Optimization of Process Parameters for MRR and Machining Time in Turning Process: A Review

Mr.Swapnil Lambe[1], Mr.Dnyaneshwar Vaidhya[2], Mr.Sagar Bhosale[3], Mr.Prashant Galatage[4], Mr. Hariprasad Chavan[5],

[1,2,3,4,5] Department of Mechanical Engineering, Adarsh Institute of Technology and Research Centre, Vita, India

Abstract- *The challenge of new industry of modern machine industries is mainly focus on achieving high quality, component accuracy, surface finish, high production rate and increase the product life with lesser environmental. Similarly work piece material which plays an important role in metal cutting parameter. In this study, focuses on the optimization of turning parameters using the Taguchi technique to obtain minimum machining time and maximum material removal rate. A number of turning experiments will conduct using the orthogonal array on computerized numerical control. The ex-periments is performing on mild steel bar using high speed steel tool under dry cutting conditions. The measured results are collects and analyze with the help of the commercial software. Analysis of variance is employed to determine the most significant control factors affecting the machining time and material removal rate. The spindle speed, feed rate and depth of cut are selected as control factors.*

Keywords - Optimization process, CNC Machine, MRR, Taguchi Method, ANNOVA.

I. INTRODUCTION

Turning is a process of removal metal from the outer diameter of a rotating cylindrical work piece, usually to specify the dimension and to produce a smooth finish on the metal. The objective of this research is to study effect of cutting speed, feed, depth of cut, machining time and material removal rate. In order to improve machining efficiency, reduce the machining cost, and improve the quality of machined parts, it is necessary to select the most appropriate machining conditions. Which is to be minimize these machining problems, there is a need to develop scientific methods to select cutting conditions and tool geometry for free machining of metals. In turning process, single-point cutting tool that is nothing but insert can complete the entire machining process in a single fixture, thereby reduced setup times as well as lower costs. Tool life is one of the important issues to be studied as the tool is subjected to wear continuously while it is operating. Taguchi method was developed by Dr. Genichi Taguchi. This method involves three stages: system design, parameter design, and tolerance design. The Taguchi method is a statistical method used to improve the product quality. Optimization of process parameters is the key step in the Taguchi method in achieving high quality without increasing the cost. Taguchi method is insensitive to the variation of environmental conditions and other noise factors. The L9 orthogonal array is used for experimentation. The machining is done on the CNC machine using carbide insert. Machining parameters that can affect the processes are: a) Cutting speed - The speed of the work piece surface relative to the edge of the cutting tool during a cut, the cutting speed is measured in meter per minute, b) Feed rate - The speed of the cutting tool's movement relative to the work piece as the tool makes a cut. The feed rate is measured in mm per revolution. c) Depth of cut - The depth of the tool along the radius of the Work piece as it makes a cut, as in a turning or boring operation.

II. LITERATURE REVIEW

Sumit K Singh et al. [1] presented that Taguchi technique and Analysis of Variance for investigating the effect of machining parameters such as Depth of cut, Feed and spindle speed on Tool life for machining of EN08 & also detailed that Spindle speed was found to be the most influencing factor.

Alagarsamy.S.V et al. [2] explained that study applies Taguchi design of experiment methodology for optimization of process parameters in turning of Aluminium Alloy 7075 using tungsten coated carbide tool. ANOVA has shown that the speed has significant role to play in producing higher material removal rate and lesser machine time. Thus, it is possible to increase machine utilization and decrease production cost in an automated manufacturing environment.

K. Ramesh [3] described that an orthogonal array, Signal to noise(S/N) ratio and analysis of variance (ANOVA) were employed to analyze the effects and contributions of depth of cut, feed rate and cutting speed on the response variable. The experiments were carried out on a CNC turning and CNC machining, using coated carbide insert for the machining of Stain-

less Steel. In order to increase accuracy and find the values that lead to a reduction of the response variables studied, it is necessary to conduct in machining operations.

Sujit Kumar Jha [4] explained that the objective of paper is to identify the impacts of process parameters such as cutting speed, feed and depth of cut on material removal rate (MRR) during machining on CNC machine of aluminium material. An orthogonal array of size L9 has been constructed to find out the optimal levels of the turning parameters and further signal-to-noise (S/N) ratio has been computed to construct ANOVA table.

Rahul Borate et al. [5] explained that the Taguchi method of optimization is used with a Two Factor-Three level L9 Orthogonal array design. The experimental runs are taken & machining time is recorded. The results are analyzed in MINITAB software using S/N ratio plots the experimental study conducted.

S. S. K. Deepak [6] explained that a geometric programming based approach to optimize the production time of the turning process within in some operating constraints is proposed. It can be concluded from this study that the obtained model can be used effectively to determine the optimum values of cutting speed and feed rate that will result in minimum production time. The developed model saves a considerable time in finding the optimum values of the cutting parameters.

J.A.Ghani et al [7] explained that an environmentally-friendly method of turning FCD700 cast iron using a carbide tool without coolant. The turning process was carried out in three types of dry conditions, i.e. without air, in chilled air and in normal air. A high feed rate produced a coarser surface finish at the beginning of the cut, but as the tools wore out the machined surface topography remained similar, regardless of the value of the feed rate used.

Krupal Pawar and R. D. Palhade [8] explained that machining parameters including cutting speed, feed rate and depth of cut on surface roughness(Ra) and material removal rate(MRR) in a turning of HSS(M2) are investigated using the Taguchi method and ANOVA. A three level, four parameter design of experiment, L9 orthogonal array using Minitab 14 software, the signal-to-noise (S/N) ratio is employed to study the performance characteristics in the turning.

III. PROBLEM DEFINITION

The major operation carried out in the machining industry is turning process. During searching of project work I have visited to "Pooja Industries Pvt. Ltd. Jaysingpur" this company is well-known in manufacturing of finished machining part, company manufacturing shafts but now company face the problem of produced parts under the turning process have high rejection because of lower material removal rate. Also required maximum machining time and result finally part has rejected at final operation that means it is overall loss of company resources, due to higher competition in market, vendor want finished component in minimum time and cost. and because of the rejection of part at CNC turning operation; it is difficult to company to produce required finished product in expected time and cost it directly affect to company profit and reputation. Here an effort is made to solve the above problem using robust design methodology. Hence company wants to minimize the machining rejection of shaft, by optimum use cutting parameters and machine capacity.

IV. TAGUCHI APPROACH

The Taguchi method involves dropping the variation in a process through forceful design of experiments. Generally objective of the method is to produce high quality product at low cost to the manufacturer. Taguchi method uses a special design of orthogonal arrays to study the absolute parameter with a small number of experiments only. The experimental results are then transformed into a signal – to – noise (S/N) ratio to measure the quality characteristics diverse from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., Smaller the better, larger the better, and nominal the best. The S/N ratio for each level of process constraint is compared based on the S/N ratio analysis. Regardless of the type of the quality characteristic, a smaller S/N ratio corresponds to better quality characteristics. The optimal intermingle of the process parameters can be predicted. Finally, a authentication experiment is conducted to verify the optimal process parameters obtained from the parameter design. The formula for Smaller-The-Better signal to noise ratio is premeditated so that an experimenter can always select the smallest S/N ratio value to optimize the quality feature of an experiment. Smaller-The-Better, S/N ratio is determined by following equations:

$$\frac{S}{N} = -10\,log_{10}\left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_i{}^2}\right]$$

For the material removal rate, the solution is "Higher-The-Better". Where, S/N = Signal to Noise Ratio, n = No. of Measurements, Y = Observed value.

V. ANALYSIS OF VARIANCE (ANOVA)

The Analysis of Variance (ANOVA) is a commanding and common statistical procedure in the social sciences. It is the relevance to identify the effect of entity factors. In statistics, ANOVA is a collection of statistical models, and their associated procedures, in which the observed variation is partitioned into components due to different informative variables. In its simplest form ANOVA gives a statistical test of whether the means of a number of groups are all equal, and therefore generalize.

VI. MATERIAL REMOVAL RATE MEASUREMENTS

Material Removal Rate (MRR) in turning is the material/metal that is removed per unit time in mm3/sec. For each revolution of the work piece, a ring shaped layer of material is removed. Material Removal Rate (MRR) = [Wi-Wf]/ρ×T mm3/sec.
Where,

Wi = initial weight of the work piece (gm)
Wf = final weight of work piece (gm)
T=machining time (sec)
ρ=density of material (kg/m^3)

Material removal rate is the volume of material removed per unit time from the work piece surface. We can estimate material removal rate as the volume of material removed divided by the time taken to cut. The volume removed is the initial volume of the work piece minus the final volume.

VII. MACHINING TIME MEASUREMENTS

Arithmetical Optimize the cutting parameter such as cutting speed, feed rate and depth of cut which considering production rate and minimum production cost.The machining time equation are expressed as below,

$$t_m = \frac{\pi D L}{10 F V}$$

Where,

t_m = Machining time per piece (sec)
D = Diameter of work piece (mm),
L = Length of work piece (mm),
V = Cutting speed (m/min),
F = Feed rate (mm/rev).

and suggests that machining time decreases with an increase in cutting speed.

VIII. METHODOLOGY

i) WORKPIECE MATERIAL
The preferred work piece material for examination is Mild Steel. The chemical compositions are shown in Table 1. In chemical composition percentage of unusual composition is shown also various properties like mechanical properties shown in table 2.

Table 1: Chemical Composition of Mild Steel (MS)

C%	Si%	Mn%	P%	S%
0.16-0.18	0.40	0.70-0.90	0.040	0.040

Table 2: Mechanical Properties of Mild Steel (MS)

Grade	Maximum Strength	Yield Strength	Elongation	Hardness
MS	400-560 MPa	300-440 MPa	10-14 %	130 BHN

ii) CUTTING TOOL MATERIAL

In turning process will be shipping out with Computer Numerical Control under dry cutting conditions. There are different cutting tool materials, which were HSS, Coated carbide insert CNMG 19 06 12 PR will be used.

iii) SELECTION OF PROCESS PARAMETERS FOR EXPERIMENTATION

According to various authors from literature review it is patent that taguchi method is finest to conclude the main effects, significant factors and optimum machining situation to obtain superior performance characteristics, cutting speed, feed, and depth of cut the most in deciding Material Removal Rate (MRR) and Machining Time. Consequently in a study of process parameter optimization of turning process, we have preferred cutting speed, feed and depth of cut as factors for experimentation.

iv) EXPERIMENTAL PLAN

Calculation of optimal turning parameters (speed, feed rate and depth of cut) is based on the Taguchi method to minimize the machining time and maximize the material removal rate (MRR). To accomplish the calculation of optimal cutting parameters, three unusual speeds (210, 290 and 350 RPM) with three unusual feed rates (0.07, 0.13 and 0.21 rev/min) are used to hold out the tests. The computr numerical control machine is used to perform the turning experiment.

v) DESIGNING EXPERIMENTS

Three Three factors and three levels have been selected for experimental work which is shown in below table 3.

Table 3: Table indicating different levels of parameters

Factor	Level		
	I	II	III
Cutting Speed	210	290	350
Feed rate	0.07	0.13	0.21
Depth of cut	1	1.5	2

VIII CONCLUSION

In this study, turing of mild steel (MS) material conduct with given turning parameters painstaking as a cutting speed, feed rate and depth of cut, outcome are obtain the material removal rate and machining time through turning process. The material removal rate mainly affected by cutting speed, feed rate and depth of cut y increasing any one of the material removal rate is increased. Optimization of parameter is conducted by using Taguchi and ANNOVA method. Here we conclude that for obtaining the maximum material removal rate and minimizing machining time, appropriate arrangement of cutting speed, feed rate and depth of cut should be required and minimum elimination of manufactured component in manufacturing company.

IX. ACKNOWLEDGMENTS

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