Experimental Investigation of Cutting Parameters Influence on Tool Wear and Surface Roughness in Turning of EN 31 Steel using Carbide Insert in CNC Turning Center

J. Rajaparthiban
Assistant Professor,
Department of Mechanical Engineering,
Kings College of Engineering.

N. Magesh
Assistant Professor,
Department of Mechanical Engineering,
Kings College of Engineering.

B. Adhichelvan
Assistant Professor,
Department of Mechanical Engineering,
Kings College of Engineering.

R. Balaji
Final year,
Department of Mechanical Engineering,
Kings College of Engineering.

A. Ananthan
Final year,
Department of Mechanical Engineering,
Kings College of Engineering.

Abstract:- In modern machining processes, there are continuous cost pressures and high quality expectations in the product. Turning is one of the prominent and fundamental process in the field of machining. Turning is largely used in aerospace, automotive, machinery design and also in manufacturing industries. Tool wear and surface roughness are widely considered most challenging aspect causing poor quality in machining of the steel. Optimization of cutting parameters is essential for the achievement of high quality and high rate of mass production. In the present work, an attempt has been made to investigate the effect of process parameter performance characteristics in turning of EN31steel using carbide insert and there by optimizing the process parameter using Taguchi's DOE method. Three process parameters namely speed, feed and depth of cut are used to optimize multi quality characteristics namely surface roughness and tool wear. The results reveal that Taguchi's technique used for minimizing the surface roughness and tool wear using MINITAB 16 produce a favourable range of the machining parameter values is proposed for efficient machining.

Keywords: EN31 steel, surface roughness, tool wear, optimization, Taguchi DOE

I. INTRODUCTION

Surface finish plays vital role in service life of components and it ensures a great reliability of components. It required to optimize process parameter for better surface finish **[1]**. The research represents an optimization model for machining parameter in steel using tungsten carbide inserts **[2]**. The research reveals that three purpose namely, systematic procedure based on, data observed, secondary finding out the optimal combination of process parameter and finally the effect of lubricating temperature in steel **[3].** The study conclude that the design of experiments (DOE) methodology constitute a better approach for roughness prediction **[4].** The effects of the cutting parameters and tool materials on surface roughness were evaluated by the analysis of variance **[5].** Experimental study of the effect of the main turning parameter such as feed rate, tool nose radius, cutting speed and depth f cut on the surface roughness of AISI 410 steel **[6].** The turning operations were carried out with TiC and TiCN coated carbide cutting tool inserts. The experiments were conducted at three different cutting speeds (80, 100 and 120 m/min) with three different feed rates (0.04, 0.08 and 0.12 mm/rev) and a constant depth of cut (0.5 mm). The predicted results are found to be closer to experimental results within 8% deviations **[7].** The experimentation plan is designed using Taguchi's L9 Orthogonal Array (OA) and MINITAB-16 statistical software is used. Optimal values of process parameters for desired performance characteristics are obtained by Taguchi design of experiment. Prediction models are developed with the help of regression analysis method using MINITAB-16 software **[8].** The performance of multi-layer TiN coated tool in machining of hardened steel (AISI 4340 steel) under high speed turning, which has also been compared with that of uncoated tool. The influence of cutting parameters (speed, feed, and depth of cut) on surface roughness have been analysed using Taguchi methodology. The machining of hard materials at higher speeds and lower feeds is improved by using coated tools **[9].** The author represents an optimization of machining parameters with multiple cutting tools. This is required to reduce the cutting forces and temperature while machining AISI 1045 steel. It is concluded that carbide cutting tools is a better option as compared to uncoated cemented carbide cutting tool for machining AISI 1045 steel as it results in lower cutting forces and temperatures **[10].** The machining outcome was used as an input develop various regression models to predict the average machined surface roughness on this material. It was concluded that the random forest regression model is a superior choice over multiple regression models for prediction of surface roughness during machining of AISI 4340 steel.

The present study investigate, the machining characteristics of EN31 steel. The research thoroughly investigates the quality characteristics of machining by predicting the optimum cutting parameters, subjected to several constraints. The Taguchi experimental design method were applied to conduct the experiment.

II. EXPERIMENTATION PROCESS

The present work deals with a turning of EN31 steel, it is an important engineering material employed in manufacturing of automotive parts in industries. The experiment deals with the machining of EN31 were carried out with carbide tools in CNC turning centre. A solid bar of EN31 with 30mm diameter 100mm length were used as the work piece. The tool holder used for this experiment are CERATIZIT make carbide tool insert with specification of CNMG 1200408EN-TMR(insert) and tool holder specification is of MCLNL 2020-K12. The effect of cutting parameter is reflected on surface roughness, surface texture and dimensional deviations of the product. The surface roughness was measured by using surface roughness tester. Tool wear is one of the most important aspects that affect tool life and product quality will measured using optical tool maker microscope, this study discuss the flank wear mechanism in various parametric levels to achieve the qualitative product. The SEM image of EN31 steel is shown in figure 1. The experiments were performed based on L9 orthogonal array as nine different trials with parameters at different levels, each repeated thrice the initial cutting parameters were selected based on the through literature survey and from design data book are tabulated in table 1 as follows.,

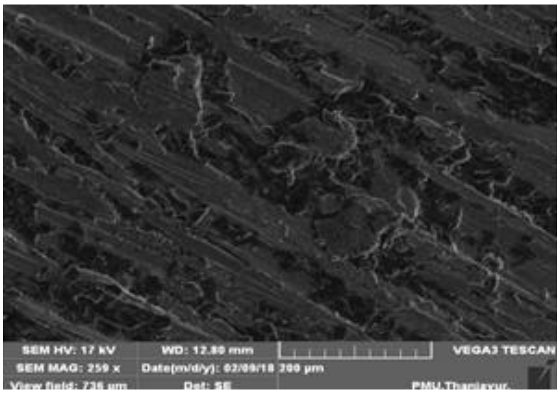

Figure1. SEM image of EN31 Steel

Table 1: Input Parameters and Levels

Sl.No	Parameter	Symbol	Units	Level 1	Level 2	Level 3
1	Cutting Speed	S	m/min	220	250	280
2	Feed	F	mm/rev	0.10	0.15	0.20
3	Depth of Cut	D	mm	0.5	0.6	0.7

III. RESULT & DISCUSSION

The Taguchi method which emphasizes on the optimization of more than one output parameters, rather than optimizing a single output parameter as in case of the Taguchi method. The Taguchi method developed by Genichi Taguchi (1990) was the most important statistical tool for the optimization of the single output parameter. It considers a set of different number of input parameters, may it be an L27 orthogonal array or an L9 orthogonal array depending upon the degree of accuracy needed. The number of experiments chosen in the article is a L9 orthogonal array comprising of the different combinations of the input parameters. Figure 2 & 3 represents the tool maker microscope and surf coder SE1200 respectively. In this section, the influence of machining parameters and its effects on surface roughness (Ra) and Tool wear on turning of EN31 with carbide inserts has been discussed. Table-2 shows the experimental results of surface roughness and tool wear.

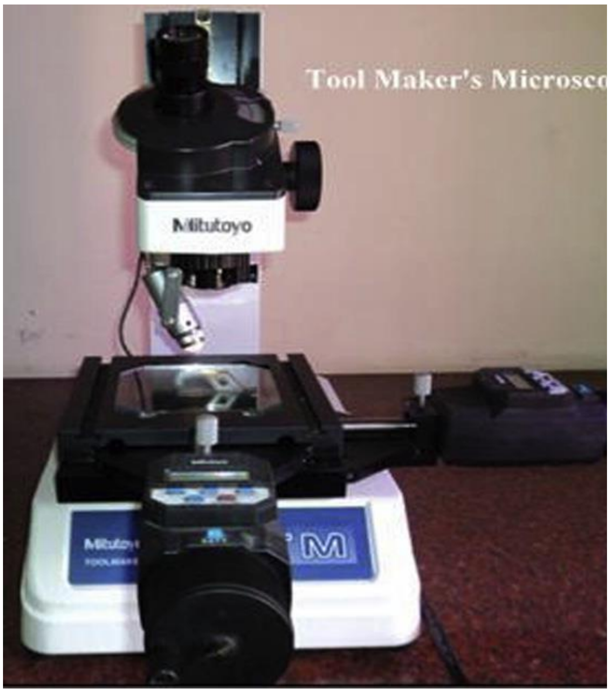

Figure 2. Tool maker Microscope

Table 2: Experimental Results

Trial No.	Speed (m/min)	Feed (mm/rev)	DOC (mm)	Ra (Microns)	Tool wear (mm)
1	220	0.1	0.5	3.56	0.2
2	220	0.15	0.6	3.63	0.34
3	220	0.2	0.7	4.98	0.31
4	250	0.1	0.6	3.38	0.38
5	250	0.15	0.7	3.54	0.39
6	250	0.2	0.5	4.83	0.43
7	280	0.1	0.7	2.62	0.41
8	280	0.15	0.5	3.35	0.22
9	280	0.2	0.6	2.25	0.30

Figure. 4 represents graphically in main effect plot for surface roughness and this graph exposes that the optimal machining parameters (speed=280m/min, feed rate=0.10mm/rev, depth of cut=0.6mm).

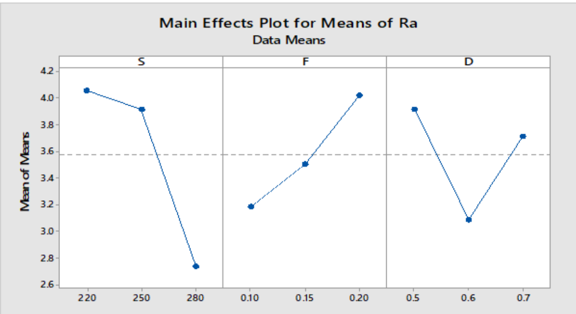

Figure. 4 Optimal machining parameters for surface roughness

Figure. 5 represents graphically in main effect plot for tool wear and this graph exposes that the optimal machining parameters (speed=220m/min, feed rate=0.15mm/rev, depth of cut=0.5mm).

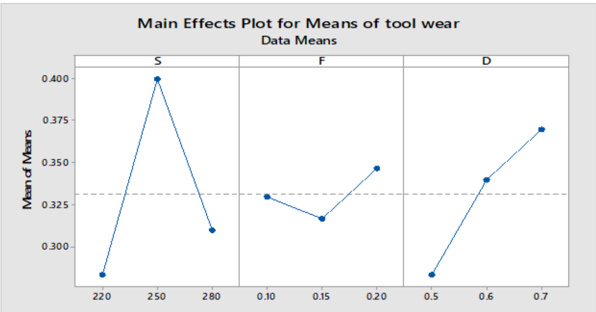

Figure. 5 Optimal machining parameters for tool wear

IV. CONCLUSION

During the current study, L9 orthogonal array Taguchi design was used to study the influence of machining parameters on surface roughness and tool wear during machining of EN31 steel. The following observation were made as follows.,

1. The results obtained from Taguchi design of experiments and analysis, the cutting speed is the main factor that has the highest influence on surface roughness as well as tool wear of turning and facing processes.
2. Optimal machining parameters for minimum surface roughness and tool wear were determined. The percentage error between experimental and predicted results shows the closeness between the processes.
3. The optimal machining parameters for surface roughness as speed=280m/min, feed rate=0.10mm/rev, depth of cut=0.6mm.
4. The optimal machining parameters for tool wear as speed=220m/min, feed rate=0.15mm/rev, depth of cut=0.5mm.
5. The present work has considered only a two dimensional problem: surface roughness and tool wear. In the future, three or more dimensional parameters or other criteria like cutting force of materials can be considered.

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