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Identification of Optimum Parameters for MRR on Hard Turning of AISI H13 Steel by using TAGUCHI ANALYSIS and ANOVA

B.R. Karthik[1], S. Sivakiran[2]

[1]UG Student, Dept. of Mechanical Engineering, SKIT, Srikalahasti,
[2] Lecture, Dept. of Mechanical Engineering, SKIT, Srikalahasti,
Email: kiran.siyarams@gmail.com

Abstract *- The main objective of this present work is to identify the optimal parameters combination, for obtaining maximum material removal rate of AISI H13 steel by using tungsten carbide tool. The Taguchi method is adopted to analyze the effect of each turning process parameter on the material removal rate.Cutting speed, Feed rate, and Depth of cut, with three levels are considered as input parameters and Material removal rate is considered as a response parameter. Total Nine combinations of experiments were conducted, MINITAB 16 software is used to analyze the experimental results for estimating optimum parameter combination to identify maximum material removal rate of hard turning.*

Key words: *Hard turning, AISI H13 steel, tungsten carbide tool, Taguchi method, Regression, ANOVA, material removal rate.*

I. INTRODUCTION

The working principle of a lathe is to remove the excess material in the form of chips, form a rotating work piece held between two centers, with the help of a cutting tool fed against the work piece.

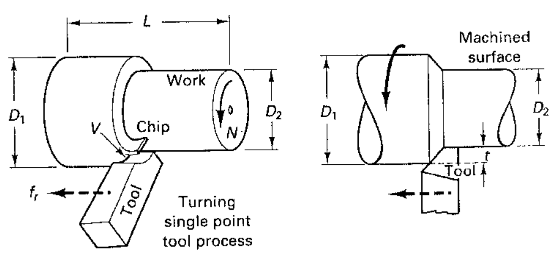

Fig 1. Operations of Lathe

CNC turning machine

CNC refers to a computer that is joined to the NC machine to make the machine versatile. Information can be stored in a memory bank. The program is read from a storage medium such as the punched tape and retrieved to the memory of the CNC computer. Some CNC machines have a magnetic medium (tape or disk) for storing programs. This gives more flexibility for editing or saving CNC programs.

II. LITERATURE RIVIEW

Breno Antunes Gonzaga et al (2003), [1] This paper is focused on continuous dry turning of annealed AISI H13 hot work die steel (230 HV) employing coated carbide tools, aiming to identify the tool material and cutting parameters which will promote longest tool life, highest metal removal rate and best work piece surface finish. The experimental work was carried out using the following cutting conditions: cutting speed from 100 to 300 m/min, feed rate from 0.3 to 0.5 mm/rot and a constant depth of cut of 1 mm. The results indicated that, in general, best performance was obtained using intermediate cutting speed and feed rate, thus leading to longer tool life and maximum metal removal.

Tugrulo zel et al (2004), [2] This paper is focused on the effects of work piece hardness, cutting edge geometry, feed rate and cutting speed on surface roughness are statistically significant. The effects of two factor interactions of the edge geometry and the work piece hardness, the edge geometry and the feed rate, and the cutting speed and feed rate also appeared to be important. Especially honed edge geometry and lower work piece surface hardness resulted in better surface roughness. Cutting-edge geometry, work piece hardness and cutting speed are found to be affecting force components. The lower work piece surface hardness and honed edge geometry resulted in lower tangential and radial forces.

Hamdi aouici et al (2011), [3] the present study, aims to investigate, under turning conditions of hardened AISI H11 (X38CrMoV5-1), the effects of cutting parameters on flank wear (VB) and surface roughness (Ra) using CBN tool. The machining experiments are conducted based on the response surface methodology (RSM). Combined effects of three cutting parameters, namely cutting speed, feed rate and cutting time on the two performance outputs (i.e. VB and Ra), are explored employing the analysis of variance (ANOVA). The results show that the flank wear is influenced principally by the cutting time and in the second level by the cutting speed. Also, it is that indicated that the feed rate is the dominant factor affecting work piece surface roughness.

III. DESIGN OF EXPERIMENTS

SELECTION OF ORTHOGONA ARRAY

The experiment designs were done based on the Taguchi Method. Genichi Taguchi a Japanese scientist developed a technique based on Orthogonal Array of Experiments. This technique has been widely used in different fields of engineering to optimize the process parameters. The control factors considered for the study are Cutting speed, Feed rate, and Depth of cut. Three levels for each control factor will be used. Based on the number of control factors and their levels, L9 orthogonal array was selected. Table-1 represent various levels of control factors and Table-2 represents experimental plan with assigned values.

Table - 1 Levels of various control factors

	Level		
Control Factors	**I**	**II**	**III**
Cutting speed	100	150	200
Feed rate	0.1	0.15	0.2
Depth of cut	0.2	0.25	0.3

Table - 2 Matrix of experiments with assigned values

S. NO	CUTTING SPEED	FEED RATE	DEPTH OF CUT
1	100	0.1	0.2
2	100	0.15	0.25
3	100	0.2	0.3
4	150	0.1	0.25
5	150	0.15	0.3
6	150	0.2	0.2
7	200	0.1	0.3
8	200	0.15	0.2
9	200	0.2	0.25

SELECTION OF MATERIAL

The work piece material used in this study is AISI H13 tool steel and its chemical composition is given in Table-3.

Table 3 Chemical Composition of AISI H13 Steel

S.No	Element	%
1	c	0.36
2	cr	4.9
3	v	0.9
4	mo	1.4
5	si	1.04
6	s	0.03
7	p	0.03

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EXPERIMENTAL WORK

The experiments were performed on SUPER JOBBER 500 CNC Lathe machine, shown in Figure-2.

Fig 2. SUPER JOBBER 500 CNC Lathe machine

MRR is calculated by using the formulae,

$$MRR = \frac{(\pi \div 4) X \left(D^2 - d^2\right) x \, Lenth}{Time \, in \, \text{min}}$$

Where, D = initial diameter in mm
d = final diameter in mm

IV. RESULTS AND DISCUSSION

The results obtained are analyzed using S/N Ratios, Response table and Response Graphs with the help of Minitab-16 software. Minitab-16 is a computer program designed to perform basic and advanced statistical functions. In this experimental results are analyzed and regression equation is developed to predict the MRR.

Table -4 Material Removal Rate (MRR)

Run	CS (m/min)	FEED (m/rev)	DOC (mm)	TIME (min)	MRR (mm^3/min)
1	100	0.1	0.2	4.55	1023.05
2	100	0.15	0.25	3.20	1809.20
3	100	0.2	0.3	2.82	2976.11
4	150	0.1	0.25	3.15	1815.30
5	150	0.15	0.3	2.12	3216.54
6	150	0.2	0.2	1.41	3205.76
7	200	0.1	0.3	2.29	2943.80
8	200	0.15	0.2	1.42	3146.68
9	200	0.2	0.25	1.18	4708.64

SELECTION OF OPTIMUM PARAMETER OMBINATION

Table - 5 Response table for Means (MRR)

Level	CUTTING SPEED (m/min)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)
1	1936	1927	2458
2	2746	2724	2778
3	3600	3630	3045
Delta	1664	1703	587
Rank	2	1	3

Table - 6 Response table for S/N Ratios (MRR) (Larger is better)

Level	CUTTING SPEED (m/min)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)
1	64.94	64.92	66.76

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2	68.48	68.42	67.93
3	70.93	71.02	69.67
Delta	5.99	6.10	2.91
Rank	2	1	3

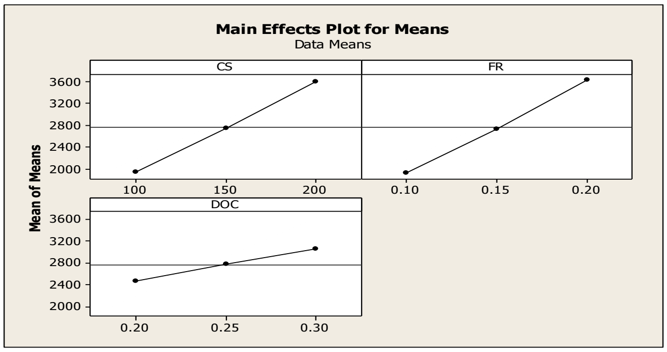

Fig 3, Response Graphs for Means (MRR)

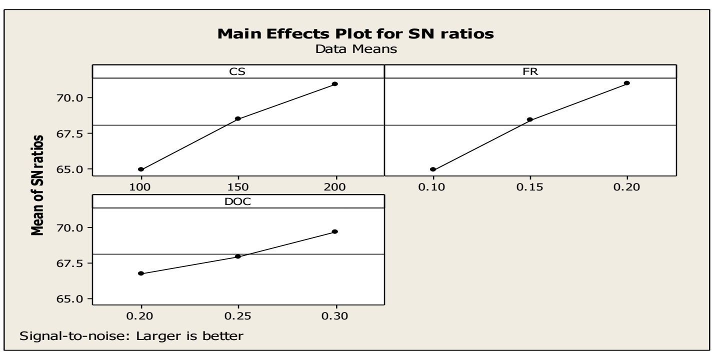

Fig 4, Response Graphs for S/N ratio (MRR)

Table - 7 Optimum combination for MRR

CONTROL FACTORS	OPTIMUM LEVEL	RANK
CUTTING SPEED	200	2
FEED RATE	0.2	1
DEPTH OF CUT	0.3	3

DEVELOPMENT OF REGRESSION EQUATION

MRR = - 3756 + 16.6 CS + 17028 F + 5870 DOC

With the help of the regression equation the predicted values of MRR is estimated and their deviation is tabulated. It is observed that the predicted values are closer to experimental values as in Table-8 and shown in graphical form in figure-5.

Table -8 Comparison of Experimental and Predicted values

Exp. No.	MRR mm^3/min		
	Experimental	Predicted	Deviation
1	1023.05	980.8	42.25
2	1809.20	1925.7	-116.5
3	2976.11	3070.6	-94.49
4	1815.30	1904.3	-89
5	3216.54	3049.2	167.34
6	3205.76	3070.6	135.16
7	2943.80	3027.8	-84
8	3146.68	3292.2	-145.52
9	4708.64	4437.1	270.94

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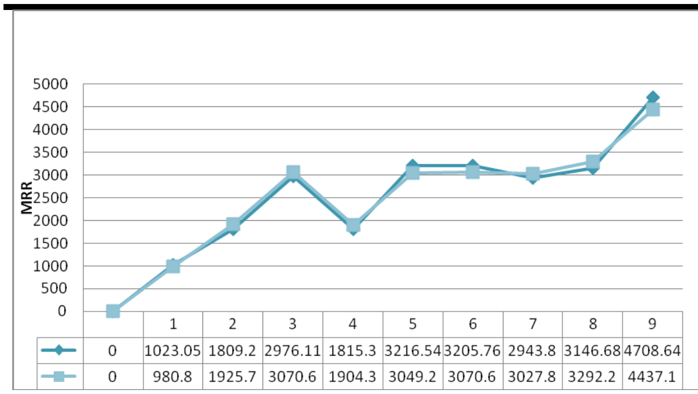

Fig 5. Graph for predicted and experimental values of MRR

V. ANOVA

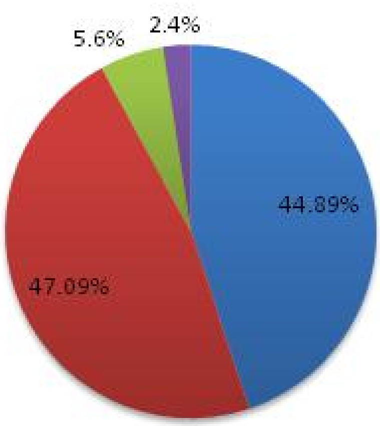

Fig 6, Percentage of contribution

The maximum percentage of contribution in feed rate is **47.09%,** next is cutting speed is about **44.89%,** Depth if cut is about **5.6%** and also error is **2.4%** are obtained by ANOVA calculations.

VI. CONCLUSION

Based on the results and discussion the following conclusions are drawn.

- It is observed that the effect of feed is maximum MRR followed by cutting speed and depth of cut has least effect on MRR.
- The optimum parameters are cutting speed 200 m/min, feed rate 0.2 mm/rev and depth of cut 0.3 mm.
- The parameters are ranked as 1, 2, 3 for feed rate, cutting speed, depth of cut.
- The developed regression equation is used to predict the MRR with 4.59% error.
- The developed regression equation is used to predict the MRR with 95.41% accuracy
- The maximum % of contribution in feed rate is 47.09%, cutting speed is about 44.89%, Depth if cut is about 5.6% and also error is 2.4% are obtained by ANOVA calculations.

VII. FUTURE WORK

- The work can be extended by considering the other parameters like different tool materials, coolant on/ off conditions and by changing tool angle, voltage and current levels etc.
- The work may be continued, for machining various materials for finding optimal combination of parameters and also by varying the work materials to find out the best material of the work.
- During the experiment, some noise factors were ignored like temperature, vibrations, etc which can be included.
- The present work is carried out using simple CNC machine. The experiment can also be conducted using fully automatic CNC machine.
- The present work is carried out by Taguchi's analysis further this work can be extended by considering any combination of Grey Relational analysis with Taguchi's orthogonal array technique.

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