International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.2, Issue No.7, pp : 626-630 1 July 2013

Comparative Performance Analysis of Insert Geometry for Turning Operation on CNC Turning Centre

Virender Singh[1], Tasmeem Ahmad Khan[2]

[1]PG student, Mechanical Engineering, Al- Falah School of Engineering & Technology, Faridabad, India.

[2] Professor, Department of Mechanical Engineering, Al- Falah School of Engineering & Technology, Faridabad, India.

[1]virendergurau@gmail.com

Abstract— ***In this research work the effect and optimization of machining parameters on surface roughness and material removal rate (MRR) in a turning operation are investigated by using the Taguchi method. The experimental studies are conducted under varying cutting parameters including cutting speed, feed rate, depth of cut and cutting nose radius of insert. An L9 orthogonal array, the signal-to-noise (S/N) ratio are employed to the study the performance characteristics in the turning of AISI 1045 Mild steel using WNMG331RP, WNMG332RP and WNMG333RP carbide inserts on CNC turning center. The conclusions revealed that the feed rate and nose radius were the most influential factors on the surface roughness and Material Removal Rate (MRR) in CNC turning process is greatly influenced by depth of cut followed by cutting speed. For simultaneous optimization of Surface roughness (R_a) and material removal rate (MRR) depth of cut is the most significant parameter affecting the performance followed by the nose radius.***

Keywords—Inserts, Taguchi, S/N ratio, Mild steel, MRR, Surface Roughness, Nose radius.

I. INTRODUCTION

Tool geometry parameters play an important role in determining the overall machining performance, including cutting forces, tool wear, surface finish, chip formation and chip breaking. The importance of optimizing tool geometry has been highlighted recently to be of enormous economic significance in maximizing tool life in machining. Over the past few decades, many investigations have been made to study the important effects of tool geometry, including tool inclination angle, on machining performance. It is well known that the tool inclination angle is a major factor in determining the chip flow direction in machining and has been used in various mathematical models of chip flow. In finish turning process, a well-controlled tool inclination angle can effectively guide the chip to flow in a desired direction to reduce the risk of chip entanglement and protect the machined surface, thus achieving effective chip control in automated machining systems.

Several angles are important when introducing the cutting tool's edge into a rotating work piece. These angles include the angle of inclination, rake angle, effective rake angle, lead or entry angle, and tool nose radius.

On the strength of the exhaustive review of work done by previous researchers [1- 12], it is found that a very little work has been found in use of inserts with different nose radius as a parameter for optimizing the surface properties.

The study demonstrates detailed methodology of the proposed optimization technique which is based on Taguchi method; and ranks the parameters namely cutting speed, feed, depth of cut and nose radius of inserts through S/N ratio. MRR of a turned product along with surface finish of work piece have been optimized.

II. MATERIALS AND METHODS

A. *CNC Turning Center*

ACE Designers Ltd. make CNC turning centre with Fanuc Oi-mate-TD controller is used to carry out the experimentation.

TABLE I

SPECIFICATIONS OF CNC TURNING CENTER

Max. Turning diameter	190 mm
Max. Turning length	200 mm
Chuck Size	135 mm
Spindle Speed	50- 4000 rpm
Spindle motor power	5.5 kW/ 3.7 kW

B. *Selection of Cutting Tools*

The cutting tool selected for present work is carbide inserts. The inserts (ANSI coding) used in present work are WNMG 331

International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.2, Issue No.7, pp : 626-630 1 July 2013

RP (a), WNMG 332 RP (b) and WNMG 333 RP (c).

The tool geometry of the inserts is as follows:

Insert WNMG 331 RP – Trigon Shape, Clearance angle 0°, Inscribed Circle size- 9.5mm, Thickness- 5mm, Nose radius- 0.4mm.

Insert WNMG 332 RP – Trigon Shape, Clearance angle 0°, Inscribed Circle size- 9.5mm, Thickness- 5mm, Nose radius- 0.8mm.

Insert WNMG 333 RP – Trigon Shape, Clearance angle 0°, Inscribed Circle size- 9.5mm, Thickness- 5mm, Nose radius- 1.2mm.

C. *Selection of Work piece Material*

The work piece material used for current work is AISI 1045 Mild Steel circular bars (ϕ 20mm x 50mm).

C. *Process Parameters and Levels used in the Experiment*

The machining process on CNC lathe is programmed by cutting speed, feed, depth of cut and insert nose radius. The parameters and levels used in the experiment are shown in Table II.

TABLE II

PROCESS PARAMETERS AND LEVELS

Levels	Variables			
	Cutting Speed, m/min (A)	Feed, mm/rev (B)	Depth of cut, mm (C)	Nose radius, mm (D)
Level 1	100	0.25	1	0.4
Level 2	150	0.3	1.5	0.8
Level 3	200	0.35	2	1.2

C. *Design Matrix*

In the present work there are three levels and four factors. According to Taguchi approach L9 has been selected. So, according to Taguchi L9 array design matrix of variables are formed.

TABLE III

DESIGN MATRIX OF VARIABLES

Experiment	Cutting Speed, m/min (A)	Feed, mm/rev (B)	Depth of cut, mm (C)	Nose radius, mm (D)
1	100	0.25	1	0.4
2	100	0.3	1.5	0.8
3	100	0.35	2	1.2
4	150	0.25	1.5	1.2
5	150	0.3	2	0.4
6	150	0.35	1	0.8
7	200	0.25	2	0.8
8	200	0.3	1	1.2
9	200	0.35	1.5	0.4

III. RESULTS AND DISCUSSIONS

A. *Material Removal Rate (MRR)*

Initial and final weights of work pieces are noted using digital weighing machine. Machining time is also recorded. Following equations are used to calculate the response Material Removal Rate (MRR):

$$\text{MRR}(\text{mm}^3/\text{min}) = \frac{[\text{Initial Weight of workpiece(gm)} - \text{Final Weight of workpiece(gm)}]}{\text{Density}(\text{gm/mm}^3) \times \text{Machining Time (min)}}$$

The density of the mild steel is taken as 7.79345 x 10^{-3} g/mm^3.

B. *Surface Roughness (R_a)*

Roughness measurement has been done using a portable stylus-type profilometer, Mitutoyo- Surftest SJ- 201P/M. The evaluation length of 2.5 mm is used to measure response R_a value in µm.

C. *Response Table*

Response table for the experimental design matrix is shown in table IV.

TABLE IV

RESPONSE TABLE OF R_a AND MRR

Exp.	A	B	C	D	R_a	MRR
1	100	0.25	1	0.4	2.5	5389.005
2	100	0.3	1.5	0.8	2.9	7931.61
3	100	0.35	2	1.2	3.8	10672.013
4	150	0.25	1.5	1.2	2.99	9036.186
5	150	0.3	2	0.4	3.27	12006.67
6	150	0.35	1	0.8	3.06	5413.576
7	200	0.25	2	0.8	3.17	12635.827
8	200	0.3	1	1.2	3.52	6552.675
9	200	0.35	1.5	0.4	3.08	9333.248

D. *Analysis of Single Response Stage*

The optimal settings and the predicted optimal values for surface roughness and MRR are determined individually by Taguchi's approach. Table VII shows these individual optimal values and its corresponding settings of the process parameters for the specified performance characteristics. It is observed that the feed is most significantly influences the R_a followed by nose radius. In case of MRR, depth of cut is the most significant parameter followed by cutting speed.

TABLE V

MEANS OF R_a AT DIFFERENT LEVELS

Levels	Mean value of R_a			
	Cutting Speed, m/min (A)	Feed, mm/rev (B)	Depth of cut, mm (C)	Nose radius, mm (D)
Level 1	3.06	2.88	3.02	2.95
Level 2	3.10	3.23	3.21	3.04
Level 3	3.27	3.31	3.41	3.43

TABLE VI

MEANS OF MRR AT DIFFERENT LEVELS

Levels	Mean value of MRR			
	Cutting Speed, m/min (A)	Feed, mm/rev (B)	Depth of cut, mm (C)	Nose radius, mm (D)
Level 1	7997.54	9020.34	5785.08	8909.64
Level 2	8818.81	8830.32	8767.01	8660.34
Level 3	9507.25	8472.94	11771.5	8553.62

TABLE VII

INDIVIDUAL OPTIMAL VALUES AND CORRESPONDING SETTING OF PROCESS PARAMETERS

Performance characteristics	Optimal parameter level	Optimum level
R_a (μm)	A1-B1-C1-D1	2.5
MRR (mm^3/min)	A3-B1-C3-D1	12743.25

F. *Analysis of Multi- response stage*

The S/N ratio considers both the mean and the variability. In the present work, a multi- response methodology based on Taguchi technique and Utility concept is used for optimizing the multi-responses (Ra and MRR). Taguchi proposed many different possible S/N ratios to obtain the optimum parameters setting. Two of them are selected for the present work. Those are, Smaller the better type S/N ratio for R_a

$$[\eta_1] = -10\log_{10}\left[R_a^2\right];$$

Larger the better S/N ratio for MRR

$$[\eta_2] = -10\log_{10}\left[\frac{1}{MRR^2}\right]$$

From the utility concept, the multi-response S/N ratio of the overall utility value is given by

$$\eta_{obs} = W_1\eta_1 + W_2\eta_2$$

Where W_1 & W_2 are the weights assigned to the R_a and MRR. Assignment of weights to the performance characteristics are based on experience of engineers, customer's requirements and their priorities. In the present work equal importance is given for both Ra and MRR. Therefore W_1 & W_2 = 0.5.

The optimal combination of process parameters (A3-B1-C3-D1) for simultaneous optimization of Surface roughness (R_a) and material removal rate (MRR) is obtained by the mean values of the multi-response S/N ratio of the overall utility value are shown in Table IX. According to the Table IX for the results of S/N ratio multiple performance characteristics, depth of cut is the most significant parameter affecting the performance followed by the nose radius. The percent contribution of the feed rate is lower and the cutting speed is much lower.

TABLE VIII

DESIGN MATRIX WITH MULTI- RESPONSE S/N RATIO

Exp.	A	B	C	D	η_1 for R_a	η_2 for MRR	η_{obs}
1	100	0.25	1	0.4	-7.96	74.63	33.34
2	100	0.3	1.5	0.8	-9.25	77.99	34.37
3	100	0.35	2	1.2	-11.6	80.56	34.48
4	150	0.25	1.5	1.2	-9.51	79.12	34.81
5	150	0.3	2	0.4	-10.29	81.59	35.65
6	150	0.35	1	0.8	-9.71	74.67	32.48
7	200	0.25	2	0.8	-10.02	82.03	36.01
8	200	0.3	1	1.2	-10.93	76.33	32.7
9	200	0.35	1.5	0.4	-9.77	79.4	34.81

G. *Interpretation of Plots*

The data is plot and developed. These results are analyzed using S/N ratio for the purpose of identifying the significant factors which affect the surface roughness and material removal rate. The plots show the variation of individual response with the four parameters i.e. cutting speed, feed, depth of cut and nose radius separately. In the plots, the x-axis indicates the value of each process parameter at three level and y-axis the response value. Figure 1 shows the main effect plot for MRR. It is observed that the maximum MRR is obtained at the 200 m/min of cutting speed, 0.25mm/rev of feed, 2 mm depth of cut and 0.8 mm nose radius. Figure 2 shows the main effect plot for surface roughness. It is observed that the maximum surface finish or minimum roughness is obtained at the 100 m/min of cutting speed, 0.25mm/rev of feed, 1 mm depth of cut and 0.4 mm nose radius. Figure 3 shows the optimum levels of process parameters for the multi-response optimization are thus determined to be 200 m/min of cutting speed, 0.25mm/rev of feed, 2 mm depth of cut and 0.4 mm nose radius.

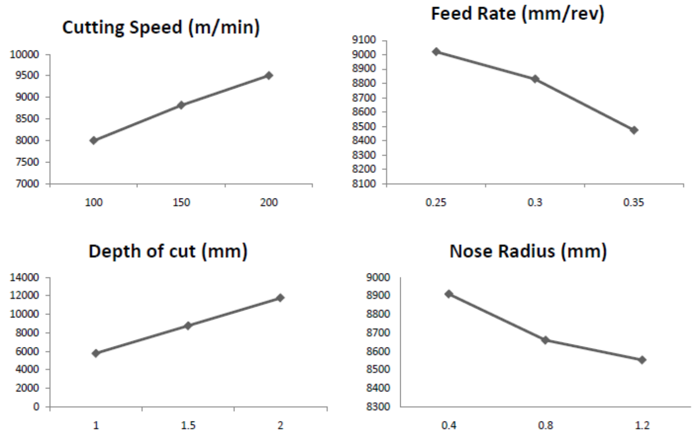

Fig. 1 Response Graph for MRR

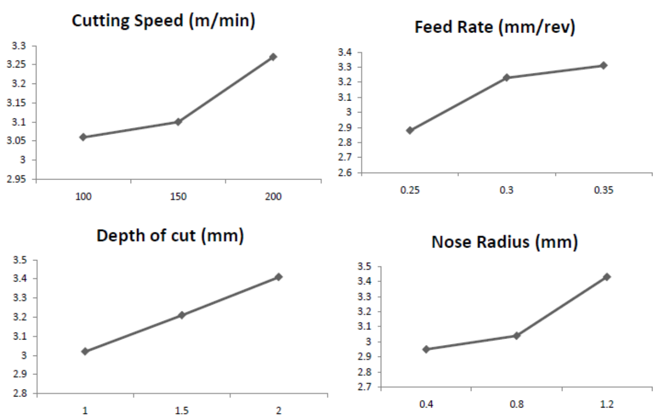

Fig. 2 Response Graph for R_a

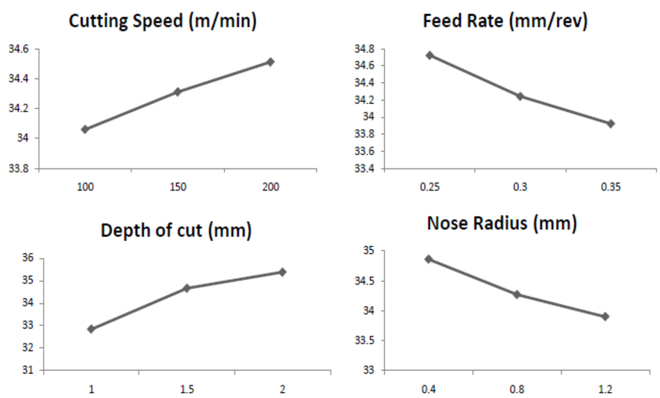

Fig. 3 Multi- Response S/N Ratio Graph

IV. CONCLUSIONS

Turning tests were performed on AISI 1045 mild steel work piece using three different carbide insert of varying nose radius. The influences of cutting speed, feed rate, depth of cut and nose radius were investigated on the machined surface roughness and Material Removal Rate (MRR). Based on the results obtained, the following conclusions have been drawn:

- The analysis of the experimental observations highlights that MRR in CNC turning process is greatly influenced by depth of cut followed by cutting speed.
- It is observed that the feed is most significantly influences the R_a followed by nose radius.
- For simultaneous optimization of Surface roughness (R_a) and material removal rate (MRR) depth of cut is the most significant parameter affecting the performance followed by the nose radius.

REFERENCES

i. *Ahmet Hascalik and Ulas Cavdas; Optimization of turning parameters for surface roughness and tool life based on the Taguchi method; The International Journal of Advanced Manufacturing Technology; September 2008, Volume 38, Issue 9-10, pp 896-903*

ii. *Chorng-Jyh Tzeng, Yu-Hsin Lin, Yung-Kuang Yang and Ming-Chang Jeng; Optimization of turning operations with multiple performance characteristics using the Taguchi method and Grey relational analysis; Journal of Materials Processing Technology; Volume 209, Issue 6, 19 March 2009, Pages 2753–2759*

iii. *Tian-Syung Lan and Ming-Yung Wang; Competitive parameter optimization of multi-quality CNC turning; The International Journal of Advanced Manufacturing Technology; April 2009, Volume 41, Issue 7-8, pp 820-826*

iv. *Zhang Xueping, Gao Erwei and C. Richard Liu; Optimization of process parameter of residual stresses for hard turned surfaces; Journal of Materials Processing Technology; Volume 209, Issue 9, 1 May 2009, Pages 4286–4291*

v. *Süleyman Neşeli, Süleyman Yaldız and Erol Türkeş; Optimization of tool geometry parameters for turning operations based on the response surface methodology; Measurement; Volume 44, Issue 3, March 2011, Pages 580–587*

vi. *Anil Gupta, Hari Singh and Aman Aggarwal; Taguchi-fuzzy multi output optimization (MOO) in high speed CNC turning of AISI P-20 tool steel; Expert Systems with Applications; Volume 38, Issue 6, June 2011, Pages 6822–6828*

vii. *Raju Shrihari Pawade and Suhas S. Joshi; Multi-objective optimization of surface roughness and cutting forces in high-speed turning of Inconel 718 using Taguchi grey relational analysis (TGRA); The International Journal of Advanced Manufacturing Technology; September 2011, Volume 56, Issue 1-4, pp 47-62*

viii. *M. Kaladhar, K. Venkata Subbaiah, Ch. Srinivasa Rao and K. Narayana Rao; Optimization of process parameters in turning of AISI202 austenitic stainless steel; Asian Research Publishing Network (ARPN)*

ix. *N. Muthukrishnan and J. Paulo Davim; Optimization of machining parameters of Al/SiC-MMC with ANOVA and ANN analysis; Journal of Materials Processing Technology; Volume 209, Issue 1, 1 January 2009, Pages 225–232*

x. *Ajay Mishra and Anshul Gangele; Application of Taguchi Method in Optimization of Tool Flank Wear Width in Turning Operation of AISI 1045 Steel; International Institute for Science, Technology & Education; Vol 2, No 8 (2012)*

xi. *J. Srinivas, R. Giri and Seung-Han Yang; Optimization of multi-pass turning using particle swarm intelligence; The International Journal of Advanced Manufacturing Technology; January 2009, Volume 40, Issue 1-2, pp 56-66*

xii. *W.H. Yang and Y.S. Tarng; Design optimization of cutting parameters for turning operations based on the Taguchi method; Journal of Materials Processing Technology; Volume 84, Issues 1–3, 1 December 1998, Pages 122–129*