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Turning Operation of AISI 304L Steel using Taguchi Technique

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Abstract:- The present work is aimed to optimize the Lathe machine turning input parameters like speed, feed and depth of on output parameters like temperature. The experiments are carried out on AISI 304L tool steel work-piece. Twenty seven (27) experiments have been conducted with these input parameters in three different levels & measured for each of the experiments run. Effects of These parameters have been optimized by Taguchi technique. It is observed that for optimal results, it has been found that speed 100 rpm, feed 0.1 mm/rev and 0.4 mm depth of cut are the best combination of this analysis. ANOVA find the significant parameters of the experiments.

***Keywords**:- Taguchi Technique, ANOVA, SN ratio.*

I. INTRODUCTION

A good understanding of the material removal process in metal cutting is essential in selecting the tool material and design. when tool wear reaches at higher value, cutting temperature increases then it starts irregulating the surface. [1] one important aspect during the cutting event is surface regularity and its measurement. the roughness has great significance on the quality and reliability of product. therefore researchers are taking more interest in this to get the accuracy of surface or its prediction or analysis methods. this has been done by take care of many environmental conditions. different modeling ways and techniques were worked-out, which essentially can be classified into four groups: l) analytical models,2) experimental methods, 3) doe (design of experiment)-based methods and 4) ai (artificial intelligence)-based methods [2, 3]. in the way of establishing the functional relationship between the responses (such as surface roughness, cutting force, tool life/wear) and the cutting parameters (cutting speed, feed, depth of cut, nose radius, cutting time, etc.), a large number of tests are needed, requiring a separate set of tests for each and every combination of cutting tool and work piece material.. As a group of mathematical and statistical techniques, response surface methodology (RSM) is useful for modeling the relationship between the input parameters (cutting conditions) and the output variables. RSM saves cost and time by reducing number of experiments required [4]. Surface roughness is a critical and important parameter it becomes essential in several features like tolerance, fatigue, limit, fit etc. [5].The surface regularity in turning operation is affected by a number of factors, such as cutting speed, feed rate, depth of cut, material characteristics, tool geometry, workpiece deflection, stability and stiffness of the machine tool - cutting tool - workpiece system, built-up edge, cutting fluid, etc. There are various parameters used to evaluate surface roughness. In the present research the average surface roughness (Ra) is selected for characterization of surface finish during turning operations, which is the most widely used surface finish parameter in industry. Many authors suggested linear and exponential empirical models for surface roughness as functions of machining parameters by the following. Various methodologies and practices are being employed for the prediction of surface roughness, such as machining theory, classical experimental design, the Taguchi method and artificial intelligence or soft computing techniques [6, 7]. Objective of this research presents the development of mathematical model for surface roughness prediction before turning process in order to evaluate the effect of machining parameters such as feed rate, nose radius and cutting time. Taguchi analysis was used to determine the correlation between a criterion variable and a combination of prediction variables. Xaviour et al. [8] referred ANOVA for the measurement of surface roughness through different oil as a cutting fluid with input parameter of Speed, feed, and depth of cut. Nexhat Qehaja et al. [9] concluded their research on assessment of surface quality. There are different specifications which changes surface quality like velocity, feed, depth of cut and also tool nose radius. Among all research was done by using three parameters feed rate tool nose radius along with machine cutting time. Experiment was performed in dry condition. A statically model designed through response surface methodology was created to optimize the outcomes with the experimental input values. The revealed result validates the regression analysis hence a model can be developed by this technique was concluded in the research. Rapeti et al. [10] experimented the turning of AISI 1040 austenitic steel on the implementation of vegetable oil based cutting fluid having nano particle emulsion. Cutting fluid used were coconut oil, sesame oil, canola oil with0.25%, 0.5%, 1% respectively dispersion of molybdenum disulphide nano particles. Parameters chosen for operation were velocity, feed, rate, nano particle dispersion and base fluid. Taguchi L27 array was applied for designing of operation. Cutting force, quality of surface, Tool-tip temperature and tool wear readings were find out by this experiment.GRA was obtained for optimization of multi objective response. It was raveled with the study that 0.5% diffusion of nano particle in to the coconut oil presents excellent improvement in above all four measurement terms.

II. EXPERIMENTATION

A. Material and set-up

The material used for the work-piece is a high strength alloy steel AISI-304L steel (AISI P-20 tool steel). The chemical Composition of AISI 304L steel is shown in Table 1.

Element	Availability (%)
Carbon	0.03 max
Chromium	18 – 20
Iron	Balance
Manganese	2 max
Nickel	8 – 12
Phosphorus	0.045 max
Silicon	1 max
Sulphur	0.03 max

Table 1. Chemical Composition of AISI 304L steel

The tool insert used in it is of coated carbide insert TNMG 160408 where:

T- Triangular shape
N- Zero clearance angle
M- Tolerances values
G- Hole shape cylindrical 16- Edge length (mm)
04- Thickness of tool (mm)
08-Nose radius (mm)

MAXTURN PLUS+ model of CNC machine was used. This MAXTURN PLUS+ model with Siemens based Sinumeric 828D controller manufactured by MTAB. Self-regulated tool changing facility is available in CNC lathe machine. Machine is having eight tools for inside and outside operation.

B. *Design of Experiment (Taguchi Technique)*

Taguchi's method is a power full design of experiments tool, which provides a simple, effective and systematic technique to determine optimal machining parameters. In this technique reduce drastically the number of experiments that are required to model response function. Traditional experimentation involved one factor at a time experiments, where in one variable is changed while the rest are held constant [8]. It is also impossible to study all factors and determine the main effects in a signal experiment. The main effect is the average value of the response function at particular level of a parameter. The effect of a factor level is the deviation it causes from the overall mean response. Taguchi technique is devised for process optimization and identification of optimal combinations factors for given responses the steps involved are:

Step-1: Identify the main function, side effects, and failure made.
Step-2: Identify the noise factors, testing conditions, and quality characteristics.
Step-3: Identify the objective function to be optimized.
Step-4: Identify the control factors and their levels.
Step-5: Select the orthogonal array matrix experiment.
Step-6: Conducted the matrix experiment.
Step-7: Analyze the data; predict the optimal level and performance.
Step-8: Perform the verification experiment and plan the future action.

Factors and level opted in the experiment is demonstrated in Table 2

	Level		
Factors	1	2	3
Cutting speed(mm/min)	100	200	300
Feed rate(mm/rev)	0.1	0.15	0.20
Depth of cut(mm)	.40	0.60	0.80
Cutting oil	Semi synthetic oil	Rice bran oil	Canola oil

Table 2. Factors and level

C. *ANOVA*

ANOVA is a path to analyze that whether your experiments are finding meaningful or not. It is the way of comparing the difference between two groups. In alternative language it helps you to acknowledged about the working parameter or non-working parameter. In short analysis of variance is an accumulation of assumption and their related procedures to analyze variation between and among groups. ANOVA depends on number of factors. It is easy to use and good for small samples. This method helps in finding out the best appropriate way through its different method that which one is best among all the aspects. ANOVA tells about the influence of every parameter by comparing every sample.

III. RESULT AND DISCUSSION

Experiments are performed, randomly, according to the L27 orthogonal array, on an AISI 304L tool steel. Each experiment used a separate tool insert used. The experimental results for surface irregularity based on L27 orthogonal array is shown in Table 3. Analysis of the result, in fig. 1, this graphs are represent irregularity is minimum with minimum speed and feed. Canola oil s to be inspected best cutting fluid during machining operation. Column effect method some data associated with first level, second level and third level is noted that and difference of largest and smallest of three levels represents —Delta.

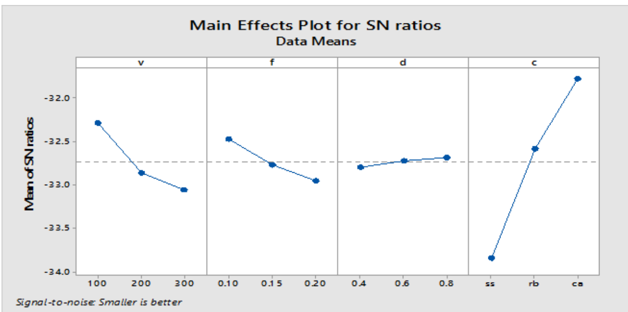

Fig 1:- Main effect plot for SN ratio

Run no.	Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Cutting fluid	Temperature (t) (ºC)
1	100	0.1	0.4	canola oil	35
2	100	0.1	0.6	Rice bran oil	46
3	100	0.1	0.8	Ss	39
4	100	0.15	0.4	Rice bran oil	44
5	100	0.15	0.6	Canola oil	43
6	100	0.15	0.8	Semi synthetic oil	36
7	100	0.2	0.4	Canola oil	40
8	100	0.2	0.6	Semi synthetic oil	46
9	100	0.2	0.8	Rice bran oil	43
10	200	0.1	0.4	Rice bran oil	45
11	200	0.1	0.6	Canola oil	35
12	200	0.1	0.8	Semi synthetic oil	54
13	200	0.15	0.4	Canola oil	42
14	200	0.15	0.6	Semi synthetic oil	57
15	200	0.15	0.8	Rice bran oil	44
16	200	0.2	0.4	Semi synthetic oil	49
17	200	0.2	0.6	Rice bran oil	40
18	200	0.2	0.8	Canola oil	35
19	300	0.1	0.4	Canola oil	40
20	300	0.1	0.6	Semi synthetic oil	48
21	300	0.1	0.8	Rice bran oil	40
22	300	0.15	0.4	Semi synthetic oil	57
23	300	0.15	0.6	Rice bran oil	38
24	300	0.15	0.8	Canola oil	36
25	300	0.2	0.4	Rice bran oil	44
26	300	0.2	0.6	Canola oil	40
27	300	0.2	0.8	Semi synthetic oil	71

Table 3. Analysis of temperature result

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Speed (rpm)	2	102.74	51.370	0.94	0.408
Feed (mm/rev)	2	37.85	18.926	0.35	0.711
Depth of cut (mm)	2	1.41	0.704	0.01	0.987
Cutting oil	2	612.07	306.037	5.62	0.013
Error	18	980.89	54.494		
Total	26	1734.96			

Table 4. Analysis of Variance for Mean data

IV. CONCLUSION

In the present study, the study is carried out on CNC lathe turning machine and parameters on terms of surface irregularity of AISI 304L steel have been studied using Taguchi technique (L27orthogonal Array). The optimal sets of process parameters were obtained. The Conclusions are as follows:

- The conclusion from this study disclosed that, the excellent combination of minimum feed amount and low depth of cut with least cutting velocity is advantageous for surface irregularity reduction.
- Surface irregularity was observed maximum when machining was done under semi synthetic cutting fluid conditions. However, At speed 300 rpm, it is maximum in semi synthetic oil condition, this may be due to improper lubrication at higher speed, but surface good condition is maximum during canola oil.
- The S/N ratio curve plotted that at speed 100 rpm. Feed 0.1 mm/rev and0.4 mm depth of cut surface irregularity is observed minimum for almost all cases.

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