
- **Depth of cut** - It is the total amount of metal removed per pass of the cutting tool. It is expressed in mm. It can vary and depending upon the type of tool and work material. Mathematically, it is half of difference of diameters.

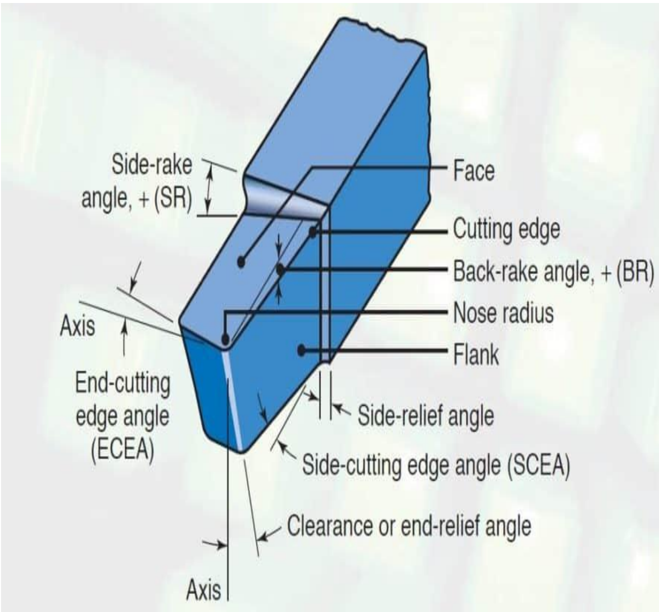

Fig -2: Tool geometry

2. Experimental Setup

The analysis is done is by changing & comparing the various process parameters to find the optimum parameters so that we can improve the tool life, surface finish, and we can reduce machining time. Here we use three various approaches for comparison

1. The Speed and Depth of cut is kept constant by increasing the Feed
2. The Feed and Speed is kept constant by increasing Depth of cut
3. The Feed and Depth is kept constant by increasing Speed

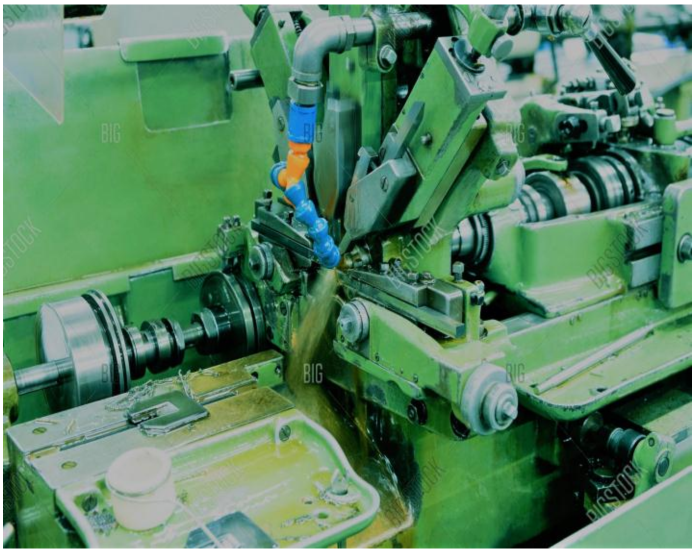

Fig -3: Experiment Machine

Table 1

S. No.	F (mm /rev)	N (rpm)	d (mm)	Cutting speed (m/min)	Surface Finish (Ra)	Machining Time (min)	Tool life (min)	MRR (m^3 /s)
1	0.014	3800	0.25	23.87	0.00024	0.338	14.41	0.0833
2	0.014	3850	0.30	24.17	0.00024	0.333	14.40	0.10
3	0.014	3900	0.35	24.49	0.00024	0.327	14.46	0.0979
4	0.014	3950	0.40	24.80	0.00024	0.325	14.46	0.105
5	0.014	4000	0.45	25.12	0.00024	0.321	14.45	0.111
6	0.014	3800	0.25	23.87	0.00024	0.338	14.44	0.083
7	0.015	3850	0.25	24.17	0.00028	0.311	14.46	0.090
8	0.016	3900	0.25	24.49	0.00032	0.288	14.45	0.097
9	0.017	3950	0.25	24.80	0.00036	0.268	14.46	0.105
10	0.018	4000	0.25	25.12	0.00040	0.25	14.46	0.113
11	0.014	3800	0.25	23.87	0.00024	0.338	14.43	0.0833
12	0.015	3800	0.30	23.87	0.00028	0.315	14.45	0.107
13	0.016	3800	0.35	23.87	0.00031	0.296	14.42	0.133
14	0.017	3800	0.4	23.87	0.00036	0.278	14.40	0.162
15	0.018	3800	0.45	23.87	0.00040	0.263	14.41	0.192

2.1 Calculation

Speed (N) = 4000 rpm
Depth of cut (d) = 0.45 mm
Feed = 0.014 mm/rev

CUTTING SPEED (V)

V = π D N/1000
Where,
Dia of the component (D) = 2 mm
Speed (N) = 4000 rpm
V = π *2*4000/1000

V = 25.12 m/min

SURFACE FINISH (h)

h = $f^2/8r$
Where,
Feed (f) = 0.014 mm/rev
Nose radius (r) = 0.1 mm

h = (0.014)^2/8*0.1

h = 0.00024

MACHINING TIME (T_m)

T_m = L/f*N
Where
Length of the rod (L) = 18 mm
Feed (f) = 0.014 mm/rev
Speed (N) = 4000 rpm
T_m = 18/0.014*4000

T_m = 0.321 min

MATERIAL REMOVAL RATE (MRR)

MRR = V*f*d
Cutting speed (V) = 25.12 m/min
Feed (f) = 0.014 mm/rev
Depth of cut (d) = 0.45 mm
MRR = 25.12*0.014*0.45

MRR = 0.111 m^3/sec

TOOL LIFE (T)

(VT = C
Where
Cutting speed (V) = 24.80 m/min
Time (T) = 180 min
C is constant
C = (24.80) $(180)^{0.25}$

C = 90.8
(VT^n) = C
Here V = 25.12 m/min
(25.12)$(T)^{0.25}$ = 90.8

T = 14.45 min

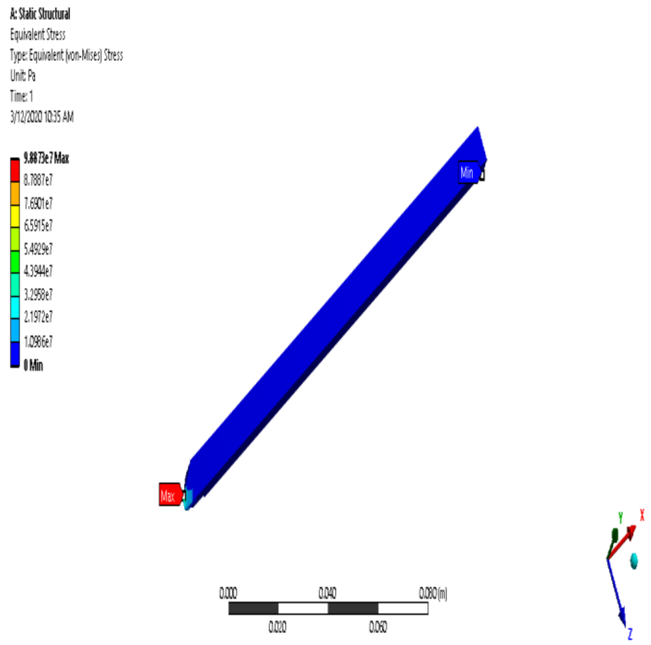

Fig. 3: Carbide tool at Depth of cut 0.25 mm

2.2 ANSYS CALCULATION

Properties

Yield s Strength = 0.31 Gpa
Youngs Modulus = 600 Gpa
Density =15.63 g/cm^3
Equivalent Stength = 0.098 Gpa(From the ansys data)

Factor of safety (n)

FOS(n) =Yield Strength/Equivalent Strength

FOS(n) = 0.31/0.098

FOS(n) = 3.137

Cutting force(Fc)

For Feed(F) = 0.014,

Speed(N) = 3800,

d = 0.25,

Cutting force(F_c)= (3800)*($f^{0.85}$)*($d^{0.98}$)

F = (3800)*($0.014^{0.85}$)*($0.25^{0.98}$)

F_c = 20 N

2.3 Effective solution

From the above analysis we take by varying the Speed (4000 rpm), Feed (0.018) and Depth of cut (0.25) is the best optimum parameter for this cutting tool to be effective.

- Reduced machining time (6 sec).
- Effective surface finish (0.0040 Ra).
- Effective cutting speed (25.14 m/min).
- Effective tool life (14.468 min).

3. CONCLUSIONS

In this work carbon steel is taken as a work material and tungsten carbide as tool material. By varying the different parameters like depth of cut, speed and feed at different conditions the tool life, surface finish, machining time and other parameters were calculated. The optimized results showed that the combined effective surface finish (0.0040 Ra), tool life, material removal rate and machining time. The optimized result also indicates the optimized cutting force in Ansys

REFERENCES

[1] Yang W.H. and Tarng Y.S., (1998), "Design optimization of cutting parameters for turning operations," Journal of Materials Processing Technology.

[2] Makadia A.J. and Nunavut J.I., (2013), "Optimization of machining parameters for turning operations based on response surface methodology," Measurement,

[3] Sharma V.K., Murtaza Q. and Garg S.K., (2010), "Response Surface Methodology to Optimization of C.N.C Turning Process," International Journal of Production Technology, **1**(1), pp. 13-31

[4] Noordin M.Y., Venkatesh V.C., Chan C.L. and Abdullah A., (2001), "Performance evaluation of cemented carbide tools in turning AISI 1010 steel," Journal of Materials Processing Technology, **116**(1) pp. 16–21.

[5] Halim, M.S.B., (2008), "Tool Wear Characterization of Carbide Cutting Tool Insert in a Single Point Turning Operation of AISI D2 Steel," B.Tech. Thesis, Department of Manufacturing Engineering, Universiti Teknikal Malaysia Mekala.

BIOGRAPHIES

K. Venkataraman
Associate Professor, Department of Mechanical Engineering,
KGiSL Institute of Technology.

K. Amrish
B.E Mechanical Engineering,
KGiSL Institute of Technology.

K. Hariprasad
B.E Mechanical Engineering,
KGiSL Institute of Technology.

R.P. Jithvin
B.E Mechanical Engineering,
KGiSL Institute of Technology.

S. Pranavamoorthi
B.E Mechanical Engineering,
KGiSL Institute of Technology.