OPTIMIZATION OF MACHINING PARAMETERS FOR SURFACE ROUGHNESS IN CNC TURNING FOR BRIGHT BAR (EN24T STEEL) BY TAGUCHI METHOD

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Abstract : — Manufacturing is the backbone of any industrialized nation. Manufacturing is derived from the Latin word manufactus, means made by hand. In modern context it involves making products from raw material by using various processes, by making use of hand tools, machinery or even computers. It is therefore a study of the processes required to make parts and to assemble them in machines. The purpose of this research work is to investigate optimum values of SR and MRR in turning of bright bar (EN24T) using CNC turning lathe machine. Thus, the surface roughness and material removal rate is planned to be measured and observed in the experiment

Keywords: **CNC Turning, Taguchi method, ANNOVA, SR, MRR**

I. INTRODUCTION

In a turning operation, it is important task to select cutting parameters for achieving high cutting performance. Cutting parameters are reflected on surface roughness, surface texture and dimensional deviations of the product. Surface finish obtained in manufacturing processes mainly depends on the combination of two aspects: the ideal surface finish provided by marks that manufacturing process produces on the surface and the actual surface finish which is generated taking into account irregularities and deficiencies. The surface of every part includes some type of texture created by any combination of the following factors; the microstructure of the material, the action of the cutting tool, cutting too instability, errors in tool guide ways and deformations caused by stress patterns in the component. The surface texture of an engineering component was very important. It was affected by the machining processes by changes in the conditions of either the component or machine. A machined surface carries a lot of valuable information about the process including tool wear, built-up edge, vibrations, damaged machine elements etc. Under stable machining conditions, the surface texture changes remarkably due to the changes in the cutting tool shape caused by wear.

The Taguchi method is used to design the variables of cutting parameter in the experiment in order to obtained data of various specimens. Optimization was involved in the research to provide a better surface roughness and to increase material removal rate predictions for turning steel. It has long been recognized that conditions during cutting, such as feed rate, cutting speed and depth of cut, should be selected to optimize the economics of machining operations, as assessed by productivity, total manufacturing cost per component or some other suitable criterion.

II. LITERATURE

L. B. Abhang, M Hameedullah [1]. This work is optimization of machining parameters in steel turning operation by Taguchi method. In this study the experimental work was carried out by turning EN-31 steel alloy using Tungsten carbide inserts. There were three main purposes of this study. The first was to explain and demonstrate a systematic procedure of Taguchi parameter design and applying it to the data on turning. The second was to find out the optional combination of process parameters based on S/N ratio and know the significance of each 8 parameter by performing ANOVA analysis. The third important aim was to find out the effect of lubricant over temperature were varied to observe the effects on responses. The main conclusion drawn from this study is that better surface finish is obtained by applying cooled lubricant. Even with higher depth of cut surface finish improved if lubricant temperature is lowered.

M.Kaladhar [2]. The Experimental investigation conducted to turn AISI 304 austenitic stainless steel using PVD coated cermet by employing Taguchi technique to determine the optimal levels of process parameters. In case of MRR response, depth of cut is dominant one followed by feed. The optimal combination of process parameters parameter is obtained at 150 m/min cutting speed 0.25mm/rev, 2mm depth of cut and 0.4 mm nose radius. **Sujit Kumar Jha, et al.[1]** research has demonstrated an application of the Taguchi method for investing the effects of cutting parameters on material removal rate in turning aluminium metal. With analysis of results in this work using S/N ratio approach and ANOVA provides a systematic and efficient methodology for the optimization of cutting parameters.

Saurav Datta [3]. The study deals with optimization of multiple surface roughness parameters in search of an optimal parametric combination capable of producing desired surface quality of the MS turned product. The study proposes an integrated optimization approach using Principal Component Analysis (PCA), utility concept in combination with Taguchi's robust design methodology. Application of PCA has been recommended to eliminate response correlation by converting correlated responses into uncorrelated quality indices called principal components which have been as treated as response variables for optimization.

Utility based Taguchi method has been found fruitful for evaluating the optimum parameter setting and solving such a multi objective optimization problem.

Aditya Kulkarni, et al. [4] studied optimization of power consumption using Taguchi"s technique. Taguchi approach is used in this study to optimize CNC turning of AISI 1040 steel for power consumption by considering input parameter as cutting speed, feed, and depth of cut, nose radius and cutting fluid concentration. The following conclusions can be deduced from the findings of this study: ANOVA result shows that cutting speed (48.15%), depth of cut (24.99%) and cutting fluid concentration (12.13%) has physical as well as statistical influence on power consumption.

Upinder Kumar Yadav, et al. [5] done experimental investigation And Optimization of Machining Parameters for Surface Roughness in CNC Turning by Taguchi Method and conclude following results . The Surface roughness is mainly affected by feed rate and cutting speed. With the increase in feed rate the surface roughness also increases & as the cutting speed decreases the surface roughness increases.

III. PROBLEM DEFINITION:

With regard to the quality characteristics of turning parts, some of the problems included surface roughness, burr, and tool wear, etc. The machining parameters such as cutting speed, feed rate, depth of cut, features of tools, work piece material and coolant conditions were highly affect the performance characteristics. It was necessary to select the most appropriate machining parameters in order to improve cutting efficiency, lower the process cost, and produce high-quality components.

a) What is the relationship between the controllable factors (in the study: spindle speed, feed rate, and depth of cut) and the response factor (surface roughness and material removal rate)?

b) What are the significant controllable factors that produce a better surface finish and increase material removal rate?

IV. DESIGN OF EXPERIMENTS

An outline of the recommended procedure of an experimental design is briefly explained below,

1. Statement of the experimental problem..
2. Understanding of the present situation..
3. Choice of response variables.
4. Choice of factors and levels.
5. Selection of experimental design procedure.
6. Performing the experiments.
7. Data analysis.
8. Analysis of the results and conclusions. 9. Confirmation test.
10.Recommendations and follow-up management.
11. Planning of subsequent experiments.

Classification of Experimental Designs

A. Factorial design
B. Fractional factorial design

The Taguchi System Of Quality Engineering

Dr. Genichi Taguchi has introduced more cost effective engineering methodology namely robust design to deliver high quality products at low cost through research and development. It can greatly improve an organization's ability to meet market windows, keep development and manufacturing costs as low as possible. Robust design uses any ideas from statistical experiment design and adds a new dimension to it by explicitly addressing two major concerns faced by all products and process designers:

1 How to reduce economically the variation of a product's function in the customer's environment?

2 How to ensure that decisions found optimum during laboratory experiments will prove to be valid and reliable in manufacturingandcustomer environments?

The major steps of implementing the Taguchi method are:

1. to identify the factors/interactions,
2. to identify the levels of each factor,
3. to select an appropriate orthogonal array (OA),
4. to assign the factors/interactions to columns of the OA,
5. to conduct the experiments,
6. to analyse the data and determine the optimal levels, and
7. to conduct the confirmation experiment.

In the field of communication engineering a quantity called the signal-to-noise (SN) ratio has been used as the quality haracteristic of choice. Taguchi, whose background is communication and electronic engineering, introduced this same concept into the design of experiments. There are several SN ratios available depending on the type of characteristic:

1. Nominal is Best Characteristics
2. Smaller the Better Characteristics
3. Larger the Better Characteristics

ORTHOGONAL ARRAYS:

Many designed experiments use matrices called orthogonal arrays for determining which combinations of factor levels to use for each experimental run and for analysing the data. In the past, orthogonal arrays were known as ‘magic squares’ Perhaps the effectiveness of orthogonal arrays in experimental design is magic.

V. Experimental Procedure and result analysis

Experimental Procedure

The turning operation is carried out on the CNC Lathe machine for the better accuracy of Result. single point cutting tool. Inserts of Sandvik GC4035 (HC) – P35 (P20 — P45) CVD-coated carbide grade for roughing and finishing of steel and steel castings under unfavourable conditions are used.

Figure.5.1 CNC Turning Lathe Machine

WORK PIECE MATERIAL FOR EXPERIMENTATION:

EN24T grade is a nickel chromium molybdenum specification usually supplied hardened and tempered as EN24T or EN24U. EN24T steel is composed of (in weight percentage) Carbon 0.35-0.45% Silicon 0.10-0.35% Nickel 1.30-1.80% Manganese 0.45-0.70% Chromium 0.90-1.40% Phosphorous 0.05% max Molybdenum 0.20-0.35% Sulphur 0.05% max.

Condition	Tensile N/mm²	YieldN/mm²	Elongation%	IzodKCVJ	HardnessBrinell
T	850-1000	650	13	35	248-302

SELECTION OF PROCESS PARAMETERS AND THEIR LEVELS

The level of parameters is the main point because it will affect the surface finish and material removal rate of the work piece. It is important task to select a good combination of parameters level for achieving high cutting performance. The experimentation for this study was based on Taguchi"s design of experiments (DOE) and orthogonal array. Based on the literature review, in present investigation three levels are defined for each of the identified factor as shown in Table.

Work piece preparation and Inspection:

Raw material of Ø25 mm was first turned on manual lathe with depth of cut 1mm and made Ø24, then on CNC machine 27 no. of components were made with desired combination of speed, feed, and depth of cut. Fig 5.6.shows work pieces finished on CNC lathe.

Surface roughness of the machined work piece at three different spot was measured using Mitutoyo SJ 201 surface roughness tester (Fig.) and mean of the result is investigated for the experimentation.

Observation Table for Surface Roughness and S/N Ratio and Mean Correlations: The results of Taguchi experiments are then transformed into a signal to noise (S/N) ratio to measure the deviation of the performance characteristics from the desired values. For SR desired characteristics is smaller is better, the desired characteristic for material removal rate is larger is better.

Sr. No.	Speed	Feed	DOC	SR	Mean SNR A	Mean SR
1	600	0.1	0.4	3.07	-9.77	3.08
2	600	0.1	0.4	3.18		
3	600	0.1	0.4	2.98		
4	600	0.15	0.8	5.50	-13.9	4.96
5	600	0.15	0.8	5.27		
6	600	0.15	0.8	4.12		
7	600	0.2	1.2	11.19	-21.1	11.38
8	600	0.2	1.2	12.94		
9	600	0.2	1.2	10.02		
10	800	0.1	0.8	4.06	-13.3	4.59
11	800	0.1	0.8	4.29		
12	800	0.1	0.8	5.43		
13	800	0.15	1.2	5.78	-16.4	6.62
14	800	0.15	1.2	7.38		
15	800	0.15	1.2	6.71		
16	800	0.2	0.4	6.99	-15.3	5.77
17	800	0.2	0.4	5.41		
18	800	0.2	0.4	4.92		
19	1000	0.1	1.2	9.04	-18.6	8.51
20	1000	0.1	1.2	9.09		
21	1000	0.1	1.2	7.42		
22	1000	0.15	0.4	4.50	-13.7	4.85
23	1000	0.15	0.4	5.11		
24	1000	0.15	0.4	4.95		
25	1000	0.2	0.8	5.15	-14.1	5.10
26	1000	0.2	0.8	4.58		
27	1000	0.2	0.8	5.57		

EFFECT OF INPUT PARMETERS ON SURFACE ROUGHNESS

Taguchi Analysis: S/F versus SPEED, FEED, DOC Smaller is better

Level	SPEED	FEED	DOC
1	**-14.98**	**-13.91**	**-12.95**
2	-15.04	-14.73	-13.83
3	-15.52	-16.9	-18.76
Delta	0.54	2.98	5.82
Rank	3	2	1

Table 5.6. Response Table for Signal to Noise Ratios (SR)

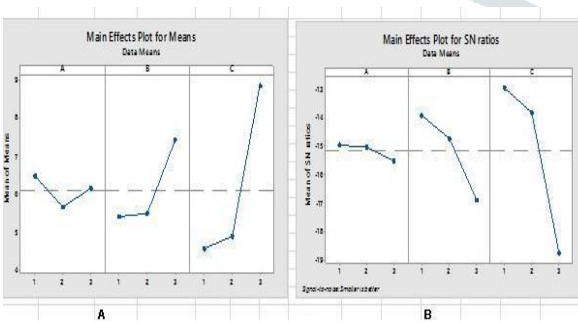
Level	SPEED	FEED	DOC
1	6.477	**5.399**	**4.57**
2	**5.666**	5.483	4.89
3	6.16	7.421	8.843
Delta	0.811	2.023	4.274
Rank	3	2	1

Table: Response Table for Means (SR)

The ranks and the delta values in above table shows that DOC have greatest effect on SR and is followed by feed and speed in that order. As SR is ' smaller the better' type quality characteristics from main effect plot (Fig. 5.8) it can be seen that that first level of cutting speed A1=600rpm ,first level of feed B1=0.10mm and first level of DOC C1= 0.4mm provide minimum SR. **(A1-B1-C1)**

Residual plots for surface roughness (a) Normal probability plot of residuals for tangential force data

Fig. 1. Plot of residuals vs. fitted values for tangential force (c) Plot of residuals vs. the Frequency histogram and (d) Residuals vs. the order of the data shown in Figures. It can be seen in Figures. that all the points on the normal plot lie close to the straight line (mean line). This implies that the data is fairly normal and a little deviation from the normality is observed. It is noticed that the residuals fall on a straight line, which implies that errors are normally distributed. In addition, Figures (b), (c) and (d) revealed that there is no noticeable pattern or unusual structure present in the data. The histogram plot indicates a mild tendency for the non-normality; however the normal probability plots of these residuals do not reveal any abnormality. Residual versus fitted value and residual versus observation order plot do not indicate any undesirable effect.



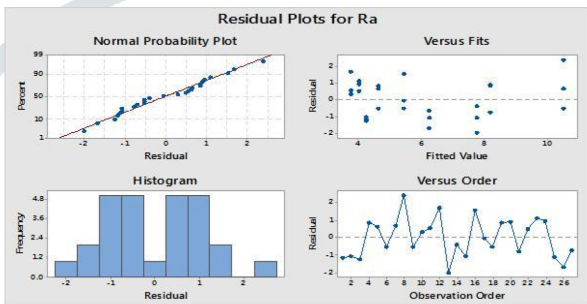


Fig. Main effect plot

Residual Plots For Surface Roughness

Fig. Residual plots for surface roughness (a) normal probability plot of residuals for surface roughness data, (b) plot of residuals vs. fitted values for surface roughness, (c) plot of residuals vs. the histogram, (d) residuals vs. the order of the data.

Predictive Equation and Verification:

The predicted values Ra at the optimal levels are calculated by using the relation:

$$ň = \sum_{i=0}^{0} (\mathrm{nim} - \mathrm{nm})$$

where,

ň =Predictable Value

nm = Total mean value of SR
nim = Mean SR at optimum level of each parameter

o =No. of main machining parameters that affect the response parameter

Applying this relation, predicted values of MRR and Ra at the optimum conditions are calculated as:

ñRa = 6.101 + [(5.666 – 6.101) + (5.399 – 6.101) + (4.57 – 6.1010)]= 3.433 µm.

5.13.1 Verifications:

1. For Surface Roughness (Ra) the response at the optimum condition (A1-B1-C1) calculated value of surface finish is 3.08 µm. The error in the predicted optimum value (3.433) and experimental value (3.08) is negative hence less than 0%.

Regression analysis was carried out to ensure a least squared fitting to error surface in Minitab 17 environment. The general first order model was developed to predict the SR over the experimental region (equation 1&2).

SR=-0.57 **-** 0.00079 SPEED+ 20.23 FEED+5.342 DOC -------------------------- (1)

VII. CONCLUSION

The conclusions of this study may be summarized as follows:

1. From the above experimental investigation it has been found that depth of cut is the most significant factor for surface roughness and material removal rate .The contribution of depth of cut towards surface roughness is 79.33% .
2. It is found that the parameter of the Taguchi method provides a simple, systematic & efficient methodology for the optimization of the machining parameters.

VIII. REFERENCES

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