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Taguchi Method for High Speed Cutting Forces

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ABSTRACT
The purpose of this study is to determine experimentally the influence of tool rake angle on EN 31Steel, MS, and Aluminum specimens as work piece materials and carbide as a tool material during a turning process. It has been found that cutting speed, feed rate, and depth of cut are all affected by the rake angle (00-160). In order to estimate the impact of material type on primary cutting force, the same cutting conditions, tool parameters, and tool material were used in many experiments on the three Specimen materials. As the tool rake angle increases from 00 to 160, the primary cutting force decreases for EN 31, M.S. specimens, however the main cutting force increases for Aluminum specimens as the angle rises. This is due to the material of the workpiece. Cutting force is highest at EN 31 specimens and MS specimens, and lowest at the aluminium specimens, according to experimental results. In this thesis, we're also looking for the best control settings to minimise surface roughness.. During a turning operation, the parameters of the process, such as cutting speed, feed rate, and cut depth, will be examined. In this study, Taguchi's design of experiments was used to analyse surface roughness using different turning process parameters of EN-31 Steel, MS, and Aluminum in a turning operation with rake angles of 40 and a S/N ratio of 1.

Keywords: *forces, taguchi method, speed*

I. INTRODUCTION

In this paper, we're also looking for the best control settings to minimise surface roughness.. During a turning operation, the parameters of the process, such as cutting speed, feed rate, and cut depth, will be examined. In this study, Taguchi's design of experiments was used to analyse surface roughness using different turning process parameters of EN-31 Steel, MS, and Aluminum in a turning operation with rake angles of 40 and a S/N ratio of 1. The purpose of this study is to determine experimentally the influence of tool rake angle on EN 31Steel, MS, and Aluminum specimens as work piece materials and carbide as a tool material during a turning process. It has been found that cutting speed, feed rate, and depth of cut are all affected by the rake angle (00-160). In order to estimate the impact of material type on primary cutting force, the same cutting conditions, tool parameters, and tool material were used in many experiments on the three Specimen materials. As the tool rake angle increases from 00 to 160, the primary cutting force decreases for EN 31, M.S. specimens, however the main cutting force increases for Aluminum specimens as the angle rises. This is due to the material of the workpiece. Cutting force is highest at EN 31 specimens and MS specimens, and lowest at the aluminium specimens, according to experimental results.

II. METHODOLOGY

2.1 Design of Experiment

As a control factor in this investigation, three turning process parameters were chosen: a 1, 2, and 3 level each for each parameter. While adopting the Taguchi orthogonal array would have reduced the number of experiments, the experimental design used an L'9 array based on the Taguchi method. Tests utilising the Taguchi method were done to examine the relationship between process parameters and response factors. The optimization process makes use of the Minitab 17 programme. Carbide is used to make a single point cutting tool. The Bevel Protractor Combination Set is used to preserve the same tool geometry between experiments. An MIRANDA S-400 workpiece is utilised as the tool. Material:

- Surface roughness optimization experiments are carried out on EN 31 steel, MS and aluminium workpieces.

The rake angle that should be used - There are a number of things to keep in mind when deciding which cutting tool is best for the job at hand:

- Dimensions of the cut-the speed at which the workpiece surface moves in relation to the cutting edge. A metre per minute rate is used.

- A cutting tool's feed rate is defined as the pace at which the cutting tool moves in relation to the work piece during a cut. mm per rotation is the unit of measurement for feed rate.

When turning or boring a workpiece, the tool's depth of cut is measured along the radius of the workpiece. In order to avoid overloading the tool and shorten its lifespan, a large cut depth necessitates a moderate feed rate. It is therefore common to machine many features at the same depth of cut. Carbide tool utilised in procedure.

Parameters of the setting	
Control factor	**Symbol**
Cutting speed	Factor A
Feed rate	Factor B
Depth of cut	Factor C

Table 1: Turning parameter of the setting

III. REVIEW LITERATURE

For turning SCM 440 alloy steel, Thamizhmanii et al. (2007) used Taguchi approach to determine ideal surface roughness under optimal cutting conditions. By employing Taguchi's method, experiments were conducted and the data were analysed using ANOVA (Analysis of Variance). Machine tool vibrations and tool chattering were shown to be responsible for the poor surface smoothness, although their impacts were overlooked in the analysis. They came to the conclusion that this method's results might be used to other studies looking at tool vibrations, cutting forces, and the like. Surface roughness was determined to be a result of only one factor: the depth of cut.

Through the use of Matlab 7 software, Natarajan, C., and colleagues (2010) developed an artificial neural network (ANN) for predicting surface roughness. Spindle speed, feed rate, and depth of cut were all considered in the evaluation of cutting parameters. In a CNC turning centre with a CNMG 120408 insert, C26000 metal was tested in a dry environment. There were a total of 36 individuals who were tested. Matlab 7 was used to compare the measured roughness values to the expected roughness values. 24.4 percent of the roughness values were determined to be out of whack with each other. The model also revealed the parameters' relationships with one another. The feed rate was shown to have the greatest impact on surface roughness, followed closely by the other variables.

Cutting force and surface roughness were evaluated in turning mild steel with an HSS cutting tool by Rodrigues, L.L.R., et al. (2012). A high-precision lathe machine was used to conduct the experiments. The ideal solution was discovered through the use of a full factorial design with two repetitions. Surface roughness was primarily impacted by feed and the connection between feed and speed, whereas cutting force variance was considerably influenced by feed, depth of cut, and the interaction between feed and depth of cut. Cutting force and surface roughness may be affected by feed and depth of cut, according to these researchers.

Al6351-T6 alloy was successfully turned to an ideal surface roughness using the setting developed by Somashekara, H.M., and Swamy, N. L. et al (2012). Regression analysis was used to create a model for the best surface roughness. There were three degrees of speed, feed, and depth of cut for each of the turning parameters that were examined. The experiment made use of a L9orthogonal array. Three times was the maximum number of repeats for the roughness test. Regression models and experimental data were shown to have error margins of less than 2%. Cutting speed was shown to be the most significant characteristic, followed by feed and depth of cut, according to ANOVA and S/N ratio.

Taguchi approach was used by Quazi, T., and Pratik Gajanan(2014) to optimise surface roughness in turning EN8, EM31, and mild steels, respectively. Cutting speed and feed rate were two of the three turning characteristics that were examined. TN60, TP0500, and TT8020 were the tool grades that were evaluated. Using a Supercut 5 turning machine, the researchers conducted their tests. An optical profiling system, the Wyko NT9100, was used to gauge the surface roughness. Minitab statistical 16 was used to construct and analyse the Taguchi process. All materials were analysed utilising a L9orthogonal array and three cutting tools. It was shown that for all three alloys, feed rate had the greatest impact on surface roughness.

Rake Angle and Feed Rate Effect on Cutting Forces in an Orthogonal Turning Process." Rake angle and feed rate affect cutting forces in an orthogonal turning process, according to this article. HSS tools were used to turn a hollow EN8 work piece at six different rake angles (00, 40, 80, 120,160, 200) A 4-component piezoelectric dynamometer was used to measure the forces during the experimentation. Feed (Fx) is greater than tangential (Fy) and longitudinal (Fz) forces, regardless of tool rake angle, according to experimental results.

Cutting depth, rake angle, and workpiece material type all have an effect on cutting force during a turning operation, according to a study published in the Journal of Machine Tools and Manufacturing Processes. An experimental investigation of the effects of cutting depth, tool rake angle, and work piece material type on cutting force and chip morphology is the subject of this research. Work piece materials included AISI 1020, Aluminum 2014, and UNS C23000.

Tool Geometry and Cutting Conditions Affect Tool Deflection and Cutting Forces" by Fata, B. Nikuei To find out how tool deflection and cutting force are affected by cutting conditions (depth of cut and cutting speed), the study uses cutting forces to measure tool form and qualification (sharp and worn cutting tools of both vee and knife edge profile). Both the workpiece and the cutting tool were constructed of high speed steel. A dynamometer was used to measure cutting forces.

Zheng Ying and Suther J.W. Finite deformation analysis and experimental verification were used to develop an orthogonal model. An orthogonal turning model based on finite deformation is presented in this study to help with force predictions.

Power prediction model for turning EN31 steel using response surface methodology, L. B. Abhang and M. Hameedullah, 1997 Using tungsten carbide tools to convert EN-31 steel (the most often used metal in the automotive sector) under varying cutting circumstances was studied in this research.

Turning parameters and surface roughness were investigated by Feng. Cang-Xue (Jack) in his dissertation. His research focused on the effects of cutting parameters such as feed rate, cutting speed, cutting depth, and the tool's and work material's nose radius on the material's surface roughness. In his study, he found that the feed had a considerable impact on the measured surface roughness, as well as strong interactions between other turning parameters.

For a single pass turning operation with a fixed feed rate and depth of cut, Gilbert (1950) presented a theoretical analysis of machining process optimization and proposed an analytical procedure to determine the cutting speed using two different objectives: maximum production rate and minimum machining cost.

IV. OUR APPROACH

Cutting speed, feed rate, and cut depth were the three factors tested in this experiment. Taguchi's L9 orthogonal array is used to guide the design of the experiment. The experiment will use a L9 orthogonal array because the three input parameters each have three levels. 7.5KW of primary drive power and a speed range of 100-4000rpm were used for the experimentation on a Lathe Machine Turning. A carbide-tipped cutting tool was used to cut aluminium.

Table-2: Turning parameter of the setting

Symbol	Control Factor	Unit	Level 1	Level 2	Level 3
V	**Cutting Speed**	**m/min**	**175**	**220**	**264**
F	**Feed**	**mm/rev**	**0.1**	**0.2**	**0.3**
D	**Depth Of Cut**	**mm**	**0.5**	**1.0**	**1.5**

Level	Cutting Speed(m/min)	Feed rate (f) (mm/rev)	Depth of cut (d) (mm
1	-6.701	-1.197	-6.110
2	-5.199	-5.621	-5.664
3	-4.685	-9.767	-4.810
Delta	2.015	8.750	1.300
Rank	2	1	3

Table 3: Response Table for Signal to Noise Ratios

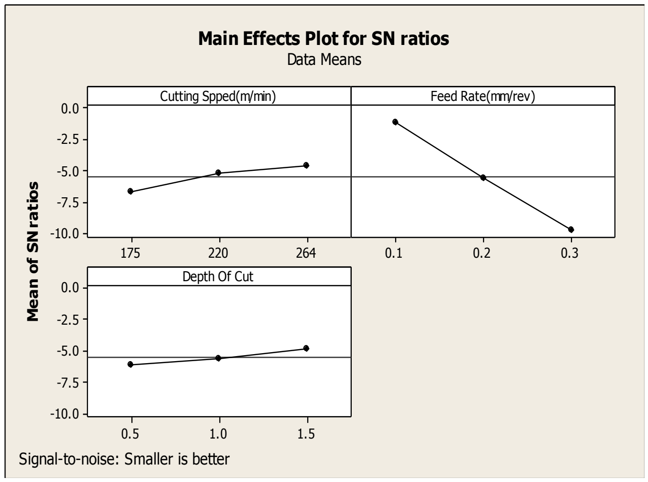

Figure 1: Main effects plot for SN ratio (Ra)

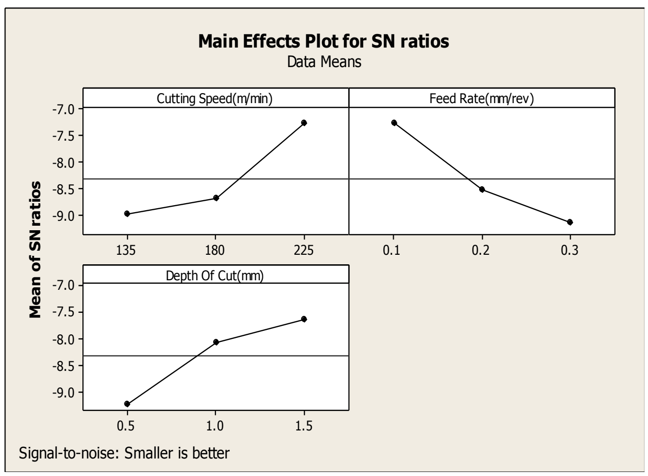

Figure 2: Main effects plot for SN ratio (Ra)

V. CONCLUSION

Surface roughness in a turning operation can be improved by using Taguchi parameter design. Cutting speed, feed rate, and depth of cut were used to calculate Ra. Using MINITAB 17 software, we were able to obtain the primary effect, interaction effect, and graphs for the response, surface roughness, by adjusting the machining parameters. Accordingly, Taguchi parameter design is an efficient and effective way for optimising surface roughness in turning operations.

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