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OPTIMISATION OF SURFACE ROUGHNESS AND MATERIAL REMOVAL RATE IN TURNING OPERATION OF MILD STEEL USING TAGUCHI METHOD

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ABSTRACT

This paper attempts on optimizing the turning process under various machining parameters by Taguchi method to develop or implement the quality of a machined product. Taguchi optimization methodology is applied to optimize cutting parameters in turning mild steel with coated cemented carbide tool under dry cutting condition. The CNC turning machine is used to conduct experiments based on the Taguchi design of experiments (DOE) with an orthogonal L9 array. The orthogonal array, signal to noise ratio (S/N) and analysis of variance were employed to find the maximum material removal rate (MRR) and minimum surface roughness.

KEYWORDS: Turning Process, Parameters of machining, mild steel, Taguchi Method, ANOVA.

I. INTRODUCTION

Conventional machines area unit manually controlled by hand wheels or levers. The machines take longer to form one element and wish one man one machine for oversight. This builds the factory-made product pricey additionally as a quality of the products varies consistent with man experience on its machine, that isn't possible during this competitive setting. The event of producing technologies to boost machining and procure high productivity has become a really necessary goal in modern machining industries. The challenge of recent machining industries is principally centered on the accomplishment of top quality, in terms of work-piece dimensional accuracy, surface finish , high production rate, less wear on the cutting tools, the economy of machining in terms of price saving and increase the performance of the product with reduced environmental impact. Quality and productivity are crucial areas however contradictory criteria in any machining operations. So as to make sure high productivity, a degree of quality is to be compromised. Productivity is taken in terms of material removal rate within the machining operation. Surface roughness and Metal Removal Rate (MRR) plays a crucial role in several areas and may be an issue of nice importance within the analysis of machining parameters.

The method parameters like cutting speed, feed rate, depth of cut, fluid condition and tool geometry affects the metal removal rate in turning. to attain the target of this analysis, by choosing best method parameters for a turning steel work piece on EMCO CNC turning machine to induce best MRR, that finally increase production. The selection of computerised Numerical control (CNC) producing method relies on optimisation of value, enhanced in productivity and improvement of quality of the products by exactness producing. CNC machine is capable of achieving the specified turning operation by high accuracy and very low processing time. This analysis has designated 3 cutting parameters particularly, cutting speed, feed rate and depth of cut optimize the MRR throughout turning processes, that additional may be assessed by the value of the factory-made product, productivity or another criterion. Recently, many researchers have worked on the optimization of machining parameters for optimum MRR and surface roughness. Some researchers work on putting in place optimum cutting speeds in CNC machining have mentioned about the parameters got to be optimized throughout CNC machining is an important and dear process for tiny and medium sort producing industries. The machining parameters supported the machining characteristics of low-carbon steel mistreatment Taguchi technique and analysis of variance analysis for determination of optimum machining parameters have analyzed.

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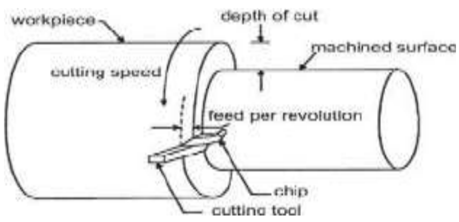

Fig.1 Turning Process Parameters

II. TAGUCHI METHOD

Genichi Taguchi could be a Japanese Engineer United Nations agency has been active within the improvement of Japans industrial product and processes since the late 1940's. He has developed each philosophy and methodology for the method or product quality improvement that depends principally on applied mathematics ideas and tools, particularly statistically designed experiments .several Japanese companies achieved nice success by applying his strategies. Taguchi has received a number of the Japan's most prestigious awards for quality action, together with the Deming Prize throughout the year 1986, he received the foremost prestigious award from the International Technology Institute-The W.F.Rockwell Honour for excellence in Technology [1]. His major contribution is that he has combined engineering and applied mathematics techniques to attain speedy enhancements in reducing the value and increasing the standard level by optimizing product style and producing processes. throughout 1983, Taguchi related to prime corporations and institutes of USA (Ford motor company, XEROX, AT&T, Bell laboratories etc.), Taguchi techniques area unit referred to as Radial approach to quality, experimental style and engineering .Taguchi technique refers to the Parameter style, Tolerance style, Quality Loss perform, style of Experiments exploitation Orthogonal Arrays and Methodology applied to judge mensuration systems. Pignatiello has known 2 totally different aspects of Taguchi technique

1. The strategy of Taguchi
2. Ways of Taguchi

Taguchi strategy is that the abstract frame work for coming up with a method or product style experiment. Taguchi ways check with the gathering of specific techniques utilized by Taguchi. Taguchi has self-addressed style, Engineering (offline) also as producing (online) quality. This idea differentiates Taguchi technique from applied math method management (SPC) that is solely a web internal control technique .Taguchi ideas may be reduced into 2 basic ideas

1. Quality losses ought to be outlined as deviation from target, not conformity to impulsive specifications.
2. To attain high system quality levels economically needs quality to be designed into product. Quality is meant, not factory-made, into the merchandise.

Taguchi techniques represent a replacement philosophy. Quality is measured by the deviation of a useful characteristic from its target price. Noises (uncontrollable factors) can cause such deviations which end up in loss of Quality. Taguchi techniques request to get rid of the result of Noises .The foremost necessary a part of the Taguchi technique is quality loss operates. Taguchi has found that a quadratic operate (parabola) approximates the behavior of loss in several cases .when the standard characteristic of interest is to be maximized or decreased, the loss operates can become a half parabola. Loss happens only if the products is outside its specification however conjointly when the product falls within its specification. Taguchi has suggested signal to noise quantitative relation (S/N ratio) as performance statistics. Signal refers to the amendment in quality characteristics of a product under investigation in response to an element introduced within the experimental style. Noise refers to the result of external factors (uncontrollable parameters) on the result of the standard characteristics.

Steps Involved in Taguchi Method

For larger-the-better characteristics, Taguchi method have been used for a parameter design includes the following steps [2]:

1. Select a suitable output quality characteristic to be optimized.
2. Select the control factors and their levels, identify their possible interactions.
3. Select noise factors and their levels.

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4. Select sufficient inner and outer arrays. Control factors assigned to inner array and noise factors to the outer array.
5. Carry out the experiment.
6. Execute statistical analysis based on S/N ratio.
7. Predict optimal output performance level based on optimal control factor level combination, and conduct a confirmation experiment to verify the result.

Analysis of variance (ANOVA)

Since their area unit an outsized variety of variables dominate the method, some mathematical models area unit needed to represent the method. However, these models area unit to be developed victimization solely the numerous parameters influencing the method instead of together with all the parameters. So as to realize this, applied math analysis of the experimental results can be processed victimization the analysis of variance (ANOVA). Analysis of variance could be a procedure technique that allows the estimation of the relative contributions of every of the management factors to the general measured response.

Table 1.Mechanical Properties of mild steel

Brinell Hardness Number (BHN)	120 HB
Density	7.85 g/cm^3
Tensile strength	841 MPA
Yield strength	247 MPA
Poisson's ratio	0.303 µ

Table 2.Experimental conditions

Work piece material	Mild steel
Length of work piece	100 mm
Diameter of work piece	50 mm
Lathe used	C N C
Measuring	Profilometer (Taylor Hobson, Surtronic 3+, UK).
Environment	DRY
Tool used	coated cemented carbide tool

Table 3 Process parameters with their values at 3 levels

Process Parameters	Parameter Designation	LEVELS		
		L1	L2	L3
Speed (rpm)	A	150	330	630
Feed (mm/rev)	B	0.4	0.5	0.7
Depth of Cut (mm)	C	0.6	0.7	0.8

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III. RESULTS AND ANALYSIS

Data Collection

MS bars of diameter 50 mm (fifty millimeter's) and length of 100 mm (hundred millimeter) is needed for conducting the experiment have been prepared first . Nine numbers of samples of same material and same dimensions are created. Then, mistreatment totally different levels of the method parameters nine specimens are turned in CNC shaping machine consequently. Once machining, surface roughness measured exactly with the assistance of a transportable stylus-type profilometer, Talysurf (Taylor Hobson, Surtronic 3 +, UK) [4].

The results of the experiments are shown in Table 4. Analysis has been created supported experimental information within the following chapter. Improvement of surface roughness and material removal rate has been created by Taguchi [5]. Substantiative tests have additionally been conducted finally to validate optimum results.

Table 4. Experimental Data Related to Surface Roughness Characteristics

Experiment no.	Spindle speed (rpm), N	Feed rate (mm/rev), f	Depth of cut (mm), d	Surface roughness, Ra (µm)	S/N ratio of surfaces roughness
1	150	0.4	0.6	2.30	-7.2346
2	150	0.5	0.7	5.70	-15.1175
3	150	0.6	0.8	6.00	-15.5630
4	330	0.4	0.7	5.40	-14.6479
5	330	0.5	0.8	4.90	-13.8039
6	330	0.6	0.6	6.10	-15.7066
7	630	0.4	0.8	3.00	-9.5424
8	630	0.5	0.6	3.80	-11.5957
9	630	0.6	0.7	5.12	-14.1854

Surface Roughness Measurement

The surface roughness check was done by exploitation Mitutoyo surface roughness tester 'Surftest SJ 201' was used. The probe was adjusted to living the Ra worth. The probe was rapt a distance of 3mm [3].

Material Removal Rate Measurement

The Material removal rate is employed to work out the quantity of material removed per second. It's given by the formula

$$MRR = 1000\ V\ f\ d$$

Where V = Cutting speed (m/min)
f = feed rate (mm/rev)
d = depth of cut (mm)
MRR = Material removal rate (mm3/ min)

As the conditions for feed, cutting rate and depth of cut area unit mounted therefore, this formula is employed to calculate the MRR rather than hard the initial and also the final weight, the higher than formula was won't to calculate the MRR [9].

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Table 5. Measurement of Material Removal Rate (MRR)

Experiment no.	Spindle speed (rpm), N	Feed rate (mm/rev), f	Depth of cut (mm), A	MRR (mm3/min)	S/N ratio of MRR
1	150	0.4	0.6	5.30	14.4855
2	150	0.5	0.7	8.11	18.1804
3	150	0.6	0.8	11.35	21.0999
4	330	0.4	0.7	12.23	21.7485
5	330	0.5	0.8	18.37	25.2822
6	330	0.6	0.6	17.97	25.0910
7	630	0.4	0.8	26.36	28.4189
8	630	0.5	0.6	27.43	28.7645
9	630	0.6	0.7	39.03	31.8879

Signal –To - Noise Ratio

Parameters that have an effect on the output are often divided into 2 parts: governable (or design) factors and uncontrollable (or noise) factors. The worth of governable factors is often adjusted by the designer however the worth of uncontrollable factors can't be modified as a result of they're the sources of variation as a result of operational surroundings. The most effective set of management factors as they influence the output is set by performing arts experiments. Smaller-the-Better is employed for surface roughness and Bigger-the-Better is employed for material removal rate as a result of we tend to minimize the surface roughness and maximize the material removal rate.

ANOVA for Surface Roughness

Results obtained for the surface roughness area unit shown within the Table 4. The results for surface roughness were obtained from the nine experiments performed of Taguchi. The experimental results analyzed with multivariate analyzed area unit shown within the Table 6. The F price calculated through MINITAB fifteen software system is shown in the second last column of multivariate analysis table that suggests the importance of the factors on the required characteristics. Larger is that the F price higher is that the significance (considering confidence level of 95%). The results show that solely feed is that the most important issue.

Table 6.Analysis of Variance for Means of Surface Roughness (Ra)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Spindle speed (rpm), N	2	3.5723	3.5723	1.8319	2.43	0.432
Feed rate (mm/rev), f	2	8.1237	8.1237	4.1487	5.12	0.292
Depth of cut (mm), d	2	3.1013	3.1013	1.6783	1.74	0.491

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Error	2	1.5236	1.5236	0.8262		
Total	8	16.3209				

Main Effect Plots for Surface Roughness

Main effect plots for surface roughness square measure shown within the figure 2. Main impact plot shows the variation of surface roughness with regard to Spindle speed, feed rate and depth of cut. X -axis represents amendment in a level of the variable and y- axis represents the amendment within the resultant response.

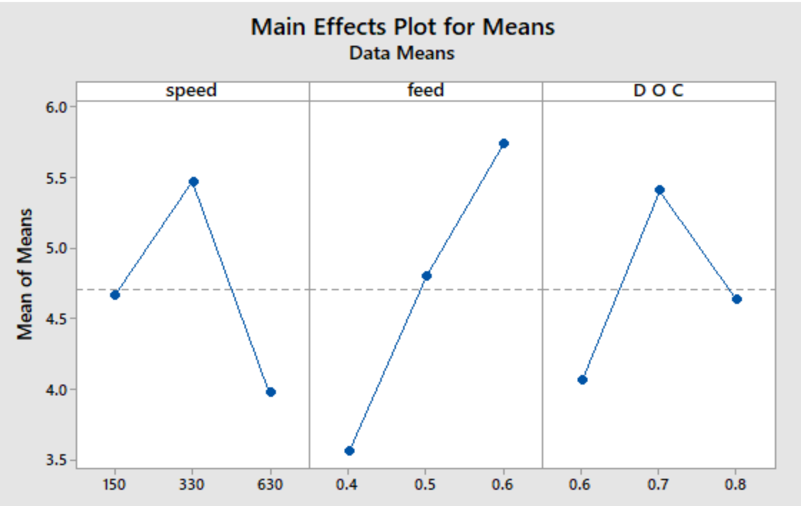

Fig 2. Main effects plot for means for surface roughness

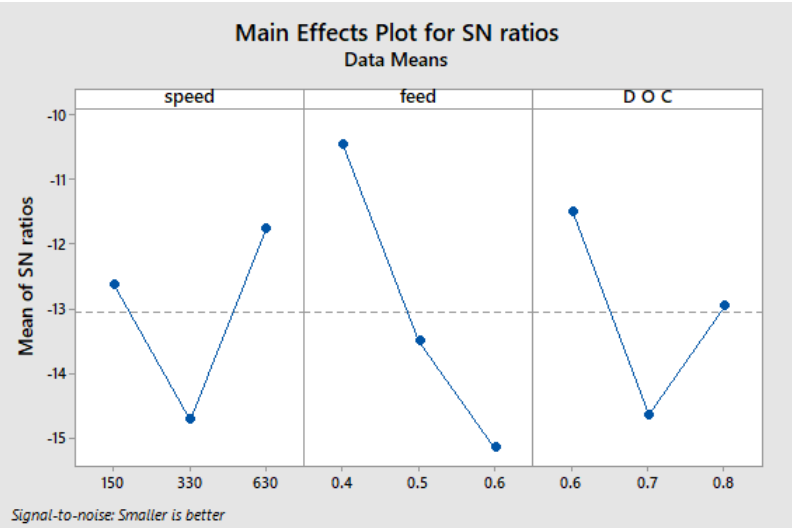

Fig 3. Main effects plot for S/N ratios for surface roughness

ANOVA for Material Removal Rate (MRR)

Results obtained for the material removal rate (MRR) square measure shown within the Table 5. The results for material removal rate (MRR) were obtained from the nine experiments performed of Taguchi. The experimental results analyzed with multivariate analysis square measure shown within the Table 6. The F worth calculated through MINITAB computer code is shown within the second last column of multivariate analysis table that suggests the importance of the factors on the required characteristics. Larger is that the F worth higher is that the significance (considering confidence level of 95%). The results show that solely feed is that the most vital issue.

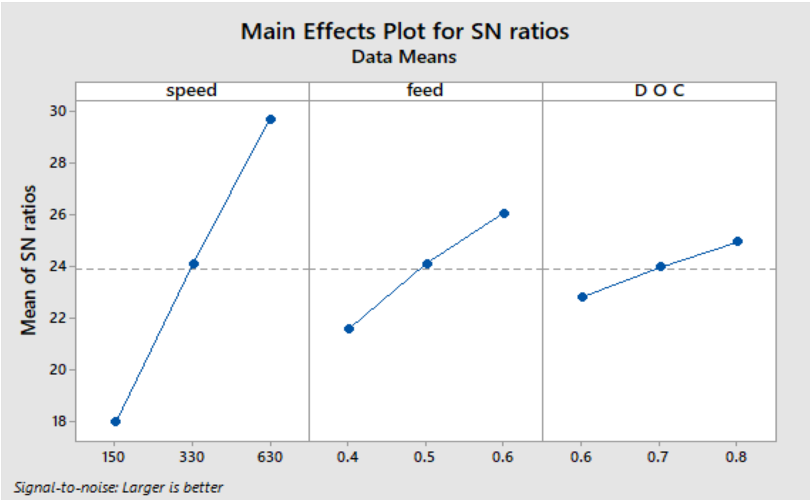

Fig 4. Main effects plot for S/N ratios for Material removal rate (MRR)

IV. CONCLUSION AND FUTURE SCOPE

The Surface roughness is principally plagued by feed rate, depth of cut and spindle speed. With the rise in feed rate the surface roughness conjointly will increase, because the depth of cut will increase the surface roughness initial increase and reduce and because the spindle speed increase surface roughness decreases.

From multivariate analysis analzsis, parameters making very important result on surface roughness area unit feed rate and depth of cut.

The parameters taken within the experiments area unit optimized to get the minimum surface roughness potential. The optimum setting of cutting parameters for prime quality turned elements is as:-

1. Spindle speed = 630 rpm
2. Feed rate = 0.4 mm/ rev
3. Depth of cut = 0.6 mm

From ANOVA analysis, parameters creating vital result on material removal rate area unit feed rate and spindle speed.
The parameters thought of within the experiments area unit optimized to realize most material removal rate .The simplest setting of input method parameters for defect-free turning (maximum material removal rate) at intervals the chosen variable is as follows:-

1. Spindle speed = 630 rpm
2. Feed rate = 0.6 mm/ rev
3. Depth of cut = 0.8 mm

Scope for Future Work

In this present study solely three parameters are studied in accordance with their effects. Alternative factors like tool radius, types of Inserts, cutting conditions (dry or wet) etc. also can be studied. Also, the opposite outputs like power consumption, tool life, cutting forces etc. also can be more.

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