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Parametric Analysis and Optimization of Turning Operation by Using Taguchi Approach

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ABSTRACT: *Every day scientists are developing new materials and for each new material, we need economical and efficient machining. Turning process is the one of the methods to remove material from cylindrical and non-cylindrical parts. Stainless steel is a widely used material in day to day applications. This paper deals with the optimization of turning process by the effects of machining parameters applying Taguchi methods so as to improve the quality of manufactured goods, and engineering development of designs for studying variation. There are three machining parameters i.e., Spindle speed, Feed rate and Depth of cut. Experiments are done by varying one parameter and keeping other two fixed so maximum value of each parameter was obtained. Taguchi orthogonal array is designed with three levels of turning parameters with the help of software Minitab 16. In the first run nine experiments are performed and material removal rate (MRR) is calculated. When experiments are repeated in second run again MRR is calculated. Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The metal removal rate was considered as the quality characteristic with the concept of "the larger-the-better. S/N ratio values are calculated by taking the help of software Minitab 16. The MRR values measured from the experiments and their optimum value for maximum material removal rate. It is also predicted that Taguchi method is a good method for optimization of various machining parameters as it reduces the number of experiments.*

KEYWORDS: *Turning, Material Removal Rate, AISI 304 Steel, Taguchi, Minitab16*

I. INTRODUCTION

Experimental work includes the turning operation which is performed on the HMT NH26 lathe machine. The input parameters are taken as spindle speed, feed and depth of cut whereas the output parameter is taken as material removal rate. The values taken for spindle speed (in rpm) are 220, 350 and 540, the values for feed (in mm/rev) are 0.388, 0.418 and 0.462, and for depth of cut (in mm) the values are taken as 0.9, 1.0 and 1.1. The experiments are performed by HSS tool on AISI 304 steel bar work piece of 40 mm diameter and 60 mm length.

Table 1.1: Composition of AISI 304 Steel

Element	C	Mn	Si	Cr	Ni	P	S
Weight %	0.08	2	1	18-20	8-10	0.045	0.03

I.1.1 MATERIAL REMOVAL RATE: Material Removal Rate (MRR) Measurement From the initial and final weight of job, MRR is calculated and the relation is given below:

$$MRR = \frac{InitialWeight - FinalWeight}{TimeTaken}$$

II. LITERATURE REVIEW

Liu et al. (2006), has made use of the basic thermo mechanical properties and the molecular mechanical theory of friction. The main aim is to extend the knowledge of minimum chip thickness values to as many materials as possible when these materials are put to wide range of cutting conditions. [1]

H S Yoon et al., has proposed an orthogonal cutting force model based on slip-line field model for micro machining. Two material flow processes are being considered- chip formation process and ploughing. The paper takes into account the effects of parameters like effective rake angle, depth of deformation and minimum chip thickness. [2]

Z J Zhou et al. (1996), has taken up the case of ultra precision machining to study the effect of diamond tool sharpness on cutting surface integrity and minimum chip thickness. Good surface integrity is an essential requirement of machining processes. Good surface integrity implies smaller surface roughness and smaller residual stresses combined with high dimensional accuracy. However, the accuracy of the relative motion between the cutting edge and the work piece governs the achievable machining accuracy. So, the performance of machine tools needs to be studied. [3]

III. MATERIALS AND METHODS

III.1 TURNING OPERATION

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters. Turning is the machining operation performed on lathe that produces cylindrical parts.

The cutting tool material used in this experiment is high speed steel (HSS). The work piece taken for this experiment is AISI 304 steel bar of 40 mm diameter and 60 mm length. Experiment has been performed on HMT NH26 LATHE. Table 3.1 shows the experimental data:

Table 3.1: Observation of first run of experiment

Spindle Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Time (sec)	Initial wt. (gm)	Final wt. (gm)	Difference (gm)	MRR 1 (gm/sec)
220	0.388	1.1	16	737	714	23	1.44
220	0.418	1	15	757	738	19	1.27
220	0.462	0.9	11.7	762	744	18	1.53
350	0.388	1	9.9	762	740	22	2.20
350	0.418	0.9	9	758	740	18	2.00
350	0.462	1.1	8	784	766	18	2.25
540	0.388	0.9	7	753	746	7	0.99
540	0.418	1.1	7.1	758	742	16	2.25
540	0.462	1	6.5	727	716	11	1.72

Table 3.2: Observation of second run of experiment

Spindle Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Time (sec)	Initial wt. (gm)	Final wt. (gm)	Difference (gm)	MRR 2 (gm/sec)
220	0.388	1.1	15.66	714	692	22	1.40
220	0.418	1	15.41	738	718	20	1.30
220	0.462	0.9	11.71	744	726	18	1.54
350	0.388	1	10.00	740	718	22	2.20
350	0.418	0.9	8.75	740	722	18	2.06
350	0.462	1.1	8.13	766	748	18	2.21
540	0.388	0.9	6.10	746	740	6	0.98
540	0.418	1.1	6.54	742	728	14	2.14
540	0.462	1	6.39	716	704	12	1.88

III.1.1 TAGUCHI METHOD

Taguchi method is a powerful tool for the design of high quality systems. It provides simple, efficient and systematic approach to optimize design for performance, quality and cost. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions. Taguchi approach to design of experiments easy to adopt and apply for users with limited knowledge of statics, hence gained wide popularity in the engineering and scientific community. The desired cutting parameters determined by handbook. Cutting parameters are reflected on surface roughness, surface texture and dimensional deviation on turned product. Taguchi method is especially suitable for industrial use but can also be used for scientific research.

III.1.1.1 DESIGN OF ORTHOGONAL ARRAY

Taguchi Orthogonal Array is designed in Minitab16 to calculate S/N ratio and Means.

III.1.1.1. ANALYSIS OF THE SIGNAL TO NOISE (S/N) RATIO

In the Taguchi approach, the term signal represents the desired value (mean) for the output characteristics and term noise represents the undesirable value (standard deviation) for the output
characteristics. Therefore, S/N ratio is the ratio of mean to the standard deviation. Taguchi uses the S/N ratio to measure the quality characteristics deriving from desired value. The S/N ratio is defined as given equation.

"the larger the better"

It is when the occurrences of some undesirable product characteristics is to be maximized. It is given by

$$S/N = -10\log_{10}\left[\frac{1}{n}\sum\frac{1}{y2}\right]$$

IV. RESULTS & DISCUSSION

After finding all the observation as given in Table 3.1 and 3.2, S/N ratio and Means are calculated and various graph for analysis is drawn by Minitab 16 software using Taguchi Method.

Table 4.1: Experiment Results and corresponding S/N ratios:

S.No.	Spindle Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	MRR 1 (gm/sec)	MRR2 (gm/sec)	S/N Ratio
1	220	0.388	1.1	1.44	1.40	2.80549
2	220	0.418	1	1.27	1.30	3.69201
3	220	0.462	0.9	1.53	1.54	2.44400
4	350	0.388	1	2.20	2.20	5.57042
5	350	0.418	0.9	2.00	2.06	5.90939
6	350	0.462	1.1	2.25	2.21	8.48077
7	540	0.388	0.9	0.99	0.98	1.38411
8	540	0.418	1.1	2.25	2.14	5.54248
9	540	0.462	1	1.72	1.88	4.84202

Since, the greater S/N value corresponds to a better performance; therefore, the optimal level of the machining parameters is the level with the greatest value.

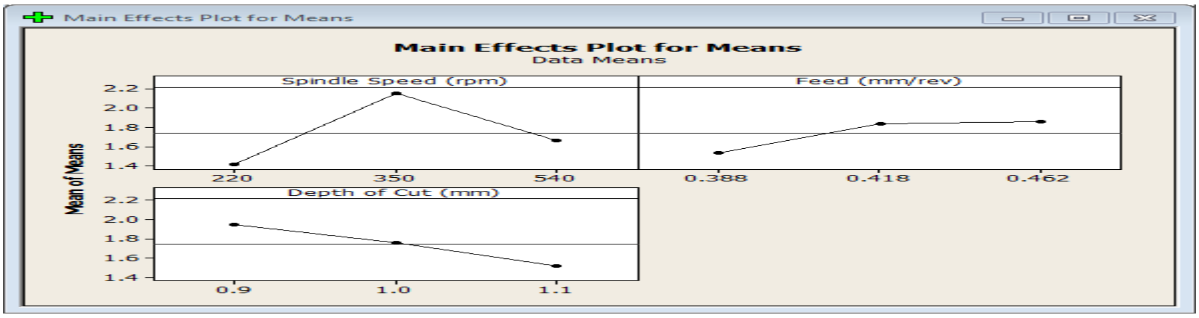

Fig 1. Effect of turning parameters on MRR for Means

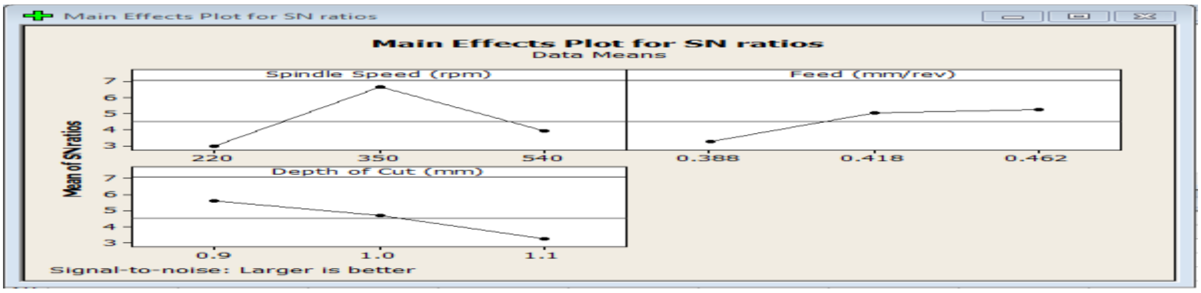

Fig 2. Effect of turning parameters on MRR for S/N ratio

V. CONCLUSIONS

The effect of parameters spindle speed on the metal removal rate values is shown above figure for S/N ratio. Its effect is increasing with increase in spindle speed upto 350 rpm beyond that it is decreasing. So the optimum spindle speed is level 2 i.e. 350 rpm.

The effect of parameters feed rate on the metal removal rate values is shown above figure S/N ratio. Its effect is increasing with increase in feed rate. So the optimum feed rate is level 3 i.e. 0.462 mm/rev.

The effect of parameters depth of cut on the metal removal rate values is shown above figure for S/N ratio. Its effect is decreasing with increase in depth of cut. So the optimum depth of cut is level 3 i.e. 1.1 mm.

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