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Optimization of Machining Parameters Using Taguchi Method

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Abstract- Today's manufacturers hope to quickly and effectively set up and optimize processes associated with new and existing processes to remain competitive. Engineers and production personnel may utilize methods and industrial technologies to achieve the optimization of process to meet the company's needs. Ideally, this takes into consideration productivity, quality, and safely. Various conventional techniques employed for machining optimization include geometric programming geometric plus linear programming, Non-Linear Programming, goal programming, sequential unconstrained minimization technique and dynamic programming etc. The latest techniques for optimization include scatter search technique, genetic algorithm, Taguchi technique and response surface methodology are being applied successfully in industrial applications for optimal selection of process variable in the area of machining. Taguchi methods is latest design techniques widely used in industries for making the product insensitive to any uncontrollable factors such as environmental variables. This paper discusses an investigation into optimizing quality characteristics, while considering productivity, through the use of Taguchi Parameter Design. A turning operation is the subject of this study, and the output parameter selected is surface roughness.

Index Terms: Machining, Dry turning, Surface roughness, Taguchi method

1. INTRODUCTION

Now-a-days, due to the increasing demand of higher precision components for its functional aspect, surface roughness of a machined part plays an important role in the modern manufacturing process. To achieve the desired surface finish, a good predictive model is required for stable machining. Generally, these models have a complex relationship between surface roughness and operational parameters.

Taguchi's parameters design is an important tool for robust design. It offers a simple and systematic approach to optimize design for performance, quality and cost. Signal to noise ratio and orthogonal array are two major tools used in robust design. Signal to noise ratio, which measures quality with emphasis on variation, and orthogonal arrays, which accommodates many design factors simultaneously. The chief machining parameters that would affect the selected quality characteristic are cutting speed, feed rate and depth of cut.

2. EXPERIMENTAL PROCEDURE

2.1 SELECTION OF WORKPIECE MATERIAL, CUTTING TOOL AND LATHE.

The specimen as workpiece material used for experimentation was unalloyed, polished(EN8),tensile strength range(500-800N/mm^2). Table 2.1 shows nominal and actual composition of(EN8) used for the study. It was subjected to turning operation with the help of single point carbide tipped cutting tool (right handed) over an all geared, autofeed Lathe Machine.

Table 2.1 Composition of EN8

Material	% C	% Mn	% Si	% P	% S
EN8	0.35-0.45	0.6-1	0.5-0.35	0.06max	0.06max

2.2 APPLICATION OF WORKPIECE MATERIAL

It is used in general engineering applications. It is used for making Heat treated axles, crank shafts, nuts, bolts and other vehicle parts.

2.3TURNING 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. The parameters selected in our study are cutting speed(rpm),depth of cut(mm), feed rate(mm/revolution). These factors are termed as controlled factors & for each of these controlled factors three levels were specifically decided. Different screening experiments were carried out, vibrational aspects were also taken into consideration and the selection of the levels was done.

2.4 TAGUCHI METHOD:
Taguchi's parameter design offers a systematic approach for optimization of various parameters with regard to performance, quality and cost. Quality is best achieved by minimizing the deviation from a target. Taguchi or an orthogonal array means the design is balanced so that factor levels are weighted equally. Firstly three levels for each of the controlled factors are selected(low, medium &high).An effective Design of experiment is then done according to taguchi's L9 orthogonal array, consisting of total 9 run of experiments. The selected response is then measured for every run. Signal to noise ratio calculations are then perfomed for every run of experiment for the selected response i.e surface roughness in our case, followed by interpretation of results.

2.5 ANALYSIS OF VARIANCE:
The analysis of variance is performed in **ANOVA** unit of MINITAB 16 software(Free Trial Version)**.** **ANOVA** is a collection of statistical models, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation. The major advantage of performing ANOVA is to validate the results obtained from Taguchi's Signal to Noise ratio Analysis, as ANOVA gives the percentage contribution of the selected controlled factors and suggests the most significant factor out of all.

Table 1.1 Taguchi L9 (3*3) orthogonal array

Trial Run	**Cutting speed**	**Depth Of Cut**	**Feed Rate**
	Level	Level	Level
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 1.2 Levels of machining parameters or controllable factors.

FACTORS	LEVEL 1	LEVEL 2	LEVEL3
Spindle speed(rpm)	87	190	373
Depth Of Cut(mm)	1.5	1	0.8
Feed(mm/rev)	0.094	0.36	0.72

2.6 DESIGN OF EXPERIMENT & MEASURED VALUES OF THE RESPONSE.
The design is made according to taguchi's L9 orthogonal array and surface roughness values corresponding to each run of experiment are measured with the help of surface roughness tester.

Table 2.1 actual experimental array with response

Spindle speed (rpm)	Depth of cu (mm)	Feed rate(mm/rev)	Surface roughness (microns)
87	1.5	0.094	4.87
87	1	0.36	6.21
87	0.8	0.72	13.07
190	1	0.094	2.83
190	0.8	0.36	5.46
190	1.5	0.72	27.58
373	0.8	0.094	1.94
373	1.5	0.36	4.34
373	1	0.72	6.00

3. ANALYSIS USING SIGNAL TO NOISE RATIO.

Basic problem is surface roughness, and need is to improve surface finish i.e to minimize surface roughness. Hence, the response is surface roughness. The parameters that influence the output can be categorized into two classes, namely controllable (signal) factors and uncontrollable (noise-temperature, material type etc.) factors. The objective of any experiment is to achieve the best possible (higher) S/N ratio. The S/N ratio employed is,

Smaller the Better: As response is surface roughness and our aim is to minimize the same, smaller the S/N ratio better would be the response and poor would be surface finish. Higher S/N ratio would give best surface finish. Hence, eqation is
(S/N)= -10 log (MSDLB)
Where, MSDLB = $\frac{1}{R}\sum_{i=1}^{R}(Yi)^2$
Yi=Measured response value.

R= number of repetitions.
MSDHB =Mean Square Deviation for Lower-the-better response

S/N ratios for measured surface roughness values

Table 3.1 S/N ratios for all runs.

Surface Roughness(microns)	S/N Ratio (smaller is better)
4.87	-13.7506
6.21	-15.8618
13.07	-22.3255
2.83	-9.0357
5.46	-14.7439
27.58	-28.8119
1.94	-5.7560
4.34	-12.7498
6.00	-15.5630

It's clear from above values that surface finish of the 7th run of expt. is best amongst all. (Its S/N ratio is higher)

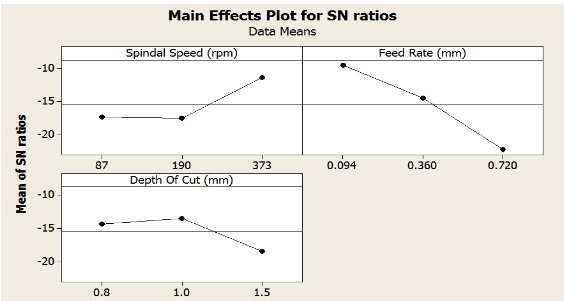
3.1 EFFECT OF CUTTING SPEED, FEED AND FEED RATE ON RESPONSE

effect of controlling factors on surface roughness is shown in following table.

Effect of Spindle speed: Effect is lowest at a speed of 373 rpm. Hence optimum level is 3rd level i.e. 373rpm.

Effect of DOC: Effect is lowest at 2nd level. Hence optimum condition is level 2 i.e. 1mm.

Effect of Feed Rate: Effect is lowest at 1st level itself. Hence optimum level is 1st i.e. 0.094mm/rev.



3.2 SIGNIFICANCE OF FACTORS USING S/N RATIO ANALYSIS- *Table 3.2 Mean S/N ratios for each factors and significant interaction.*

	LEVEL	Spindle speed	Depth of cut	Feed rate
Mean S/N ratio	1	-17.31	-14.27	-9.514*
	2	-17.53	-13.487*	-14.452
	3	-11.356*	-18.437	-22.233
	Delta	6.174	4.951	12.719
	Rank	2	3	1

(*indicates optimum level)

optimized process parameters are

1.Spindle Speed=373rpm

2.Depth of Cut=1.00mm

3.Feed Rate=0.094mm/rev

Analysis of variance(ANOVA): Table 3.3 Analysis of variance of S/N ratios for Surface Roughness.

Sources of variation	SS	DF	MS	F Value	P value	% contribu-tion
SPEED	92.75	2	46.37	1.32	0.431	18.20
DOC	85.43	2	42.72	1.22	0.451	16.77
FEED	261.01	2	130.51	3.72	0.212	51.24
Residual Error	70.18	2	35.09			
Total	509.37	8				

Analysis of variance showed that feed is the most significant factor 51.24%,followed by speed18.20%& DOC16.77%

4. CONFIRMATION OF RESULTS

To verify the results, single run experiment was performed separately.

Table 4.1 Confirmation test for Surface Roughness

Sr. No	Optim-um values of control paramet ers	Predicted Surface roughness value from Taguchi method	S/N ratio obtained from Taguchi results	Practical-lly obtained valve of Surface Roughnes s
1	Speed= 373rpm Doc=1 mm Feed rate=0.0 94mm/r ev	1.5061	-3.55765	1.212

As the practically obtained value of roughness is very much closer to the one predicted by Taguchi's method of optimization, the validity of the analysis and results obtained is thus justified with confirmation.

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