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Optimization of Cutting Parameters in Rough Turning using Taguchi Method

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Abstract: This paper presents an optimization method of the cutting parameters (cutting speed, depth of cut and feed) in rough turning of EN8 steel to achieve Minimum power consumption and Maximum Material Removal Rate (MRR). The experimental layout was designed based on the Taguchi's L9 (3^4) Orthogonal array technique and analysis of S/N ratio was performed to identify the effect of the cutting parameters on the response variables In this study taguchi method is used to optimize cutting parameters for material removal rate (MRR) and power consumption. main effect plots are generated and analysed to find out relationship between cutting parameter and variables. The detail of experimentation and analysis are given in following context.
Keywords: Taguchi Method, S/N ratio, Orthogonal Array, Power Consumption, MRR

I. INTRODUCTION

Metal cutting is one of the important and widely used manufacturing processes in engineering industries. The metal cutting studies focus on the features of tools, work material composition and mechanical properties, and above all the machine parameter settings that influence the process efficiency and output quality characteristics (or responses). A significant improvement in process efficiency can be obtained by process parameter optimization that identifies and determines the regions of critical process control factors leading to desired outputs or responses with acceptable variations ensuring a lower cost of manufacturing.

The primary objective in machining operations is to produce products with low power consumption and high MRR. Machining parameter optimization plays an important role in achieving this goal. Machining parameter optimization operations usually involves the optimal selection of cutting speed, feed rate and depth of cut. Determination of optimal cutting parameters for satisfying certain technological and economical conditions has been one of the most important elements in process planning for metal cutting operations. Examining the economics of machining operations has significant practical importance. Machining is defined as a process, in which the metal is removed in the form of chips by means of single or multiple wedge-shaped cutting· tools.

Spindle speed -The rotational speed of the spindle and the work piece in revolutions per minute (RPM). The spindle speed is nothing but the cutting speed / circumference of the work piece where the cut is done.

Feed rate -The speed of cutting tool' movement relative to the work piece as the tool makes a cut. The feed rate is measured in (mm/min)

Depth of cut -A large depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. For rough turning depth of cut is not matters because it is not dealing with surface quality.

II. RESEARCH METHODOLOGY AND APPROACH

A. Taguchi Method

Taguchi is the developer of the Taguchi method. He proposed that engineering optimization of a processor product should be carried out in a three-step approach, i.e.

1) *System design:* In system design, the engineer applies scientific and engineering knowledge to produce a basic functional design prototype, this design including the product design stage and the process design stage.
2) *Parameter design:* The objective of parameter design is to optimize the settings of the process parameter values for improving quality characteristics and to identify the product parameter values under the optimal process parameter values.
3) *Tolerance design:* Tolerance design is used to determine and analyze tolerances for the optimal settings recommend by the parameter design. Tolerance design is required if the reduced variation obtained by the parameter design does not meet the required performance, and involves tightening tolerances on the product parameters or process parameters for which variations result in a large negative influence on the required product performance.

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III. METHODOLOGY

To carry out experiment, Taguchi design parameter was used and flow chart for Taguchi to Parameter Design, is shown below. Figure provides a brief overview of the process followed by Taguchi's approach to parameter design.

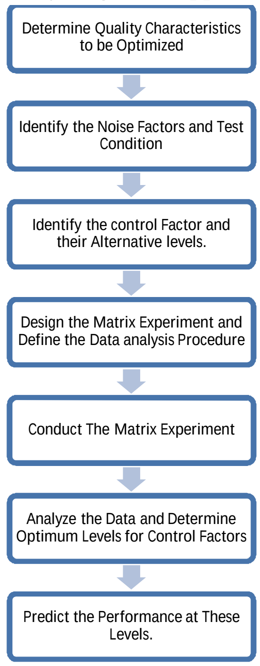

Fig. flow chart of taguchi analysis

IV. ANALYSIS FOR CUTTING PARAMETERS

Following steps are taken to complete the experimental work as per the synopsis.

A. *Orthogonal array experiment*

The experimental layout for the three cutting parameters using the L9 orthogonal array is shown in Table . The L9 orthogonal array has three columns, and three levels. L9 Orthogonal was selected on the basis of number of parameters (3) and levels (3)

B. *Analysis of the S/N ratio-*

Taguchi uses the S/N ratio to measure the quality characteristic deviating from the desired value. The S/N ratio n is defined as,

$$n = -10 \log (\text{M.S.D.}) \qquad (1)$$

Where M.S.D. is the mean-square deviation for the output characteristic. As mentioned earlier, there are three categories of quality characteristics, i.e. the-lower-the-better, the higher-the-better, and the-nominal-the-better. To obtain optimal cutting performance, the-higher-the-better quality characteristic for material removal rate must be taken. The mean-square deviation (M.S.D.) for the-higher-the-better quality characteristic can be expressed as:

$$\text{M.S.D.} = 1/\, m \sum 1/T_i^2 \qquad (2)$$

Where m is the number of tests and Ti is the value of material removal rate and the i th test. On the other hand, the-lower-the-better quality characteristics for surface roughness should be taken for obtaining optimal cutting performance. The M.S.D. for the the-lower-the-better quality characteristic can be expressed as:

$$\text{M.S.D} = 1/m \sum s_i^2 \qquad (3)$$

Where Si is the value of surface roughness for the i th test. Regardless of the-lower-the-better of the higher-the-better quality characteristic, the greater S/N ratio corresponds to the smaller variance of the output characteristic around the desired value. This is to accomplished by separating the total variability of the SIN ratios, which is measured by the sum of the squared deviations from the total mean S/N ratio, into contributions by each of the design parameters and the error. First, the total sum of squared deviations SST from the total mean SIN ratio nm can be calculated as:

$$SS_T = \sum (n_i - n_m)^2 \qquad (4)$$

Where n is the number of experiments in the orthogonal anay and ni is the mean S/N ratio for the i^{th} experiment. The total sum of spared deviations SS_T is decomposed into two sources: the sum of squared deviations SS_d due to each design parameter and the sum of squared error SS_e. The percentage contribution % by each of the design parameters in the total sum of squared deviations SST is a ratio of the sum of squared deviations SSd due to each design parameter to the total sum of squared deviations SS_T.

C. Confirmation Tests

Once the optimal level of the design parameters has been selected, the final step is to predict and verify the improvement of the quality characteristic using the optimal level of the design parameters. The estimated S/N ratio n· using the optimal level of the design parameters can be calculated as,

$$\bar{n} = n_m + \sum_{i=0}^{o} (n_i - n_m)$$

Where n_m is the total mean S/N ratio, ni is the mean S/N ratio at the optimal level, and is the number of the main design parameters that affect the quality characteristic.

V. EXPERIMENTATION

Turning operations are accomplished using a cutting tool; the high forces and temperature during machining create a very harsh environment for the cutting tool. Therefore, MRR is an important index to evaluate cutting performance in a_turning operation. In addition, the purpose of turning operations is to produce a low Power consumption of the machined work piece. Therefore, Power consumption is another important index to evaluate cutting performance. The cutting experiments are carried out in our collage workshop on CNC Turning Centre, Maxturn+ MTAB Automatics Ltd

A. Work Material

1) Material selected is : MILD STEEL(EN8)
2) Yield strength : 280 Mpa
3) Tensile Strength : 550Mpa
4) CNC Speed Range for given material: 320 to 360 m/min
5) Specimen Dimensions: D= 32mm , L=80mm

Fig. work piece before machining

Fig.Cutting Tool

B. Cutting Tool

Turning Tool MVVNN 2020-K 16 WIDAX.
Turning insert VNMG 16 0408.

Symbol	Cutting Parameter	Level 1	Level 2	Level 3
A	Cutting Speed	360	340	320
B	Feed Rate	270	320	365
C	Depth Of Cut	0.8	1.2	1.6

Table – cutting parameters and their levels

Expt.no	Cutting Speed (m/min)	Feed Rate(mm/min)	Depth of cut(mm)
1	360	270	0.8
2	360	320	1.2
3	360	365	1.6
4	340	270	1.2
5	340	320	1.6
6	340	365	0.8
7	320	270	1.6
8	320	320	0.8
9	320	365	1.2

Table. L_9 for cutting parameters

VI. OBSERVATIONS OF EXPERIMENT

The experimental observations are shown in following table

Expt.no	Cutting Speed (m/min)	Feed Rate(mm/min)	Depth of cut(mm)	Initial wt.(gm)	Final wt.(gm)	Machining Time(sec)
1	360	270	0.8	513	501	14
2	360	320	1.2	510	490	13
3	360	365	1.6	511	484	11
4	340	270	1.2	510	492	14
5	340	320	1.6	510	485	13
6	340	365	0.8	511	501	11
7	320	270	1.6	514	488	14
8	320	320	0.8	512	502	13
9	320	365	1.2	513	495	11

Table. Experimental results for MRR

A. *MRR Calculations*

For calculation of MRR the casting bar 80mm length and 28mm diameter is selected. Initial weight of each test bar is taken from load cell. Depth of cut, speed & feed rate are selected as per L9 orthogonal array. Machining is carried out on specified length of material (50mm). Machining time is taken directly from CNC machine. After machining, final weight of each test bar is determined from load cell. Finally MRR is calculated by using formula,

$$MRR = (\text{Initial weight} - \text{Final weight}) / \text{machining time}$$

The S/N ratio n is defined as,

$$S/N = -10 \log (M.S.D.)$$

Where, M.S.D. is the mean-square deviation for the output characteristic. To obtain optimal cutting performance, the-higher -the-better quality characteristic for MRR must be taken. The mean-square deviation (M.S.D.) for the-higher-the-better quality characteristic can be expressed as:

$$MSD = 1/n \sum (1/y^2)$$

calculation for S/N ratio for MRR is shown in Table No.8

Expt.no	Cutting Speed (m/min)	Feed Rate(mm/min)	DOC(mm)	MRR(kg/sec)	S/N ratio
1	360	270	0.8	0.8571	-1.33937
2	360	320	1.2	1.5385	3.74195
3	360	365	1.6	2.4545	7.79926
4	340	270	1.2	1.2857	2.18279
5	340	320	1.6	1.923	5.67959
6	340	365	0.8	0.9091	-0.82777
7	320	270	1.6	1.8571	5.37671
8	320	320	0.8	0.7692	-2.27921
9	320	365	1.2	1.6364	4.27779

Table no. 8 Experimental results for MRR and S/N

Computation of S/N ratio:

S/N= -10 log (M.S.D.)

Where, MSD= $1/n\sum (1/y^2)$

Calculation:

Reading No. I

For MRR,

Initial Weight (gm) =513,

Final Weight (gm) =501,

Machining Time (s) = 14

MRR = (513-501)/12

MRR= 0.8571gm/sec

For S/N Ratio,

S/N= -10 log ($1/1 *[1/0.8571^2]$]

S/N= -1.33937

Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio.

B. Calculation Of Power Consumption-

Power consumption is calculated by using analyzer. Analyzer is connected to stabilizer of the CNC machine using 9 no of probes. Analyzer gives no of parameters such as -current ,voltage ,power consumption, variance , in 3 phases . These readings can be taken for particular time interval . such as 3 sec , 6 sec, 9 sec. for our experiment we have chosen 3 sec of time interval so that we can get accurate power consumption. Table obtained from analyzer gives active power, Reactive power , Apparent power, Harmonic power , Unbalanced power and above listed energies also. From which we are dealing with only Active power which gives power consumed by CNC machine for machining of work piece for particular time interval .

Total power consumed by work piece is calculated by adding the all active power for machining time of that specific work piece divided by machining time.

Power consumed = ∑active power for machining time / machining time

Experimental result for power consumption -

Expt.no	Cutting Speed (m/min)	Feed Rate(mm/min)	Depth of cut(mm)	Power consumption
1	360	270	0.8	1.36667
2	360	320	1.2	1.49600
3	360	365	1.6	1.63714
4	340	270	1.2	1.43500
5	340	320	1.6	1.51400
6	340	365	0.8	1.31500
7	320	270	1.6	1.58389
8	320	320	0.8	1.38588
9	320	365	1.2	1.38473

Table. Experimental result for power consumption

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Experimental result for power consumption and S/N ratio

Expt.no	Cutting Speed (m/min)	Feed Rate(mm/min)	Depth of cut(mm)	Power consumption	S/N ratio
1	360	270	0.8	1.36667	-2.71327
2	360	320	1.2	1.49600	-3.49863
3	360	365	1.6	1.63714	-4.28172
4	340	270	1.2	1.43500	-3.13704
5	340	320	1.6	1.51400	-3.60252
6	340	365	0.8	1.31500	-2.37852
7	320	270	1.6	1.58389	-3.99449
8	320	320	0.8	1.38588	-2.83451
9	320	365	1.2	1.38473	-2.82730

Table no. 11

Computation of S/N ratio= -10 log $(M.S.D)^2$
Calculation
Reading no 1-
n= -10 log $(1.3667)^2$
= -2.71327
Regardless of the lower – the – better of the higher –the –better quality characteristics ,the greater s/n ratio corresponds to smaller variance of the output characteristics around the desired value the S/N response table for power consumption is shown in table

VII. ANALYSIS OF EXPERIMENTAL

The S/N response table for MRR is shown in following Table

Level	Speed (A)	Feed rate (B)	DOC (C)
1	2.458	2.073	-1.482
2	2.345	2.381	3.401
3	3.401	3.750	6.285

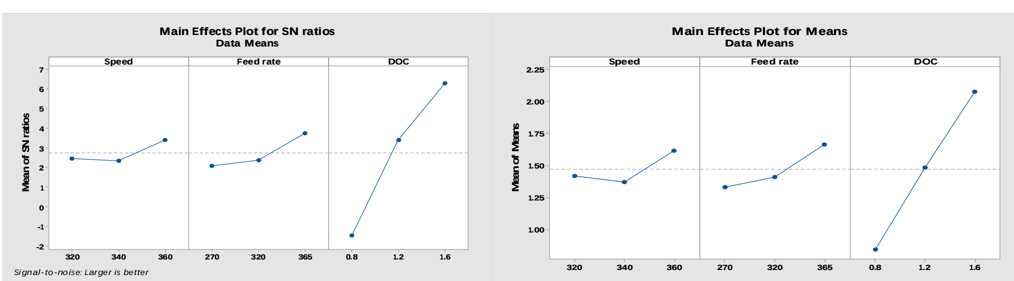
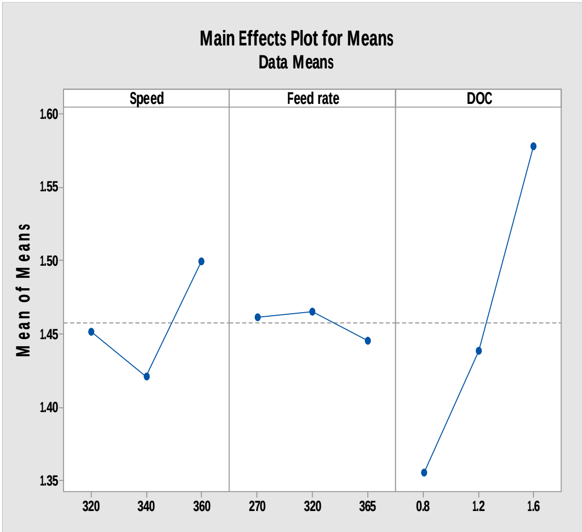


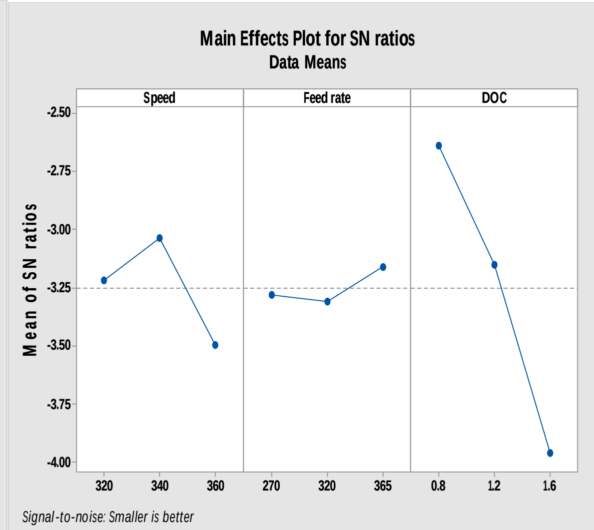
Fig no. Plots for MRR

S/N response table for power consumption -

Level	Speed (A)	Feed rate (B)	DOC (C)
1	-3.219	-3.282	-2.642
2	-3.039	-3.312	-3.154
3	-3.498	-3.163	-3.960

Table S/N response table





VIII. CONFIRMATION TEST

The estimated S/N ratio ($n^{\wedge}$) using the optimal level of the design parameter can be calculated as:

$$n\wedge = \mathbf{n}_m + \sum_{i=0}^{0} (n_i - n_m)$$

The estimated S/N ratio using the optimal cutting parameters for MRR and Power consumption can be calculated By using above equation.

Table.13. shows comparison of the predicted MRR with actual MRR using the optimal cutting parameter, good agreement between the predicted and actual MRR being observed.

	Initial parameters	Optimal cutting parameters	
		Prediction	Expt.
Level	A1B2C2	A3B3C3	A3B3C3
MRR	1.923	2.10	2.027
S/N ratio	5.67959	7.9667	7.2051

Table. Comparison between predicted value and experimental optimal values. for MRR.

The initial cutting parameters were as follows cutting speed(A1 360 m/min, Feed rate(B2)320mm/min and depth of cut (C2) 1.2mm.MRR for initial cutting parameters were 1.923 kg/sec. Optimal cutting parameters were taken from table no S/N response table for MRR. Optimal values found out to be Cutting speed at level 3 (320),for feed at level 3(365)and depth of cut (1.6mm)Improvement of S/N ratio=7.2051-5.67959

=1.52551dB

Computation of predicted S/N ratio= $n\wedge = \mathbf{n}_m + \sum_{i=0}^{0} (n_i - n_m)$……………….(for larger is better)

Calculations:

Predicted S/N ratio= $n\wedge = \mathbf{n}_m + \sum_{i=0}^{0} (n_i - n_m)$

=2.73467+{(3.401-2.734670+(3.750-2.73467)+(6.285-2.73467)}

=7.9666dB

For MRR, $7.9666 = -10\log\{(1/y^2)/2\}$

y= **2.10**

Table.14 Shows the comparison of the predicted Power consumption value with the actual using the optimal cutting parameter, where a predicted power consumption consistent with actual power consumption is noted.

	Initial parameters	Optimal cutting parameters	
		Prediction	Expt.
Level	A1B3C1	A2B3C1	A2B3C1
Power consumption	1.63500	1.14	1.251
S/N ratio	-2.37852	-4.164438	-2.43849

Table. Comparison between predicted value and experimental optimal values. for Power consumption.

The initial cutting parameter were as follows cutting speed (A1)360(m/min),feed(B3) 365mm/min and depth of cut (C3)1.6 mm. Power consumption for this initial cutting parameters was 1.63500 kw. Optimal cutting parameters are taken from the table @.S/N response table for power consumption .Optimal values for power consumptions are speed (A2)340m/min, feed rate(B3)365mm/min and depth of cut(C1)0.8.

Improvement of S/N ratio=-2.43849-(-2.37852)

=0.05997dB

IX. RESULT AND DISCUSSION

A. Results

In this study, an investigation on the MRR and power consumption based on the parameter design of the Taguchi method in the optimization of turning operations has been investigated and presented. Summarizing the mean, experimental results of this study, the following generalized discussion can be drawn.

B. Discussion

Based on the experimental results, the highly effective parameters on MRR and power consumption were determined.

1) Based on S/N ratio and Main effect plot for MRR, We conclude that A3B3C3 are Optimal. Machining parameter for maximizing material remove rate.[Where A= Speed, B=Feed rate, C= Depth of cut and 1,2,3 shows particular level)
2) Use of cutting speed at level 3 (360m/min), feed at level 3(365 mm/min) and depth of cut at level 3 (1.6mm) is recommended to obtain higher MRR.
3) Based on S/N ratio and Main effect plot for power consumption we conclude that A2B3C1 are optimal parameter for minimizing power consumption.
4) Use of cutting speed at level 2 (340 m/min), feed at level 3(365 mm/min) and depth of cut at level 1 (0.8mm) is recommended to obtain better power consumption.
5) Confirmation experiments verified the effectiveness of the present approach in finding optimal machining parameters.

C. Conclusion

This project has presented an application of the parameter design of the Taguchi method in the optimization of turning operations. The following conclusions can be drawn based on the experimental results of this study.

This project demonstrates how to use Taguchi parameter design for optimizing machining performance with minimum cost and time to industrial readers. This project has discussed an application of the Taguchi method for optimization the cutting parameters in turning operations It has been shown that MRR and power consumption can be improved significantly for turning operations. The confirmation experiments were conducted to verify the optimal cutting parameters

REFERENCE

[1] W.H.Yang, Y.S. Tang, Design Optimization of cutting parameters for turning operation based on the Taguchi method, Journal of Materials Processing Technology,84(1998), 122-129.
[2] D.Philip Selvaraj et al “Optimization of surface roughness of ASI 304 austenitic stainless steel in dry turning operation using Taguchi method”, Journal of Engineering and Science technology Vol.5, No.3(2010) page 293-301, School of engineering, Taylor’s University Collage.
[3] Quazi T Z , Pratik More , Vipul sonawane, Case Study of Taguchi Method in the Optimization of Turning Parameters, International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001 :2008 Certified Journal, Volume 3, Issue 2, February 2013).
[4] Vishal Francis, Ravi.S.Singh, Nikita Singh, Ali.R.Rizvi, Santosh Kumar (2013) Application of Taguchi method and ANOVA in Optimization of cutting parameters for material Removal rate and power consumption in turning Operation, Department of Mechanical Engineering SSET SHIATS Allahabad-211007, Uttar Pradesh, INDIA,(ISSN 0976-6359 Volume 4, Issue 3, May -June (20l3), pages(47-53).

[5] Shubhra Banerji (2012) Orthogonal Array Approach for Test Case Optimization, of Advanced Research in Computer and Communication Engineering (international journal of advanced research in computer and communication engineering vol.1 , issue 9 November 2012.
[6] S.R.Das, R.P.Nayak D Dhupal (2012) Optimization of cutting parameter of too\ flank wear and work piece surface temperature turning of ASIS Steel (International journal of Thinking lean Volume 3,Issue 2).
[7] Ajay Mishral, Dr. Anshul Gangele (2012) Application of Taguchi Method in Optimization of Tool Flank Wear Width in Turning Operation of AlSl l045 Steel, Research Scholar, Department of Mechanical Engineering, Suresh Gyan Vihar University, Jaipur. (ISSN 2224-6096 (Paper) ISSN 2225-0581 (online) Vol 2, No.8, 2012).
[8] Krishankant Jatin Taneja ,Mohit Bector, Rajesh Kumar, Application of Taguchi Method for Optimizing Turning process by effects of Machining Parameters, Internal Journal 0.f Engineering and Advanced Technology (IJEAT) ISSN: 2249 -8958, Volume-2. Issue-], October 2012.