ELK
Asia Pacific Journals

ELK Asia Pacific Journals – Special Issue
ISBN: 978-81-930411-8-5

INVESTIGATION AND OPTIMIZATION OF SURFACE ROUGHNESS IN TURNING OF C-45 ALLOY STEEL BY USING TAGUCHI METHOD

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Abstract-

The purpose of this research paper is focused on determining the optimum process parameters in order to get minimum surface roughness or maximum surface finish in turning of C-45 alloy steel using Taguchi method.The experiment was conducted by using Taguchi method and for three factor, three level L-9 Taguchi orthogonal array was used in order to perform the nine experiment. The result was analyzed by using well known technique ANNOVA.Taguchi method shown that feed rate has most significant parameter to produced minimum surface roughness in turning of C-45 alloy steel followed by cutting speed, depth of cut has insignificant effect on surface roughness. Analysis of variance shown that feed rate has major percentage contribution on surface roughness followed by speed and depth of cut respectively.

Keywords: HMT-Lathe, Turning, C-45 alloy steel, surface roughness, Taguchi method, ANNOVA

I. INTRODUCTION

One of the most important area in which modern machine industry is focused on achieving the high quality of work, Increasing productivity and production rate, reducing manufacturing lead time, reducing surface roughness, increasing surface finish, increasing material removal rate, reducing component of cutting forces, reducing power consumption during machining and hence reducing specific energy consumption in order to achieve maximum output at minimum effort [1].Turning is one of the most famous and oldest method which is frequently adopted by the manufacturing industries for metal cutting [2]. It is simplest and efficient machining process which are most widely used for machining of external surface of rotating cylindrical work piece [3]. In turning operation a single point cutting tools are used to remove the unwanted materials from the surface of rotating cylindrical work piece [4]. In this Operation the cutting tools are feed linearly in a direction parallel to the rotational axis of the cylindrical work piece.Thamizhmaniiet. al. [1] had conducted experiment on SCM440 alloy steel work piece to analyze surface roughness by turning process. They were conducted 18 experiments and used Taguchi and analysis of variance (ANOVA) to analyze the data. They find that depth of cut has most significant factor which affect the surface roughness.Valera et.al. [2] Conducted experiment on EN-31 alloy steel with Tin+Al_2+TiCN coated tungsten carbide tool to analyze power consumption and surface roughness by turning process. They found that feed rate has more impact on surface roughness. Kumar et. al. [3] was mainly focused on optimize the machining parameters for optimum surface finish in turning of EN-19 steel by using Taguchi method. They are take feed rate, cutting speed and depth of cut as an input parameters and used signal to noise ratio(S/N ratio) and analysis of variance (ANOVA) to analyze the data. They conclude that feed rate has greater effect on surface finish. Yang & Tang [4]they are mainly focused on optimization of machining parameters for surface roughness in turning operation. They take speed feed depth of cut as an input parameter in order to find there's effect on process parameters. Taguchi and signal to noise ratio are used to analyze the process parameters from there experiment they found that feed has maximum effect on surface roughness.

In year 1950 Dr. G. Taguchi give the method to design the system with high quality and performance in order to increase the efficiency, effectiveness and productivity of the manufacturing society by reducing the losses associated with the production. It is a simple, systematic and user friendly, one should be used without the too much knowledge of statics [1, 3, 4, 5 and 6].One of the most significant criteria used by Taguchi in his method to analyzing the experimental data is signal to noise ratio which is frequently called S/N ratio [6].In case of surface roughness smaller is the better quality characteristics of S/N ratio give optimum surface finish.

Nominal is the better:

$$\frac{S}{N_T} = 10log\frac{y}{S_y^2}$$

Larger is the better:

$$\frac{S}{N_L} = -10log\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_i^2}\right)$$

Smaller is the better:

$$\frac{S}{N_S} = -10log\left(\frac{1}{n}\sum_{i=1}^{n}y_i^2\right)$$

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II. EXPERIMENTATION

1. Work Material

The work material C-45 alloy steel with maximum carbon solubility of (0.45%) is categories in the category of medium carbon steel. this type of steel are normally used for the engineering application due to its high strength and toughness. To find the wide application in manufacturing of connecting rod, crank shaft and power drives [5].

Figure.: C-45 alloy steel

Quantity	**Value**	**Unit**
Young's modulus	20000	Mpa
Tensile strength	650-880	Mpa
Elongation	8-25	%
Fatigue strength	275	Mpa
Yield strength	350-550	Mpa

Table:1Mechanical Properties of C-45 alloy steel

Quantity	**Value**	**Unit**
Thermal conductivity	25	w/m.k
Specific heat	460	J/kg.K
Melting temperature	1450-1510	^{0}C
density	7700	Kg/m^3

Table:2 physical properties of C-45 alloy steel

2.Preparationof job and experiment performed

Hindustan machine tool lathe was used for this purpose. The shape and size of work piece is depend on the availability. In order to perform the turning operation the shape of the work piece must be cylindrical. First of all initial turning is performed on to the cylindrical work piece in order to make the uniform diameter throughout its length and removing the rough surface from its outer periphery. After performing initial turning the diameter of the work piece is reduced from 35 mm to 33 mm which is measured with the help of digital vernier caliper. The length of the job was 52.2 cm and 9 slots has been created at a distance 22 mm in order to make nine individual work piece on the samejob.

Figure: setup of work piece on HMT lathe

Parameters	Designation	Level-1	Level-2	Level-3
Speed	A	325	550	715
Feed	B	0.08	0.12	0.16
Depth of cut	C	0.4	0.8	1.2

Table:3 Parameters and their levels

3.Orthogonal array selection: Appropriate selection of orthogonal array was depends on number of process parameters and their levels, for three factor three level L_9 Taguchi orthogonal array was used.Signal to noise ratio and experimental layout of L_9 Taguchi orthogonal array for nine experimental run to determine optimum surface roughness was shown in table-5

4.Determination of surface roughness:

After removing the material from outer periphery of nine cylindrical work piece corresponding to the given speed, feed and depth of cut, now the surface roughness of nine work piece was measured with the help of HANDYSURF type surface roughness tester.

Figure: Handysurf surface roughness tester

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III. RESULT AND DISCUSSION

Table:4 Response table for S/N ratio in case of surface roughness

Level	Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)
1	-7.499	-3.404	-6.527
2	-6.275	-5.591	-5.980
3	-4.336	-9.115	-5.603
Delta	3.162	5.712	0.923
Rank	2	1	3

Table:5Value S/N ratio and mean for surface roughness

Speed	Feed	Depth of cut	Ra(µm)	S/N ratio	MEAN
325	0.08	0.4	2.16	-6.6891	2.16
325	0.12	0.8	2.32	-7.3098	2.32
325	0.16	1.2	2.66	-8.4976	2.66
550	0.08	0.8	1.25	-1.9382	1.25
550	0.12	1.2	2.17	-6.7292	2.17
550	0.16	0.4	3.22	-10.157	3.22
715	0.08	1.2	1.20	-1.5836	1.20
715	0.12	0.4	1.37	-2.7344	1.37
715	0.16	0.8	2.72	-8.6914	2.72

From the response table of S/N ratio in case of surface roughness, it could be see that maximum value of signal to noise ratio (-4.336) for cuttingspeed occurs at level-3A (715rpm), maximum value of signal to noise ratio (-3.404) for feed rate occurs at level-1B (0.08mm/rev) and maximum value of signal to noise (-5.603) for depth of cut occurs at level-3C (1.2mm).

From the main effect plot of S/N ratio, as cutting speed increases from (325 to 550rpm), S/N ratio increases continually beyond which it is also increases hence optimum level for cutting speed is level-3A (715rpm) in turning of C-45 alloy steel.

From the main effect plot of S/N ratio, as the feed rate increase from (0.08 to 0.12), S/N ratio decreases continually beyond which it is also decreases hence optimum level for feed rate is level-1B (0.08 mm/rev).From the main effect plot of S/N ratio, as depth of cut increase from (0.4 to 0.8mm), S/N ratio increases continually beyond which it is also increases hence optimum level for depth of cut is level-3C (1.2 mm).

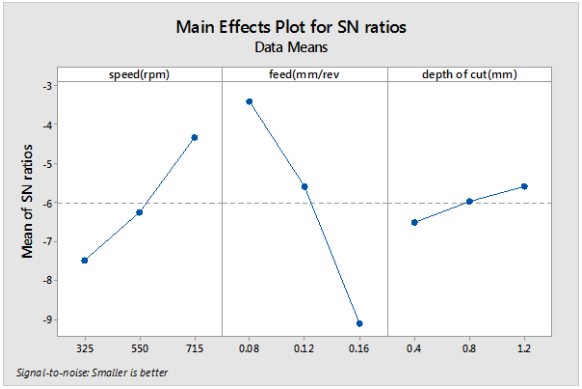

Table:6Analysis of variance (ANOVA) for surface roughness

	DOF	SS_P	SS_m	F-ratio	%
Speed	2	15.25	7.62	1.10	19.03
Feed	2	49.82	24.91	3.62	62.17
Depth of cut	2	1.29	0.64	0.09	1.61
Error	2	13.76	6.88	1	17.17
Total	8	80.14			

- From ANOVA table the percentage contribution of cutting speed, feed rate and depth of cut on surface roughness was 19.0364%, 62.1776% and 1.6104% respectively.
- Percentage contribution of feed rate is much larger than that of cutting speed and depth of cut hence feed rate has most significant process parameter affecting surface roughness in turning of C-45 alloy steel.
- The variation of depth of cut in the range taken in the experiment has an insignificant effect on surface roughness.
- From ANOVA table it could be see that F-ratio for cutting speed, feed rate and depth of cut are 1.1085, 3.6209 and 0.0939 respectively. Fisher ratio for feed rate is much larger than that of cutting speed and depth of cut hence feed rate has most significant process parameters among all.

Regression equation for surface roughness: Surface roughness (**µ**m) = 1.176- 0.001532 cutting speed + 16.63 feed rate - 0.300 depth of cut

Taking the optimum value of cutting speed (rpm), feed rate (mm/rev) and depth of cut (mm) for surface roughness.

Putting these value in surface roughness regression equation:

Surface roughness (**µ**m) = 1.176 – (0.001532*715) + (16.63*0.08) – (0.300*1.2) = 1.05102**µ**m

Table: 7Confirmation table

	Experimental	Taguchi Result	Reduction in Ra
Factor	A3B1C3	A3B1C3	
Ra (µm)	1.20	1.05102	0.1489

IV. CONCLUSIONS

In surface roughness it was found that Feed rate has most significant process parameter followed by cutting speed and depth of cut was insignificantly effect the surface roughness in turning of C-45 alloy steel.The optimum level of process parameters such as cutting speed, feed rate and depth of cut for surface roughness was level-3A (715rpm), level-1B (0.08mm/rev) and level-3C (1.2mm) respectively.The percentage contribution of process parameters such as cutting speed, feed rate and depth of cut for surface roughness was 19.0364%, 62.1776% and 1.6104% respectively.

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