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Application of Taguchi Method & Anova in turning of AISI 1045 to improve surface roughness by Optimize cutting factor

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ABSTRACT: *The improvement of surface roughness in the turning of AISI 1045 was investigated by using parameters as cutting speed, feed rate, and depth of cut. Theseparameters are most responsible for surface roughness and their working range is set. Taguchi method is used to collect the experimental data.*
An orthogonal design L-9, signal to noise ratio and analysis of variance were employed to improve surface roughnessFeed rate exerted the higher effect on surface roughness, monitored by depth of cut.
The surface roughness increases with increasing feed rate, depth of cut and decrease with decreasing cutting speed.
Keywords*- MINITAB-17, TAGUCHI L-9 ORTHOGONAL ARRAY, AISI 1045 STEEL*

I. Introduction

Current days, increase productivity and quality of the cutting machine (in terms of piecework dimensional accuracy, and the completion of a good surface, and less wear of the blocks and metal tools high removal rate and the economy in machining, and the cost of each component and the performance of the product) are the main challenges for the manufacture of metal pieces during manufacturing operations different **[1]**
It can improve the design quality by improving quality and productivity. These include the activities concerned with the quality of product planning, product design and process design **[2]**
Taguchi method involves the reduction of variation in the process through powerful design of experiments. The overall objective of this method for the production of low cost high quality products to the manufacturer. Therefore, the quality is poor in the process affects not only the manufacturer but also the community. This is a way to design tests to check how different parameters affect the contrast medium and the process that you know how the process works well performance feature. Experimental design proposed by Taguchi involves the use of orthogonal arrays on the organization of the parameters that affect the process and the levels at which they should be varied. It allows for the collection of data needed to identify the factors that affect the product with the most minimal experimentation quality, thereby saving time and resources. Variation on the data collected from the design of experiments, Taguchi analysis can be used to determine a new parameter values to improve performance characteristic. **[3]**
Performance characteristics are affected by parameter such as cutting speed, feed rate and depth of cut. Various examiners calculated that the effect of cutting circumstances cutting speed, depth of cut and feed rate**[4], [5], [6]** the influence of work piece hardness, the tool geometry, cutting time, tool materials and effect of cutting lubrication fluid. **[7, 8]**

II. Experimental Details

2.1 Material

The work piece material selected for experiment was an AISI 1045 is a carbon steels a category of steels with 0.43 to 0.50% carbon content. AISI is a medium carbon steel designed to be able to function in areas requiring greater strength as well as rigidity. This steel retains admirable size precision, concentricity, and straightness which together enable to reduce wear in high speed solicitations. AISI 1045 formed into turned, ground and polished bars that can be machined unsymmetrically with limited distortion. Table 1 & 2 shows the chemical composition and mechanical properties of AISI 1045 steel respectively.

Table 01 *Chemical Composition of AISI 1045 steel*

Element	Content %
Carbon (C)	0.43-0.50
Manganese (Mn)	0.60-0.90
Sulphur (S)	0.05(max)
Phosphorous (P)	0.04 (max)
Iron, Fe	Balance

Table 02 *Mechanical Properties of AISI 1045 steel*

Properties	Metric
Tensile strength	585 MPa
Yield strength	450 MPa
Modulus of elasticity	200 GPa
Shear modulus (typical for steel)	80 GPa
Poisson's ratio	0.29
Hardness	163

2.2 Design of Experiment

Forthe effect ofcuttingparametersonsurface roughnessin the process ofturning of AISI 1045 larger numbers oftestsare needed. Butwiththreeparameter andthree levelsin theL9Taguchiorthogonalgroupprovidesnine setsofexperiments. Most of theimpacts of cutting parameters arecutting speed, feed rate and depth ofcut.
Table 3 and table 4 represent level of parameters and Taguchi orthogonal array respectively.

Table 3 Level of Parameters

Cutting Parameter	Level of Parameters		
	Low	Medium	High
Cutting speed (m/min)	58.908	86.3938	113.8827
Feed rate (mm/rev.)	0.1	0.2	0.3
Depth of cut (mm)	0.4	0.6	0.8

Table 4 Taguchi's L-09 Orthogonal Array

Exp. No.	Factorial combination		
	V	f	d
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	1
6	2	3	3
7	3	1	3
8	3	2	1
9	3	3	2

2.3 Application of Taguchi Method

One method presented in this study is the process of experimental design call design Taguchi method. Taguchi design is a set of methodologies that have been taken of the inherent variability of materials and manufacturing processes into account in the design phase. The application of this technique has become widespread in many American and European industries after the 1980s.
Taguchidesignis thatmultiple factorsconsideredat the same time.

Moreover, it seeksthe nominaldesignpointwhichis insensitiveto changes inproductionenvironmentsand easyto improve theyieldin manufacturing andreliabilityin theperformanceof the product.Therefore,factors thatcan be consideredcontrolledonly that,but the noisefactorsas well.Despite thesimilarityin the design ofexperiment(DOE), andthe design ofTaguchionlybeingbalanced(orthogonal) experimentalgroups, which makes thedesignmore effectiveTaguchioffractionalfactorialdesign. **[9]**

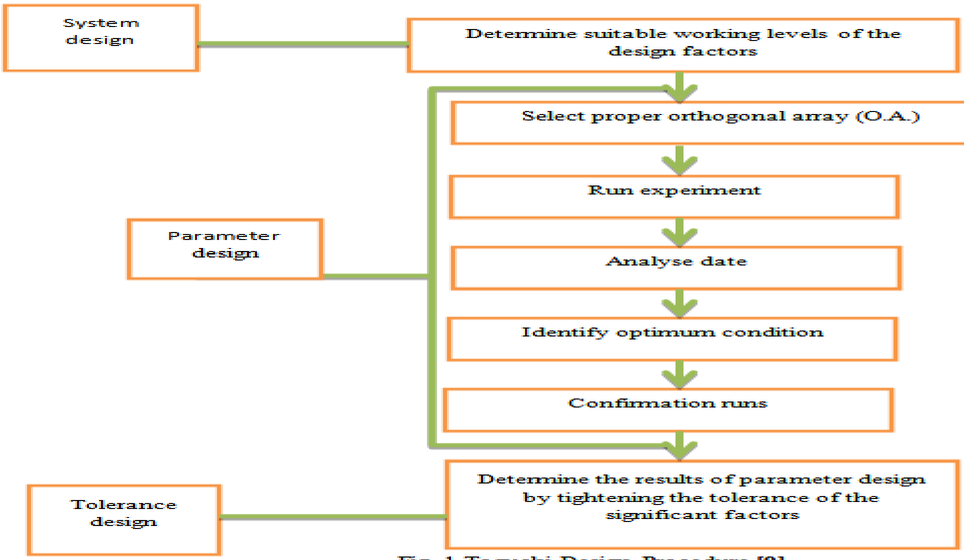


Fig. 1 Taguchi Design Procedure [9]

Classic parameter set by the Fischer complex design and not easy to use. In particular, a large number of experiments to be implemented when the number of parameters increases. To solve this task, Taguchi method special design of the space orthogonal arrays to study the whole parameter with a small number of experiments used only.

Then the definition of loss of function to calculate the deviation between the experimental value and the desired value. Taguchi recommends the use of job loss to measure the performance characteristic deviation from the desired value.

III. RESULTS AND DISCUSSION

3.1 Optimization and Analysis by Taguchi Technique:-

Table 05 Surface Roughness Based on Taguchi Technique

Exp. No.	Taguchi cutting parameters v	f	d	Actual value: Cutting speed(m/min)	Feed rate (mm/rev.)	Depth of cut (mm)	Surface roughness (μm)
1	1	1	1	58.9048	0.1	0.4	2.220
2	1	2	2	58.9048	0.2	0.6	2.423
3	1	3	3	58.9048	0.3	0.8	2.589
4	2	1	2	86.3938	0.1	0.6	2.949
5	2	2	1	86.3938	0.2	0.4	3.133
6	2	3	3	86.3938	0.3	0.8	3.173
7	3	1	3	113.8827	0.1	0.8	2.480
8	3	2	1	113.8827	0.2	0.4	2.530
9	3	3	2	113.8827	0.3	0.6	2.673

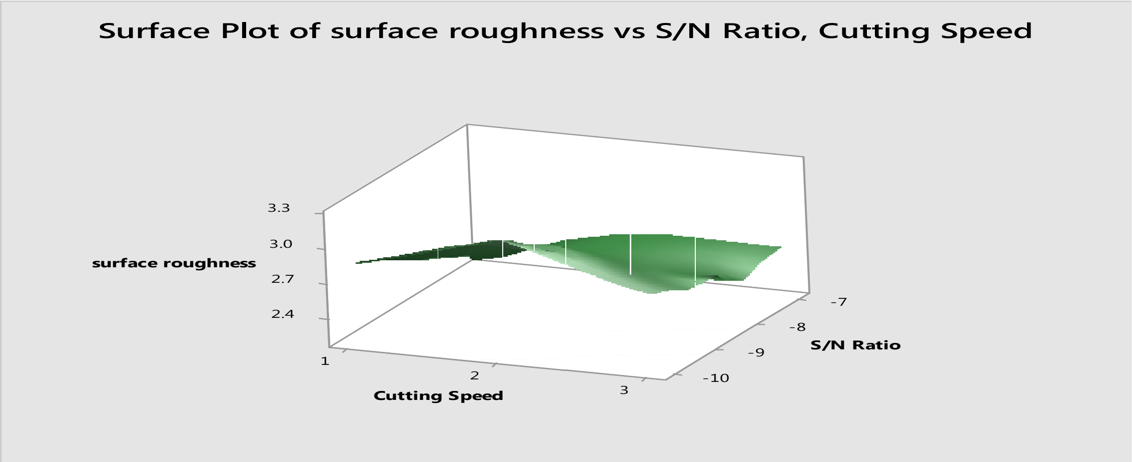
Table 06 S/N Ratio Table for Smaller is better

Exp. No.	Taguchi cutting parameters v	f	d	Actual value: Cutting speed(m/min)	Feed rate (mm/rev.)	Depth of cut (mm)	Surface roughness (μm)	S/N Ratio
1	1	1	1	58.9048	0.1	0.4	2.220	-6.9271
2	1	2	2	58.9048	0.2	0.6	2.423	-7.6871
3	1	3	3	58.9048	0.3	0.8	2.589	-8.2626
4	2	1	2	86.3938	0.1	0.6	2.949	-9.3935
5	2	2	1	86.3938	0.2	0.4	3.133	-9.9192
6	2	3	3	86.3938	0.3	0.8	3.173	-10.0294
7	3	1	3	113.8827	0.1	0.8	2.480	-7.8890
8	3	2	1	113.8827	0.2	0.4	2.530	-8.0624
9	3	3	2	113.8827	0.3	0.6	2.673	-8.5400

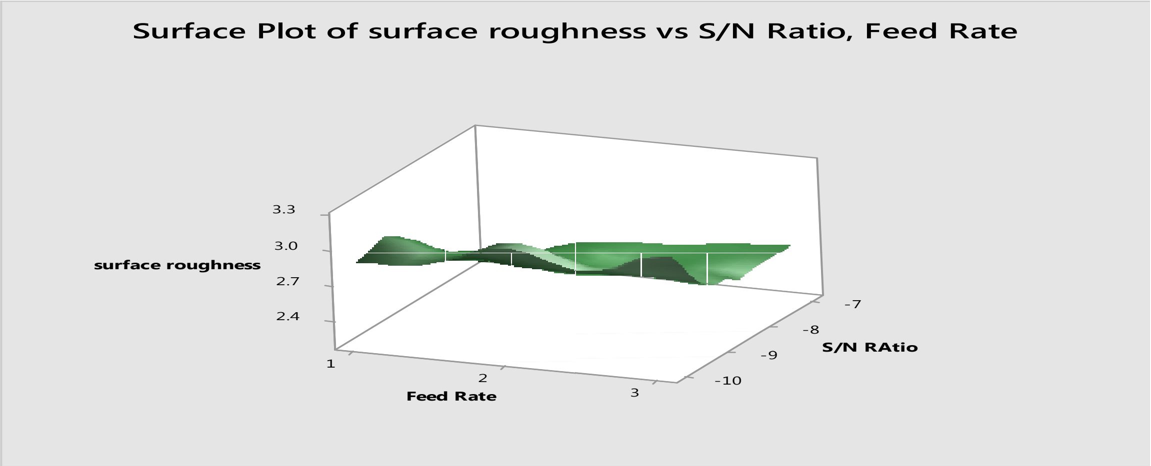
Table 07 Analysis of Variance for S/N Ratio

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Cutting speed	2	7.54853	3.77427	0.965	0.003
Feed rate	2	1.15105	0.57553	7.048	0.016
Depth of cut	2	0.18573	0.09286	2.176	0.093
Error	2	0.01903	0.00952	-	-
Total	8	8.90434	-	-	-

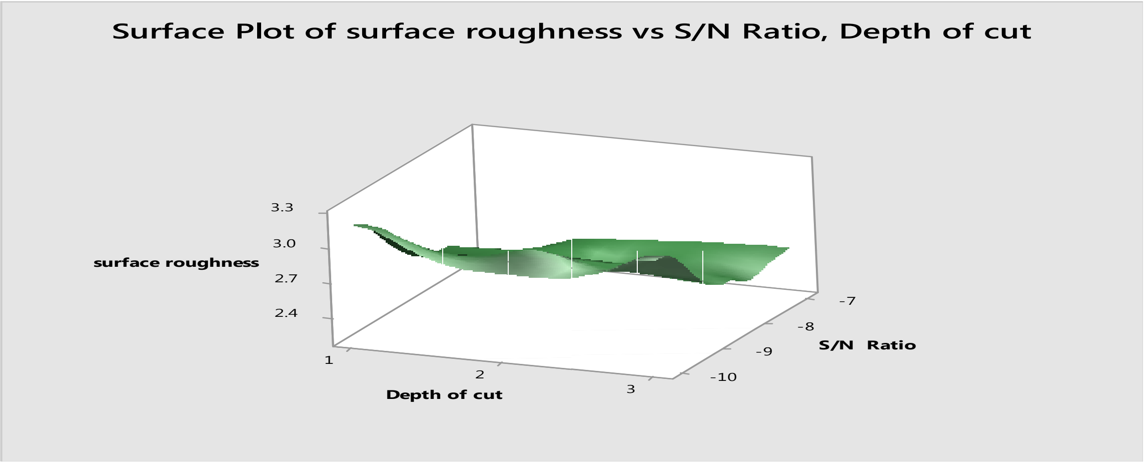
3.2 3-D Graph



(a) Effect of Cutting Speed on Surface Roughness and S/N Ratio

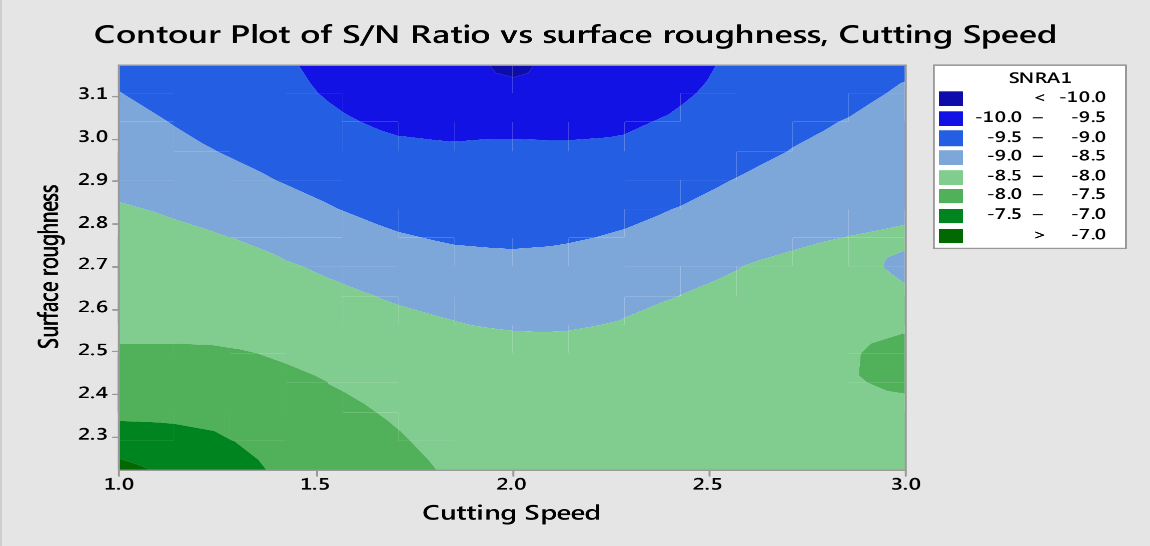


(b) Effect of Feed Rate on Surface Roughness and S/N Ratio

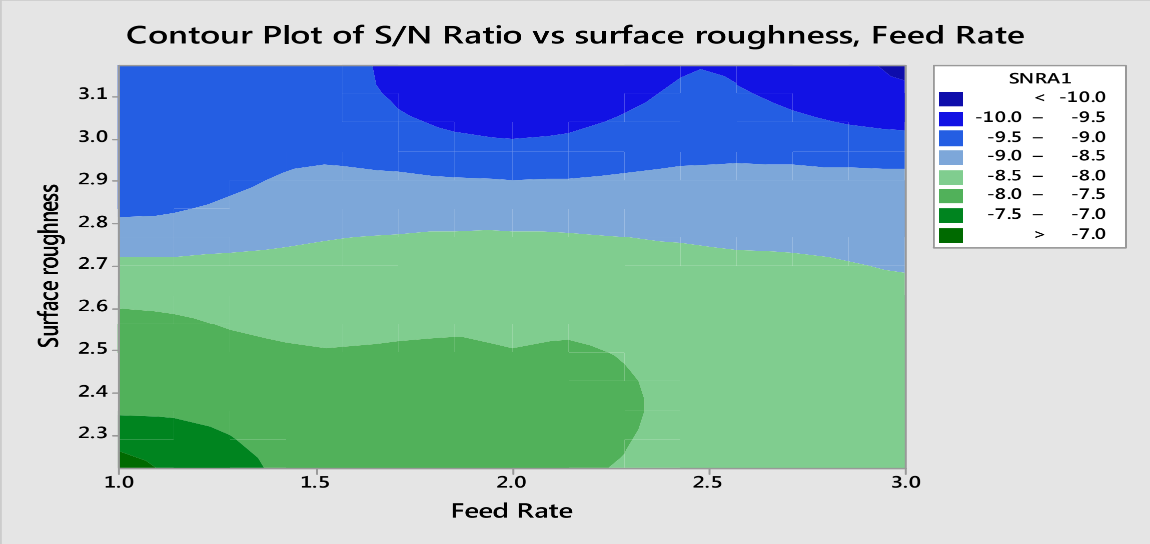


(c) Effect of Depth of Cut on Surface Roughness and S/N Ratio

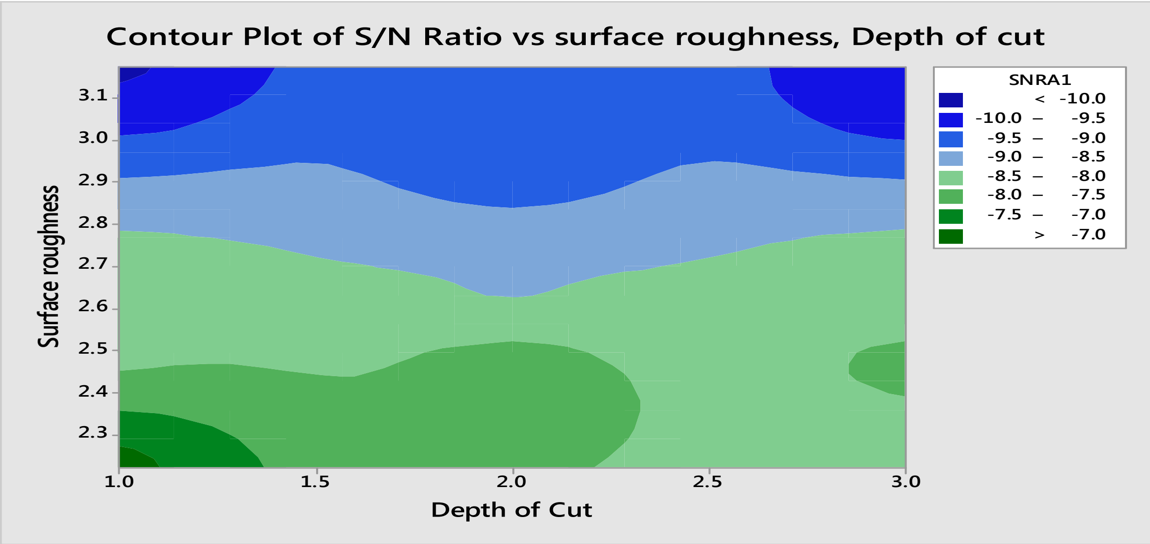
3.3 Contour Plot



(d) Effect of Cutting Speed on Surface Roughness and S/N Ratio



(e) Effect of Feed Rate on Surface Roughness and S/N Ratio



(f) Effect of Depth of Cut on Surface Roughness and S/N Ratio

IV. CONCLUSIONS

The following conclusion may be drawn from several cutting conditions in machining the AISI 1045.

Feed rate exerted the higher effect on surface roughness, monitored by depth of cut.

The surface roughness increases with increasing feed rate, depth of cut and decrease with decreasing cutting speed.

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