Application of Taguchi Method in the Optimization of Cutting Parameters for Surface Roughness in Turning on EN-362 Steel

Sandeep Kumar
M. Tech Student
University Institute of Engineering & Technology Kurukshetra University, Kurukshetra

Manjeet Bohat
Assistant Professor
University Institute of Engineering & Technology Kurukshetra University, Kurukshetra

Abstract

This paper point of the optimizing the cutting parameters for the surface roughness obtained in turning operation using taguchi technique. The array, the signal-to-noise ratio, and analysis of variance are employed to study the performance characteristics of EN 362 steel bars using tungsten carbide cutting tools Mainly cutting parameters namely, insert radius, feed rate, and depth of cut, are optimized with considerations of surface roughness. Experimental results obtained are established to illustrate the effectiveness of this approach.
Keywords: Turning, Surface Roughness Taguchi Techniques, Orthogonal Arrays, Analysis Of Variance (ANOVA)

I. INTRODUCTION

In a machining process, turning operation is an important operation to remove the material from the work piece. In present scenario, manufacturing industry are growing day by day. The main target of any organisation is to get more and more profit by minimum cost. For achieve the economic objective, it is also an important to select cutting parameters for getting high cutting performance. It can achieve minimum production cost, minimum production time. [1]This type of material used to manufacture a component which has better reliability and surface roughness. It should be surface integral with economic time structure. [2] There are many factors that affect surface roughness during the operation. Machine shop can't get the targets without knowing that how it can operated in desired optimal conditions and it is done by proper selection of cutting tool parameters and optimal conditions and a methodical approach by experimental methods, mathematical as well as statistical models. It also requires design experiments and analyse data. [3] Surface roughness is an important parameter as it is very useful to prevent impulsive fatigue failure, and to increases corrosion resistance. It also helps to increase product life. [4]Taguchi method is very useful to examine effect of turning parameters. It studies alteration and range analysis open. Feed rate is main turning parameter effecting surface roughness, tracked by cut speed, while depth of cut display negligible influence [5]. The surface roughness improve with the increase of feed rate and it decreases with the increase of work piece hardness. We can say that, the depth of cut, work piece hardness and feed rate are the three main machining parameters that affect the cutting forces. The optimal machining conditions can produce the lowest surface roughness. [6]In Taguchi method, for L9 orthogonal array taken for three different levels of cutting speed, feed rate and depth of cut, taguchi could reduce a list of experiment in the same operation. It could design optimum cutting conditions for satisfying results that may be helpful in future theoretical and manufacturing studies. [7]Taguchi method offers a modest, regular, and effective methodology which world will use to optimize the cutting parameters. The insert radius and feed rate are also main parameters like as three other factors (insert radius, feed rat output performance characteristics e and depth of cut) which affect the surface roughness in case of ATST 1030 carbon steel. [8] It is found that when feed rate increase the surface roughness also improved. Feed rate is one of the important parameter which produces greater impact on surface roughness tracked by cutting speed. [9] It is examine, contact effect of one input parameter over another parameter to finding their effect on output performance characteristics. It can be find impact of single parameter on the output performance characteristics [10]

In this paper, turning of EN 362 is considered in dry cutting conditions. The effect of the three cutting parameter including cutting speed, feed rate, and depth of cut, on surface roughness (Ra) is examined by using Taguchi technique. Orthogonal array and signal-to-noise (S/N) ratio are used for experimental proposal and data investigation.

II. EXPERIMENTAL METHODOLOGY

A. *Work Material*

The work specimens nominated for experiment are EN 362 two bars of 300mm long and 32 in diameters.

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Table – 1
Material description: En 362 steel

ELEMENT	*C*	*Si*	*Mn*	*Cr*	*Mo*	*Ni*
WEIGHT IN %	*0.98*	*0.20*	*0.70*	*0.60*	*0.68*	*0.12*

B. Cutting Tool

We use the tungsten carbide insert as cutting tool material. It is a composite material. It consists of a hard material and a relatively soft binding material. It is very hard material. It has high wear resistance and high hot-hardness. It is in rectangular shape.

C. Surface Roughness Measurement

Surface roughness can affect a lot of the product's functional attributes of a machined product, like contact causing surface friction, wearing, light reflection, heat transmission, ability of distributing and holding a lubricant, coating, and resisting fatigue [11]. There are many ways to describe surface roughness. One of these is average roughness which is quoted as Ra defined as the arithmetic value of the departure of the profile from the centreline along sampling length. It can be shown in mathematical relationships [12].

$$R_a = \frac{1}{L}\int_0^L |Y(x)|\, dx$$

Where R_a = the arithmetic average deviation from the mean line,
Y = the ordinate of the profile curve

The surface roughness is measured by digital portable surface roughness tester .it's easy to use and its reading accuracy is better than any other.

III. EXPERIMENTAL PROCEDURE

The experiment performed on the basis of L16 orthogonal array design with three process parameter cutting speed, feed rate, depth of cut for surface roughness. The experimental setup work piece for turning EN-362
Experimental Conditions

Table - 2
Experimental Setup

Machine tool	HMT lathe machine
Work material	EN-362, 600mm in length and 32 mm in diameter
Inserts	Tungsten carbide
Noise radius	0.4 mm
Cutting speed	420 rpm, 550 rpm, 715 rpm, 930 rpm
Feed rate	0.04 mm/rev, 0.06 mm/rev, 0.08 mm/rev, 0.10mm/rev.
Depth of cut	0.1 mm, 0.3 mm, 0.5 mm, 0.7 mm
Size	Diameter = 32 mm and Length =600 mm

IV. EXPERIMENT DESIGN

In past decants, experiment design approaches were very large and not easy to use. Numbers of experiment were increase by increase the machining parameters. In that condition it is not easy to optimise the results of these experiments. Therefore, numbers of factor affected on the off-line quality improvement [13]. But now one of the best experimental techniques which help in reducing the number of experiments using orthogonal arrays knows as taguchi method. It is also help to improve quality in the design phase. Taguchi method saves time and money [14]. It is also use to design parameter levels for quality characteristic. It is able to arrange number of factors in appropriate order to finding the better results from them. Taguchi method has lots of significant in quality engineering [15]. In this experiment with three factors at four levels each, the fractional factorial design used is a standard L_{17}orthogonal array. This orthogonal array is selected for checking the capability between the interacting factors. One trial is represented by the each row of the matrix. The experiment is randomized in these trails.

V. RESULTS AND DISCUSSION

Table – 3
Cutting parameter and their levels

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Levels	S/Speed (rev/min)	Feed Rate (mm/min)	Depth of Cut (mm)
1	420	0.04	0.3
2	550	0.06	0.5
3	715	0.08	0.7
4	930	0.10	0.9

Table - 5
L16 Orthogonal Array

SR No	Speed (rpm)	Feed rate mm/rev	depth of cut (d)	Surface roughness (Ra) (μm)	S/N Ratio
1	420	0.04	0.3	1.465	-3.3168
2	420	0.06	0.5	1.276	-2.1170
3	420	0.08	0.7	2.345	-7.4029
4	420	0.10	0.9	3.048	-9.6803
5	550	0.04	0.5	1.847	-5.3293
6	550	0.06	0.3	1.175	-1.4008
7	550	0.08	0.9	2.149	-6.6447
8	550	0.10	0.7	2.032	-6.1585
9	715	0.04	0.7	1.034	-0.2904
10	715	0.06	0.9	1.133	-1.0846
11	715	0.08	0.3	1.407	-2.9659
12	715	0.10	0.5	2.214	-6.9036
13	930	0.04	0.9	2.071	-6.3236
14	930	0.06	0.7	2.475	-7.8715
15	930	0.08	0.5	2.189	-6.8049
17	930	0.10	0.3	3.197	-10.0949

The experiments are carried out in such orthogonal array arrangement. Different levels of each factor in this experiment appear in the same frequency. It ensures that degree of freedom is in the statistical sampling. This method helps to technical and sensible grouping of different levels of factor. S/N ratios are assumed with randomized experiments, for making the experimental results more reliable. Surface roughness measure by using cutting speed, feed rate and depth of cut. The surface roughness was measured by varying the machining parameters and the corresponding values. The statistical analysis is done using MINITAB (version17) software for obtaining the main effect, interaction effect and graphs. The surface roughness plots for means and signal to noise ratio.

Table – 6
Response Table for Signal to Noise Ratios (Smaller is better)

Level	Speed	Feed Rate	Depth of Cut
1	-5.629	-3.815	-4.445
2	-4.883	-3.118	-5.289
3	-2.811	-5.955	-5.431
4	-7.774	-8.209	-5.933
Delta	4.963	5.091	1.489
Rank	2	1	3

Table – 7
Analysis of Variance for SN ratios

Source	DF	Adj SS	Adj MS	F-Value	P-value	% contribution
Speed	3	50.373	16.791	4.84	0.048	36.18
Feed	3	63.416	21.139	6.09	0.030	45.55
Depth of cut	3	4.590	1.530	0.44	0.732	3.29
Error	6	20.835	20.835	3.473		14.98
Total	15	139.214				

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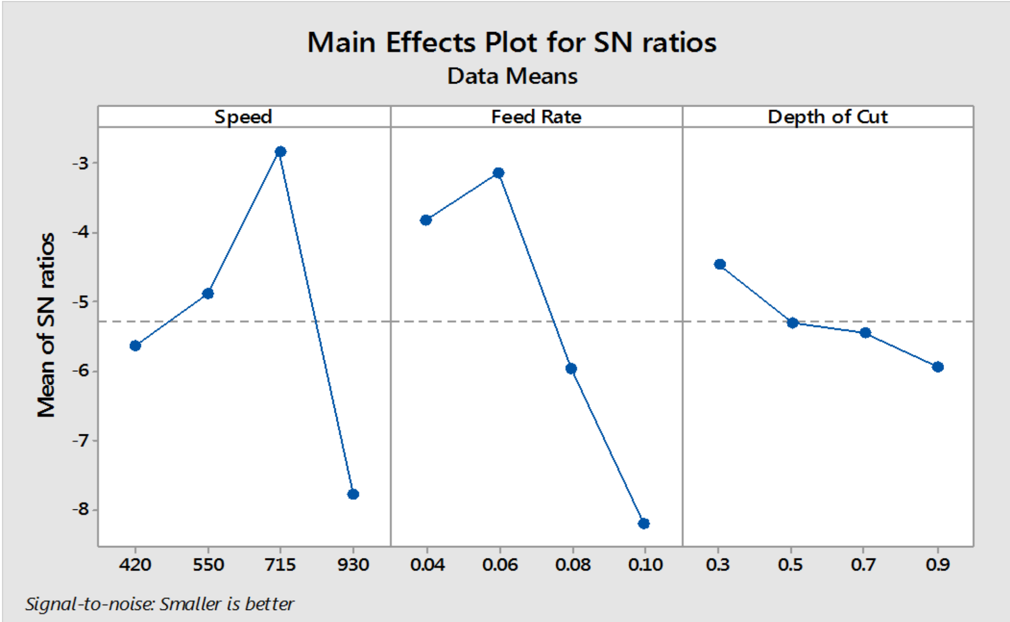

Fig. 1: Main Effects Plots for SN ratios

Table - 8
Response Table for Means

Level	*Speed*	*Feed Rate*	*Depth of Cut*
1	*2.034*	*1.604*	*1.811*
2	*1.801*	*1.515*	*1.882*
3	*1.447*	*2.023*	*1.972*
4	*2.483*	*2.023*	*2.100*
Delta	*1.036*	*1.108*	*0.289*
Rank	*2*	*1*	*3*

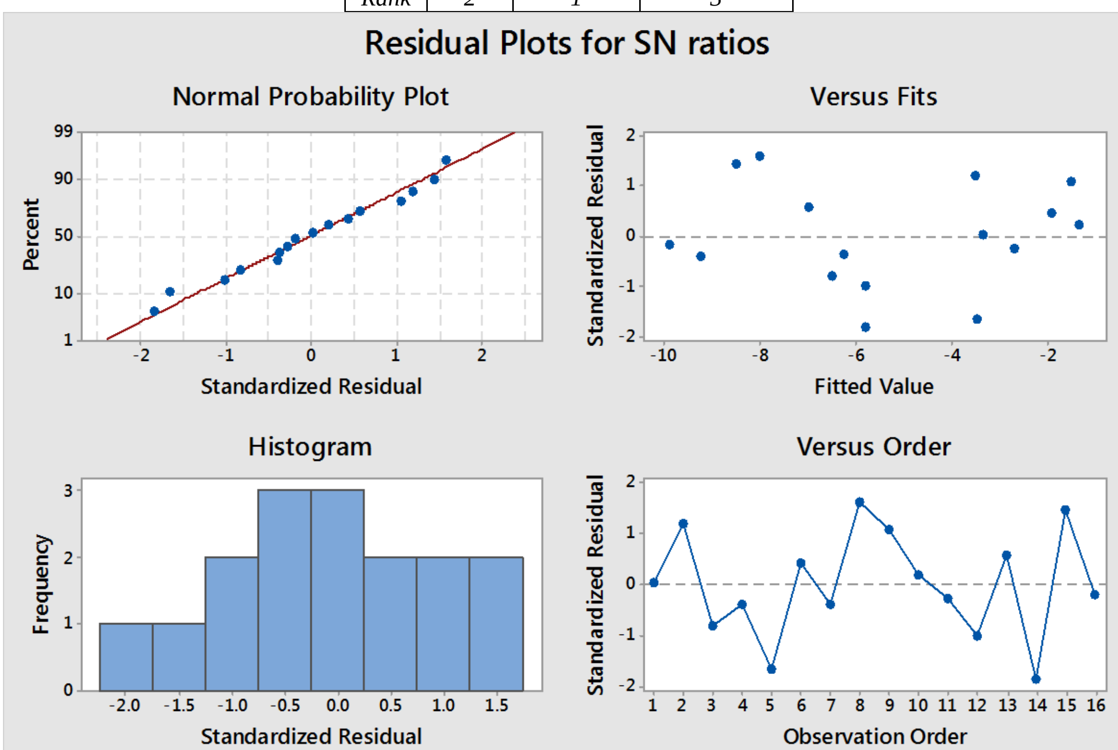

Fig. 2: residual analysis for Surface Roughness

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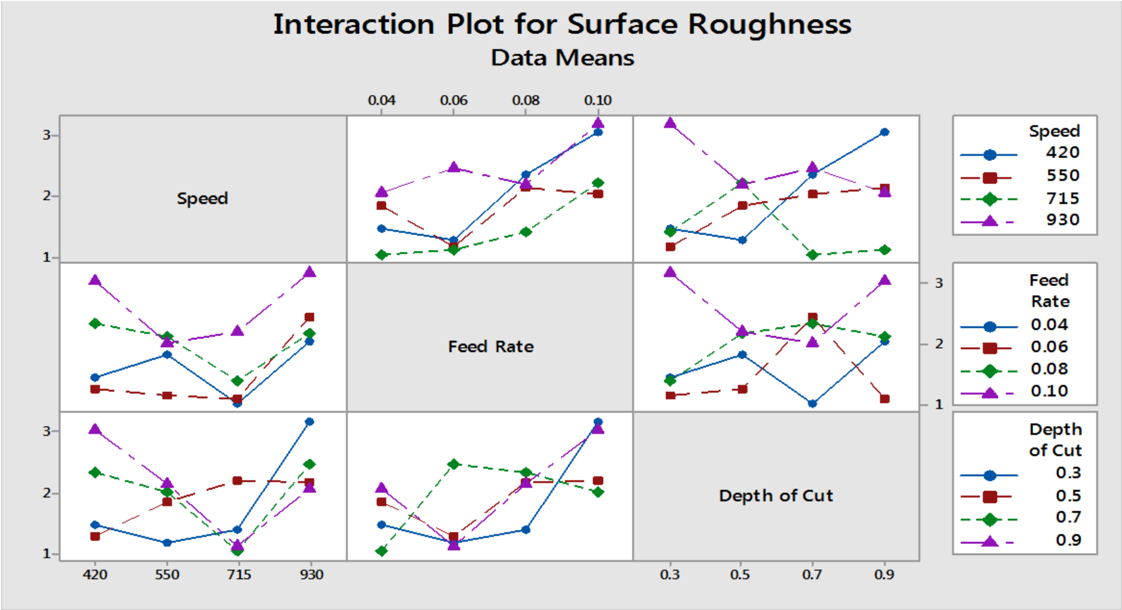

Fig. 3: Interaction Plot for SN ratio for Surface Roughness

VI. CONCLUSION

In this experiment, the statistical methods of signal-to-noise (S/N) ratio and the analysis of variance (ANOVA) are applied to calculate the effects of cutting parameters on surface roughness and to find the optimal condition for better surface roughness found in turning of EN 362. The output from this study are given below.

This results again showed that for one more time again, taguchi technique is a design and analysis of experiment method that can be implemented in industrial and academic researches effectively. The smallest value of surface roughness is found in after the optimization of all parameter which use in this experiment. This experiment show the effect of primary parameter on the surface roughness. The feed rate is most significant factor which contributes to the surface roughness 45.55% subsequently followed by speed which contributes 36.18% and depth of cut has least significant factor contributes 3.29% The optimized factors for minimum surface roughness (Ra) is feed rate 0.06 followed by speed 715 and depth of cut is 0.3. Confirmation test is held for verify the result and in this test show that result is 0.458µm.It is satisfactory.

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