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Analysis of Tool Wear and Surface Roughness in Turning Operation of EN 31Steel by Taguchi Approach

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Abstract

In the field of material removal, metal cutting is one of the most important manufacturing methods. The parametric optimization of the turning mechanism is the subject of this article. Cutting speed, feed rate, and cut depth are specific input parameters. MINITAB 18 uses a L9 orthogonal array to design the combination of these parameters. Turning operations are based on the Design of Experiment are used to assess tool wear and surface roughness. The Taguchi method was used to design and optimize the experiment. ANOVA was used to assess which cutting parameters have a major impact on surface roughness and tool wear. To optimize surface roughness and finish, EN 31 is used as a workpiece and SNMG120408MS is used as a carbide cutting tools wear .Cutting speed (40, 60, and 90 m/min), feed rate (0.1, 0.15, and 0.2 mm/rev), and cut depth are the turning parameters (0.5, 0.75 and 1.0 mm). Arm wear at each cutting edge of the tool is determined by toolmaker microscope and surface roughness is measured by Talysurf profilometer (Taylor Hobson Surtronic 3). Cutting speed is the most important tool parameter, according to the findings.

Keywords: **ANOVA, Cutting speed, Depth of Cut, Feed rate, Taguchi Orthogonal Array.**

1. Introduction

Turning is one of the major machining processes is the removal of metal from a workpiece in the form of a chip in order to produce a finished product of the desired size and shape.. Machining conditions in a significant position in estimating the performance of a machining operation. The machining conditions such as cutting speed, feed rate, depth of cut affect the operation to a great extent. These parameters must be taken to optimize the machining operation. In present work is to analyze the effectiveness of turning parameters on surface roughness (Ra) and tool wear. Test performed in Turning machine (LT20C Lathe) with a carbide tool. The workpiece material is EN 31 steel and the carbide Cutting tool is SNMG120408MS. The effect of feed rate, cutting speed, and depth of cut on surface roughness and tool wear was studied using MINITAB 18 analysis software. The Taguchi method was used to design the experiment and optimization. The Analysis of Variances (ANOVA) used to determine which cutting parameters significantly affect the surface roughness and tool wear.

1.1 Literature Review

Dennison et. al. [1] In this work analyze the effect of tool-work interface temperature observed during Turning of AISI 4340 cylindrical steel components in three different machining environments, namely flooded, non-dry, and dry, with three different CNMG-PEF 800 diamond finish Titanium Nitride (TiN) coated carbide cutting tools.. The machining parameters are cutting velocity, feed rate, and depth of cut. The experiments were planned based on the full factorial design (3^3) and performed in an All Geared Conventional Lathe. [2] Rajamurthy et. al. In this work, the experiments Taguchi's L9 orthogonal array was used in the experiments. The EN 31 alloy steel workpieces were machining on a CNC lathe with a coated insert tool. For minimum surface roughness and overall material removal rate (MRR), the optical parameters were individually und using Taguchi's approach.compared with the results obtained from Grey relation analysis. [3] Siddique et. al. This analysis work involved with machining of the AISI-4140 steel. Result found that the multilayer-coated inorganic compound inserts have performed well. [4] Chaudhari et. al During this work the machining of the EN-31 steel work piece is allotted exploitation uncoated and coated inorganic compound insert tool. the bottom tool wear was found with a coting tool. [5] Kumar et. al. Applied the CCD primarily based RSM approach to perform an Associate in experimental study on turning of AISI- 202 steel by a TiAlN coated inorganic compound insert tool. it's ascertained that feed is that the most vital issue poignant the surface roughness, whereas the sole important issue poignant the tool wear was found to be the depth of cut. [6] Suraj et. al. Conducted the experiments on the EN-24 steel material with the assistance of PVD coated TiAlN insert tool and uncoated inorganic compound insert tool. it's found that spindle speed and depth of cut are distinguished factors that affect surface roughness. [7] Reddy et. al. Examined the multi-response optimization of turning technique in machining of EN-31 tool. it absolutely was seen from the results that cutting speed is that the most vital parameter for surface roughness. [8] Govindan et. al. Used the Taguchi approach and examined that this approach includes a potential for savings in experimental time and value on product or method, development and quality improvement. it absolutely was finished from study that cutting speed and feed has most vital impact on surface roughness. [9] Bh. et. al. Generate a Response Surface Methodology is a model that predicts tool flank wear of AISI-D3 hardened steel exploitation (RSM). The depth of cut is a factor in tool flank wear. The pace and feed have only a minor impact on the overall variance. [10] Sahu et. al. Given a technique for optimizing cutting parameters in dry turning of AISI-D2 steel in order to achieve minimal tool wear and work piece surface temperature and most MRR. The results showed that depth of cut and cutting speed are the foremost dominating parameters poignant the tool wear. [11] Kivak, Practiced the Taguchi technique and multivariate analysis to work out the machinability of Hadfield steel with PVD TiAlN and CVD $TiCN/Al_2O_3$ coated inorganic compound inserts below dry edge conditions. The results showed that feed rate was the foremost necessary parameter poignant surface roughness and cutting speed was the necessary parameter poignant flank wear. [12] Saini et. al. In his analysis work used RSM approach to work out the optimum machining parameters resulting in minimum surface roughness in turning method. it's additionally finished that feed rate is that the most vital issue poignant surface roughness followed by depth of cut. [13] Kumar et. al.Have completed Experiments are being carried out to increase the merchandise's surface consistency by optimizing input parameters. Feed rate, spindle speed, and cut depth are used as input parameters, with dimensional tolerances as an output parameter. Cutting speed is the most important factor in reducing dimensional variance and minimizing surface roughness, according to the results of the experiments. [14] Makadia et. al. Studied the appliance of RSM on the AISI-410 steel is allotted for turning operation. The tool nose radius decreased as the feed rate increased, while the surface roughness increased. It was discovered that the surface roughness increased as the feed level increased and it decreased with increase within the tool nose radius. [15] Abhang et. al. Had done Associate in experimental work to machine the EN-31 steel alloy by exploitation metal inorganic compound inserts tool. the info was analyzed exploitation analysis of variance technique, 1st order and second order power consumption prediction models were developed by exploitation RSM. it's finished that A second-order model is more accurate than a first-order model. the most conclusion drawn from this study was that higher surface end is obtained by applying cooled stuff. [16] Sharma et. al. Applied the DOE techniques Taguchi & Response Surface Methodology to optimize the turning method parameters to get higher surface end. it absolutely was finished from study that cutting speed and feed has most vital impact on surface roughness. [17] Selvaraj et. al. Allotted AISI-304 is turned dry. primary solid solution steel 304 . analysis of variance results showed that feed rate, cutting speed and depth of cut affects the surface roughness. [18] Nalbant et. al. Studied the machining of AISI 1030 steel while not exploitation cooling liquids.. Results showed coated tool provides higher surface roughness values instead of uncoated tool. [19] Thamizhmanii et. al. Analyzed the foremost favorable cutting conditions to induce least surface roughness in turning SCM- 440 steel by Taguchi technique. Results showed that the depth of cut is most vital parameter poignant surface roughness followed by feed.[20] Yang et. al. Worked on Taguchi technique to search out the optimum cutting parameters for turning operations. The cutting characteristics of S45-C steel bars exploitation metal inorganic compound cutting tools were examined. it absolutely was finished that feed rate has important impact on surface roughness.

1.2 Objective

Objective of this research work are following:

1. To evaluate the effect of different process parameter on surface roughness and tool wear
2. Find out the optimal value of cutting speed, feed rate and depth of cut to give lowest surface roughness and tool wear.

2. Material & Method

- Machine for turning operation - LT20C Lathe
- Cutting tool - SNMG 120408MS
- Work piece – EN 31 Steel
- Equipment for measurement - For surface roughness - Talysurf Profilometer (Taylor Hobson Surtronic) For tool wear - Tool maker microscope
- Machining parameter and their level for experiment
- Design of experiments by Taguchi approach in Minitab software

Table 1: Specification of Cutting Tool (mm)

Cutting Edge Length	12.7
Inscribed Circle or Height	12.7
Thickness	4.76
Hole Diameter	5.16
Corner Radius	0.8
Side Clearance	0°

Table 2: Physical Data EN 31 Steel

Density (lb/cu.in.)	0.284
Specific Gravity	7.43
Specific Heat (Btu/lb/Deg F)	0.17
Electrical Resistivity (microhm-cm)	426
Melting Point (Deg F)	2595
Modulus of Elasticity (N/mm^2)	215000

Table 3: Chemical Composition of EN 31

C	Mn	Si	Cr	Fe	P	S
1.07	0.58	0.32	1.12	96.84	0.04	0.03

Table.4. Machining Parameter and Their level

Control Parameter					
Parameter	Symbol	Level			Unit
		1	2	3	
Cutting Speed	S	40	60	90	m/min
Feed Rate	F	0.1	0.15	0.2	mm/rev
Depth of Cut	D	0.5	0.75	1.0	mm

Dr. Genichi Taguchi is widely regarded as the leading proponent of robust parameter design, an engineering approach for product or process design that focuses on minimizing variance and/or noise sensitivity. . A process designed with this goal will produce more consistent output. L9 basic types of standard orthogonal arrays (OA) used for the experiment of Taguchi parameter design. Since three factor are taken in the experiment, three level of each factor are considered. Therefore, an array L9 is selected for the experiment.

3. Result and Discussions

3.1 Experiment Result

Table 5: Experiment Result of EN 31 Steel

Run	S	F	D	Tool Wear (Micron)	Surface Roughness (Micron)
1	40	0.10	0.50	0.812	1.749
2	40	0.15	0.75	1.032	1.258
3	40	0.20	1.00	1.035	1.49

4	60	0.10	0.75	1.129	1.38
5	60	0.15	1.00	0.810	1.90
6	60	0.20	0.50	0.679	1.69
7	90	0.10	1.00	0.990	1.88
8	90	0.15	0.50	1.310	1.43
9	90	0.20	0.75	1.398	3.42

3.2 Taguchi Analysis and ANOVA

Taguchi Analysis: Tool Wear versus Cutting Speed, Feed Rate, Depth of Cut

Condition of analysis: Smaller is better

Table 6: Response Table for Signal to Noise Ratios

Level	Cutting Speed	Feed Rate	Depth of Cut
1	0.41216	0.28077	0.94202
2	1.37968	-0.26291	-1.39384
3	-1.70406	0.06992	0.53960
Delta	3.08373	0.54367	2.33586
Rank	1	3	2

3.3 Taguchi Analysis and ANOVA

Taguchi Analysis: Tool Wear versus Cutting Speed, Feed Rate, Depth of Cut

Condition of analysis: Smaller is better

Table.7: Response Table for Means

Level	Cutting Speed	Feed Rate	Depth of Cut
1	0.9597	0.9770	0.9337
2	0.8727	1.0507	1.1833
3	1.2297	1.0343	0.9450
Delta	0.3570	0.0737	0.2497
Rank	1	3	2

The main effect plot of S/N ratios and means for tool wear is plotted graphically using Minitab 18 software (Fig 1 & 2). Both the Graph indicates the influence of various factors on the tool wear. Cutting speed is identified as the most significant factor controlling the tool wear because of its larger deviation from the mean as compare to others. The second largest deviation is depth of cut, then feed rate. All factors are significant for controlling the tool wear. From the main effect plots for means the optimal solution for tool wear is evident at combination of “S2 F1 D1” i.e. cutting speed of 60 m/min, feed rate of 0.10 mm/rev, depth of cut of 0.5 mm.

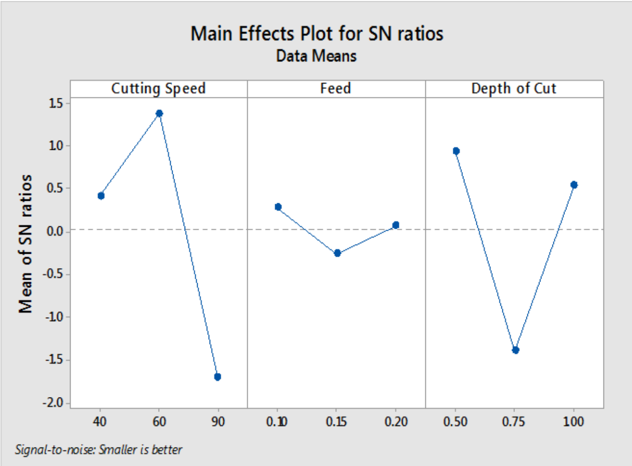

Fig 1: Main Effect Plot for S/N Ratios

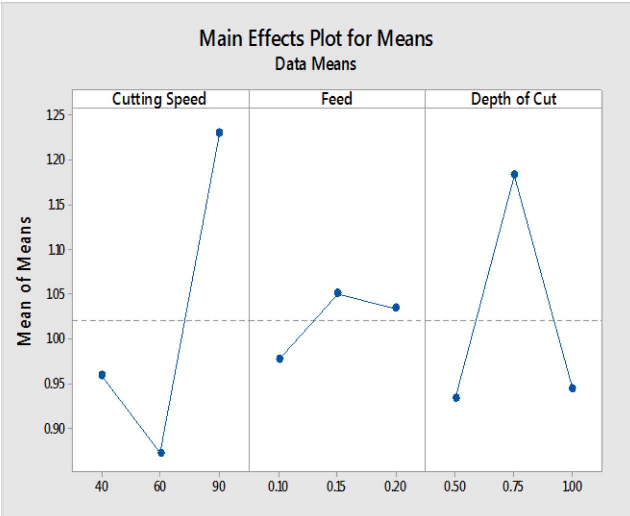

Fig 2: Main Effect Plot for Means

- Taguchi Analysis: Surface Roughness versus Cutting Speed, Feed Rate, Depth of Cut

  Condition of analysis: Smaller is better

Table.8.Response Table for Signal to Noise Ratios

Level	Cutting Speed	Feed Rate	Depth of Cut
1	-3.438	-4.379	-4.173
2	-4.310	-3.558	-5.157
3	-6.423	-6.234	-4.841
Delta	2.986	2.676	0.984
Rank	1	2	3

Table.9: Response Table for Means

Level	Cutting Speed	Feed Rate	Depth of Cut
1	1.499	1.670	1.623
2	1.657	1.529	2.019
3	2.243	2.200	1.757
Delta	0.744	0.671	0.396
Rank	1	2	3

Analysis of Variance for Surface Roughness, using Adjusted SS for Tests

Table.10: Analysis of Variance for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
S	2	0.923	0.923	0.461	0.64	0.610
F	2	0.750	0.750	0.375	0.52	0.657
D	2	0.243	0.243	0.122	0.17	0.855
Error	2	1.440	1.440	0.720		
Total	8	3.358				

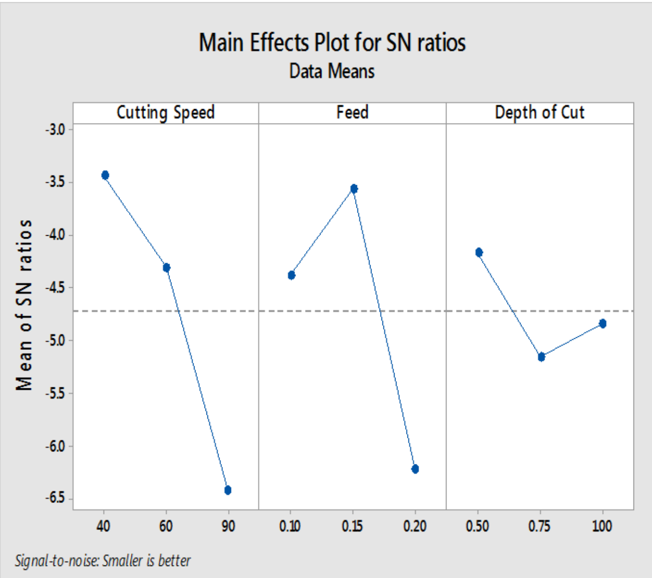

Fig 3: Main Effect Plot for S/N Ratios

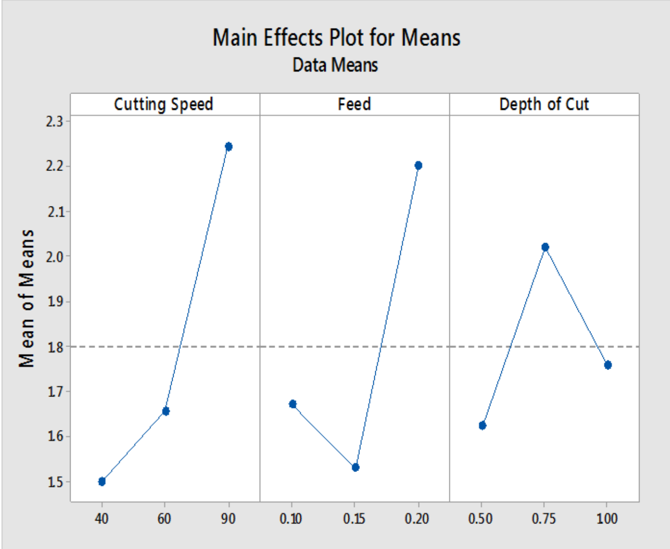

Fig. 4: Main Effect Plot for Means

The main effect plot of S/N ratios and means for surface roughness is plotted graphically using Minitab 18 (Fig. 3 & 4) both the Graph indicate the influence of various factor on the surface roughness. Cutting speed is identified as the most significant factor controlling the surface roughness because of its larger deviation from the mean as compare to others. The second largest deviation is for feed rate, then depth of cut. All factors are significant for controlling the surface roughness. From the main effect plots for means the optimal solution for surface roughness is evident at combination of "S1 F2 D1" i.e. Cutting speed 40 m/min, feed rate of 0.15 mm/rev, depth of cut of 0.50 mm.

Conclusions

The conclusion selected from the optimized graph plot and optimized factors and levels.

- The use of a Design of Experiment to perform pattern analysis of surface roughness and tool wear in turning operations with respect to various combinations of design variables has been found to be a good technique (Feed rate, Cutting speed and Depth of Cut). Taguchi method was used to design the experiments.
- The optimal solution for tool wear is evident at combination of " S2 F1 D1" i.e. 60 m/min cutting speed, 0.10 mm/rev feed rate, .0.50-millimeter-deep cut.
- The best solution for surface roughness is a mix of factors. "S1 F2 D1" i.e. Cutting speed 40 m/min, feed rate of 0.15 mm/rev, depth of cut of 0.50 mm.

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