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Optimize The Turning Parameter Using Taguchi Methodology

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ABSTRACT

Turning is a most popular cutting process which is widely used in small as well as large scale industries. The selection of better combination of input parameter be means enhancement in productivity. The aim of this paper is to optimize the turning parameter (cutting speed, feed rate, depth of cut) using Taguchi methodology for minimizing surface roughness. The experiment were performed according to the L_9 orthogonal design matrix on the lathe machine. The result shows that optimal condition of the parameters gives surface finish which is better than initial . The cylindrical turning is a popular metal cutting prceses used in the indusrties to removed unwanted material in desired workpiece material.

Keywords : Turning, Cutting, Taguchi, Roughness , Optimization , ANOVA, Experimentation

I. INTRODUCTION

Cynindrical turning is a metal cutting operation use in each and every production to increase the productivity ,reliability and quality of the object . The cylindrical turning is a metal cutting operation is use to remove extra unwanted material in desired workpiece during turning of any garde material workpiece or any material workpiece . In this cylindrical turning performed on the centre lathe machine remove extra material in form of chips .During this operation single point cutting tool which is only one cutting edge remove the extra unwanted material in form of chips .This operation is performed in the centre lathe machine remove the extra mareial [1,2].Turning is primary metal cutting operation is remoeved the material and increase surface finish of an object . Turning operation is used to remove the unwanted material desired workpiece in form of chips. The general turning operation is involves to rotating workpiece hold in three jaw chuck in a centre lathe machine.In most cases tool fixed in centre lathe machine at 90 º angle .The point cutting tool in one cutting edge remove the workpiece material in form of chips [3,4].Turning proceses is remove the internal as well as eexternal diameter of the cylindrical rotating objects. The surface quality of the workpiece material is mostly depend upon the various input parameters give on the lathe machine. The input parameters of a as cutting speed , depth of cut , feed rate its effect directly and indirectly surface quality of an object [4,5].

The turning operation is most popular indusatrial process for machining of circular object .In production industries are facing more and more difficulties like clamping ,holding ,chattering /vibration and dynamic instabilities etc.[5,6].Turning generally axially symmetric with a single point cutting remove the extra material in form of a desired shape and size .It is metal removing process used in each industries removed extra unwanted material in form chips .Due to important of turning operation resarchers always make effort to improve the efficiency of a product al low cost .Thesse operation enhance the productivity , quality , reliability af an objects . [7,8]. It is a metal removal process perfomed in diiferent type of lathe machine.Turning is used machining of conventional as well as advanced and difficult –to machine engineering materials . It is type of cutting technology reduce the material in form of chips desired shape and size[8,9].These proceses is largely used in manufacturing industries to cut a material from the both surface i.e external as well as internal .The turning is metal cutting proceses reduce the material in in form of a desied shape and size .

II. LITERATURE REVIEW

The performance of turning process were analysed by various researcher to identify the significant parameter. Manoj et al. [10] performed Turning operation on lathe machine consider input parameter (cutting speed, depth of cut, feed rate) to produce good surface finish. Further they determine optimum value of Ra using Taguchi and Anova methodology.Hassan and Afzal et al. [11] performed turning operation of stainless steel workpiece. They conducted experiment on Lathe Machine using a hybrid whale optimization algorithm. (Cutting speed, Depth of cut, Feed rate) consider as a input parameter as performed as output as a good surface finish in an optimum condition. The application of Taguchi approach for optimization of the control parameter related to the different machining processes was tested by many researchers [12-14]. Yang et al. [15] optimized the cutting parameters related to the turning operation using Taguchi approach. Nalbant et al. [16] optimize the control parameters such as nose radius , feed rataind depth–of–cut to minimize the surface roughness of the turned parts. The optimum level of cutting parameters for minimum value of the cutting force and surface roughness were determined using Taguchi method during turning of cast Iron .Asiturk and Akks [18] used L_9 orthogonal array to optimize surface roughness during hard turning of the AISI4140 steel. Thamizhmani et al. [19] were also optimized the parameter related to the turning operation using Taguchi approach.Therefore, the Taguchi based optimization technique has been applied to optimize the process parameter of the dual turning process. The aim of the present study is to optimize the control parameters of the turning process. For this, experiments were performed in the centre lathe machine. All the experiment were performed according to the L_9 Design matrix considering the effect of cutting speed, feed rate, depth of cut on the average surface roughness (Ra). The analysis of variance (ANOVA) technique has been used to analysis the experimental data and also discusses the most influential turning parameter.

III. EXPERIMENTATION

All the experiment is perform on the centre lathe machine (Manufactured by Payal machine tool). The workpiece is held into three jaw chuck in centre lathe machine.The experimental setup shown in centre larhe machine as Figure-1

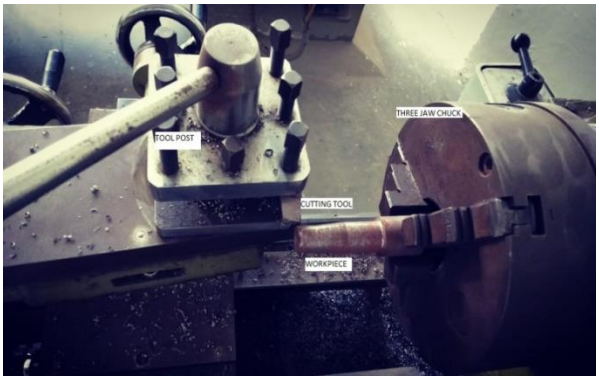

Figure- 1 Experimentation on Centre Lathe Machine

The experimentation Alloy steel AISI1040 (UNSG10400) is consider as workpiece material. This alloy steel is used in couplings crankshaft and cold headed parts. The diameter of workpiece is taken 30mm for easy to hold in three jaw chuck in a centre lathe machine for the turning operation. In this experiment single point cutting tool used to cut the material in specified dimensions.This single point cutting tool is one cutting edge penetrate the workpiece material to cut the desired shpe and size.In this experiment used the cutting tool made of a HSS material easy to cut a AISI1040 alloy steel .This cutting tool material is very high hot hardness capacity easy to cut a workpiece as very high cutting speed .This experiment performed on a centre lathe machine .The workpiece material AISI1040 alloy steel hold in the three jaw chuck on acentre lathe machine .The single point cutting tool made of HSS material remove the extra unwanted material from the desired shape and size .This experiment obtained the data from one Way ANOVA analysis of variance and optimize process parameter using the Taguchi Methodology .The result show that surface roughness Ra optimal condition better than initial condition .This Ra surface roughness meaure by the help of TR-200 surface measuring instrument .

Figure-2 TR -200 Measuring Instrument

The Experiment three parameter are selected for turning of Alloy Steel (AISI1040) the range and Level of each parameters summarised in Table -3

Table-1 Range and Level of each Parameter

Parameter	Symbol	Level-1	Level -2	Level-3
Cutting Speed (mm/min)	V	20	30	40
Feed rate (mm/rev)	F	0.25	0.5	0.75
Depth of cut (mm)	D	0.5	1	1.5

To optimize process parameter minimized Ra surface roughness .The process parameters is (cutting speed, feed rate, depth of cut) optimize using Taguchi approach, a well- known L_9 orthogonal design matrix for four –factors with three level is select to perform the experiments. The signal (S/N) ratio is use to analyse the experiment results. The analysis of variance (ANOVA) technique is apply to check the feasibility of the experimental results and the percentage contribution of each factor. Generally three quality characteristics such as “nominal is better”, “higher is better” and “lower is better” are used to analyse the experimental results. In present study, the surface roughness has been taken as response parameter [23]. Therefore the “lower is better” quality characteristic has been use to analyse

the experimental results which can be determined as [21, 22].

$$S/N = 1/n\sum_{i=1}^{n} y_i 2$$

Where y_i = observed response or quality value at the *i*the experiment run order and n=number of trials at the same level of the parameters.

A Data Collection

This experiment show analysis of experiment data total 9 – number of experiments is conduct on centre lathe machine. The Taguchi based L_9 orthogonal design matrix is use to optimize the experimental data [31]. The experimental observation with the S/N ratio for each factors summarised in Table-2

S.No	V	F	D	Ra_1	Ra_2	Ra_3	Ra (ave)	S/N ratio
1	1	1	1	1.60	2.10	2.90	2.2	4.84
2	1	2	2	1.45	2.15	2.45	2.01	4.04
3	1	3	3	1.25	2.00	2.02	1.75	3.06
4	2	1	2	1.40	2.10	2.80	2.1	4.41
5	2	2	3	1.90	2.45	3.80	2.71	7.34
6	2	3	1	1.10	2.15	2.66	1.97	3.88
7	3	1	1	1.15	2.65	2.40	2.06	4.24
8	3	2	3	2.00	2.50	3.00	2.5	6.25
9	3	3	2	2.00	2.16	3.16	2.44	5.9

B Analysis of Variance (ANOVA)

Check the feasibility and accuracy of the experiment result analysis of variance (ANOVA) technique applied. Generally, ANOVA is a statistical technique used to analyse the experimental observation data collect by the experimenter using standard experimental techniques. This is widely used to separate the total variability established between the random and systematic parameters. It is also used to determine the impact of independent variables on the dependent variables during analysis of the regression models [10,21]. There are many test used to know the adequacy of data such as sum of square (SS), degree of freedom (DF), Mean sum of square (MSS), Mean square error (MSE), F-valuetc. Therefore, ANOVA analysis has been carried out and summarised in the Table -3

Group	Count	Sum	Average	Variance
Column-1	9	270	30	75
Column-2	9	4.5	0.5	0.046875
Column-3	9	9	1	0.1875

Table -4 ANOVA Results

Factor	SS	DF	MSS	F-value	p-value	F-Critical
V	77.04	2	38.52	1.44	1.84E-10	2.816708
F	1711.5	2	855.7	32.08		
D	77.04	2	38.52			
R	53.34	2	26.67			
Total	**1918.92**	8	959.41	959.41		

C Analysis of Data Using Taguchi Methodology:

Taguchi Methodology is a statistical technique that used to optimize the single as well as the multi objective optimization problem. It needs to perform the experiments according to the orthogonal design matrix. Therefore the total 9 – number of the experiment observations summarized in Table 4 are analysed to find the S/N ratio of each factor using equation (1). Generally, S/N ratio are used to identify the rank and optimal cutting condition for each controlled parameter. The S/N ratios for each factor with their level and respective ranks are summarised in Table 7. It has been observed by (Table 4) that rank of the each control parameter (based on S/N ratios) are as cutting speed (1), feed rate (2), depth of cut (3).

Instead of this the optimal level of the control parameters i.e Cutting speed (mm/min). Feed Rate (mm/rev), depth of Cut (mm) are as Level 1, Level 2, Level 3respectively. Thus it has been decided that the optimal combination of control parameter as $V_2F_2D_3$ has been more suitable for the better quality [32-36].

TABLE 5: Effect of factors level on the S/N Ratio

Factor		S/N ratio		Delta Max-Min	Rank
	Level-1	Level-2	Level-3		
V	3.98	5.211	4.84	1.23	I
F	4.49	5.87*	4.29	1.58	II
D	4.32	4.8	5.55	1.23	III

*optimum value

D Experimental Validations

Experiment have been carried out on the same cylindrical workpiece material as AISI(1040) alloy steel. Firstly the experimental validation has been conducted at the optimal condition of the parameter obtained by Taguchi's methodology as cutting speed =40mm/min, Feed rate =0.5 mm/rev, Depth of Cut =1.5mm. The Ra value obtained at optimal condition of control parameter has been compared with Ra value obtained at initial set condition of parameters such as speed =20mm/min, Feed Rate =0.25mm/rev, Depth of cut =1.5mm the comparative analysis of Ra values at different Turning condition has been summarised in Table -9

TABLE 6: Comparative Analysis of Ra

Response	Initianal Condition	Optimum Condition
Level	$V_1F_1D_1$	$V_3F_2D_3$
S/N ratio	4.01	2.85
Ra(μm)	2.84	1.40

Percentage of improvement in S/N ratio =70%

Percentage of improvement in Ra value =50%

In has been observed Table 8 that the optima combination of input parameter gives better surface finish as compared to the initial combination of input parameter for the turning of a alloy steel (AISI1040). In similar way the S/N ratios also improved sat the optimal condition between the parameters. The percentage improvements (at optimal condition) in the S/N ratio and in the Ra value are as 50% and 70% respectively. The initial and optimal value of Ra as shown in Figure-6

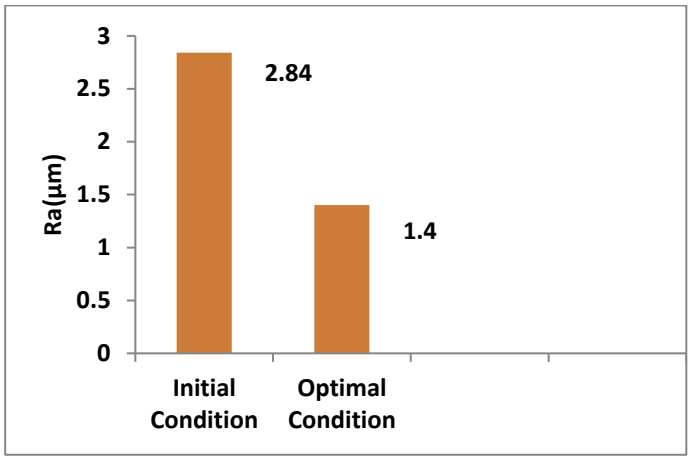

Figure -3 Comparisons between Initial and Optimal Ra(μm)

The Initial and optimal value of the surface roughness shown in the Bar Chart as shown in Figure-4

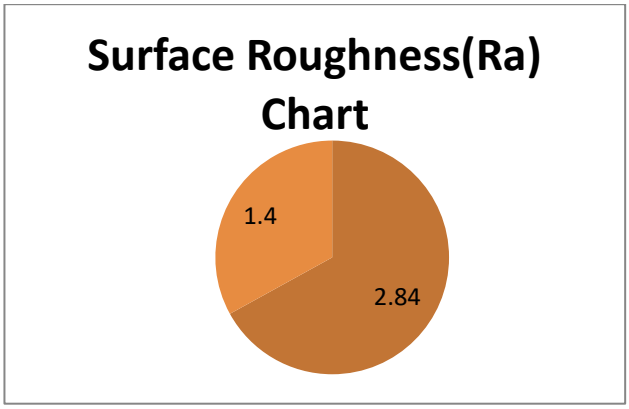

Figure -4 Pie Chart Initial and Optimum Value of Ra (μm)

IV. CONCLUSION

In present study an effort has made to optimize the process parameter for minimization of the surface roughness during the turning of AISI 1040 alloy steel. The effect of the controlled parameter such as cutting speed, feed rate, depth cut has analysed on the average surface roughness using Taguchi optimization technique. After careful analysis, following conclusion have been drawn.

1. The cutting speed is very important parameter `cutting directly and indirectly surface finish during turning of Alloy Steel 1040.
2. The primary depth of cut is low (among all the process parameter) effect on the surface finish within the range of the selected input parameters.
3.The optimum combination in between the control parameters as $V_3F_2D_3$ is obtaine with the range of the selected input parameters.
4. The depth of cut is low (among all the process parameters) effect on the surface finish within the range of the selected input parameter.
5.The S/N has been improved (approximately 70) at contribution of parameter as compared to the initial condition of controlled parameter.
6. The optimal combination of the input parameter gives better surface finish as compare to initial se parameters
7.The percentage improvement in surface finish at optimum level of controlled parameter is 50% higher is obtaine as compared to the initial parameters condition of the normal turning of AISI1040.

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