International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

An Investigation for CNC Turning Parameters for Machining EN-24

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Abstract: The present experimental research on Plain turning studies the process parameters that are affecting the machining performance and productivity of Plain Turning. A combined approach is used for the optimization of parameters and performance characteristics based on Taguchi method. The design of experiments is based on Taguchi's L9 orthogonal array. The response table and response graph for each level of machining parameters are obtained from Taguchi method to select the optimal levels of machining parameters. In the present work, the machining parameters are Speed, Feed Rate and Depth of Cut, which are optimized for maximum material removal rate (MRR) and minimum Surface Roughness during turning of EN-24. Analysis of Variance is also used to find out variable affecting the various responses mentioned above. The cutting speed and depth of cut were found to be the major dominating factors for MRR and surface roughness. Feed was found to be least influencing parameter for both MRR and Surface Roughness.
Keywords: CNC Turning, MRR, Surface Roughness, EN-24

I. INTRODUCTION

Due to the advancement of technology demand of the hour is increasing. Maintaining the economic production with optimal use of resources is of prime concern for the engineers. Metal machining is one of them. In machining process, there are various parameters involved. Some challenges that the engineers come across are to find out the optimal parameters for the desired product quality and to maximize the performance of manufacturing using the available resources. In today's manufacturing industry, special attention is given to dimensional accuracy, surface finish and hardness of material. The surface quality is an important parameter to evaluate the productivity of machine tools as well as machined components. Surface roughness is used as the critical quality indicator for the machined surface. Formation of a rough surface is a complicated mechanism involving many parameters. The quality of the work piece (either roughness or dimension) are greatly influenced by the cutting conditions, tool geometry, tool material, machining process, chip formation, work piece material, tool wear and vibration during cutting. Extensive effort has been done to observe the critical parameters which affect the surface roughness. This work aims at one such Taguchi optimization study of process parameters for material removal rate, surface roughness and hardness as the response.

S.R. Das et al [1] conducted experiments on Tungsten AISI 4340 steel with Coated Graphite tool inserts. Feed was found to be most significant parameter for the workpiece surface roughness (Ra) with a percent contribution of 52.55%. Cutting speed was found to be the next significant parameter for Ra with contribution of 25.85%. Depth of cut was found a negligible influence in case of Ra. Jitendra. M. Varma et al [2] conducted experiments on AISI 4340 using solid lubricant with coated carbon tool inserts. It is concluded that the application of solid lubricant in dry machining has proved to be a feasible alternative to cutting fluid, if it can be applied properly. There is a considerable improvement in surface roughness and quality of product produced.

Karanam Krishna et al [3] carried an investigation using ANN for material removal rate on Aluminum in turning. This work investigated the influence of the operating parameters like feed rate, depth of cut, clamping length and spindle speed. It was evident that each of these parameters studied contributed to the error in the dimensions of the machined component. Depth of cut and the feed rate had more effect on the accuracy than the other parameters. Based on this ANN prediction, the NC program could be corrected before commencing the actual machining operation, thus improving the accuracy of the component at less cost and time. A.Sathyavathi et al [4] carried a study on different researches conducted. The most of researchers are interested in optimization of machining condition with corresponding surface roughness. In past reviewed found, none of researcher involved for TiBN coated cemented carbide tool. In this paper uncoated carbide tool and PVD (TiBN) coated carbide tool involved for performance of quality of surface and optimization of cutting parameter with aid of DOE and GA.

M.M.A. Khan et al [5] carried an investigation to analyze the effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oil-based cutting fluid. They concluded that the chips produced under both dry and wet condition are of ribbon type continuous chips at lower feed rates and more or less tubular type continuous chips at higher feed rates. The significant contribution of MQL jet in machining the low alloy steel by the carbide insert undertaken has been the reduction in flank wear,

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which would enable either remarkable improvement in tool life or enhancement of productivity (MRR) allowing higher cutting velocity and feed. The Surface finishes also improved mainly due to reduction of wear and damage at the tool-tip by the application of MQL. M. Venkata Ramana et al [6] carried experiments to study the effect of process parameters on tool wear in Turning of Titanium Alloy under different machining conditions It was concluded that the MQL machining shows advantage mostly by reducing tool wear as well as environmental problems, which reduces the friction between the chip - tool interaction. Using ANOVA, the effect each individual factors on tool wear found to be significance and the contribution of cutting speed is more followed by tool material, depth of cut, feed rate and coolant condition in order to minimizing tool wear.

Vikas B. Magdum et al [7] carried investigation to evaluate and optimize the machining parameters for turning of EN 8 steel using HSS M2, Carbide and Cermet tools. N.Zeelan Basha et al [8] optimized turning process parameters on Aluminium 6061 using Genetic Algorithm. Optimum surface finish was obtained at maximum cutting speed, minimum feed and minimum depth of cut. Y.B. Kumbhar et al [9] investigated tool life and surface finish optimization of PVD TiAlN/TiN multilayer coated Carbide tool inserts in semi hard turning of hardened EN-31 alloy steel under dry cutting conditions. Maximum tool life is obtained at low cutting speed, moderate feed and depth of cut. Feed rate was found to be the most significant factor for tool life. Feed rate was also the most significant factor for surface roughness.

Gopal Krishna, P. V et al [10] studied the effect of cryogenic processing and carried out experiments on cryogenic treated tools in turning. Significant influence is seen on tool life which gets improved up to 90%. They concluded that the life of the tools has increased due to cryogenic treatment while machining both soft and hard materials. The cryogenic treated tools are found to be most productive at high speeds and feeds. Hemant B. Patil et al [11] reviewed the effects of cryogenic on tool steels. It was concluded that cryogenic induces wear resistance as the soft austenite is converted into hard martensite. The dimensional accuracy and surface finish also get improved. They also concluded that the use of cryogenic increases the cutting force which can be reduced by the use of secondary liquid nitrogen.

Lakhwinder Pal Singh et al [12] compared cryogenic treated and un-treated high speed steel tool in turning. It was concluded that after cryogenic treatment of high speed steel the performance of the tool was enhanced. Less power consumption was observed. M.Dhananchezian et al [13] investigated the effects of cryogenic cooling by liquid nitrogen in orthogonal turning of Ti-6Al-4V. The cryogenic reduces the cutting temperature. The cutting force was found to be increased. The chip thickness was reduced by 25% as compared to dry turning.

II. EXPERIMENT AND METHODOLOGY

Experiments are conducted on SIEMENS CNC TURNING MACHINE. The machine is as shown in the figure below. The material is removed from the work-piece by the linear motion of tool towards work-piece in form of chips. The machine setup is shown in figure 1. The material used for this work is EN 24. The bar of workpiece was of 20mm diameter. The tool material used for this work is HSS.

Fig. 1 Setup of EN-24 specimen for experiments on CNC Turning Machine

The parameters selected for present research are speed, feed rate and depth of cut while the responses selected are MRR and Surface Roughness. The experiments were designed on the basis of Taguchi L9 orthogonal array and the experiments were performed accordingly. Surface roughness was measured by using Talysurf surface roughness tester that measures the value by the stylus that moves over the machined surface. The following table 1 shows the set of parameters with corresponding values of MRR and Surface Roughness.

Table I: Experimental Values Of Mrr And Surface Roughness

Exp. No	Speed (RPM)	Speed (m/min)	Feed (mm/rev)	Depth of Cut (mm)	MRR (mm^3/min)	Surface Roughness (µm)
1	50	3.14	0.06	0.2	37.68	6.73
2	50	3.14	0.10	0.4	125.6	6.92
3	50	3.14	0.14	0.6	263.76	7.08
4	100	6.28	0.06	0.4	150.72	7.21
5	100	6.28	0.10	0.6	376.8	7.71
6	100	6.28	0.14	0.2	175.84	7.07
7	150	9.42	0.06	0.6	339.12	7.82
8	150	9.42	0.10	0.2	188.4	7.28
9	150	9.42	0.14	0.4	527.52	8.01

III.RESULTS AND DISCUSSION

A. Material Removal Rate

Material removal rate can be calculated by using the relation below

$$\textbf{Speed in} \frac{\textbf{m}}{\textbf{min}} = \textbf{Shaft Diameter (mm)x Speedin RPM x 0.001 x } \pi$$

$$MRR = 1000 \times Speed\ in \frac{m}{min} \times feed\ in \frac{mm}{rev} \times depth\ of\ cut\ in\ mm$$

The following table II shows the ANOVA for MRR. It's clear from the table that the major influencing parameters for MRR are speed and depth of cut with a contribution of 36.60% and 32.40% respectively while the least influencing is feed with a contribution of only 18.24%.

TABLE II: ANOVA for MRR

Source	DOF	SS	Adj MS	F Value	Contribution
Speed	2	66046	33023	2.87	36.60%
Feed	2	32918	16459	1.43	18.24%
Depth of Cut	2	58474	29237	2.54	32.40%
Error	2	23032	11516		12.76%
Total	8	180470			100%

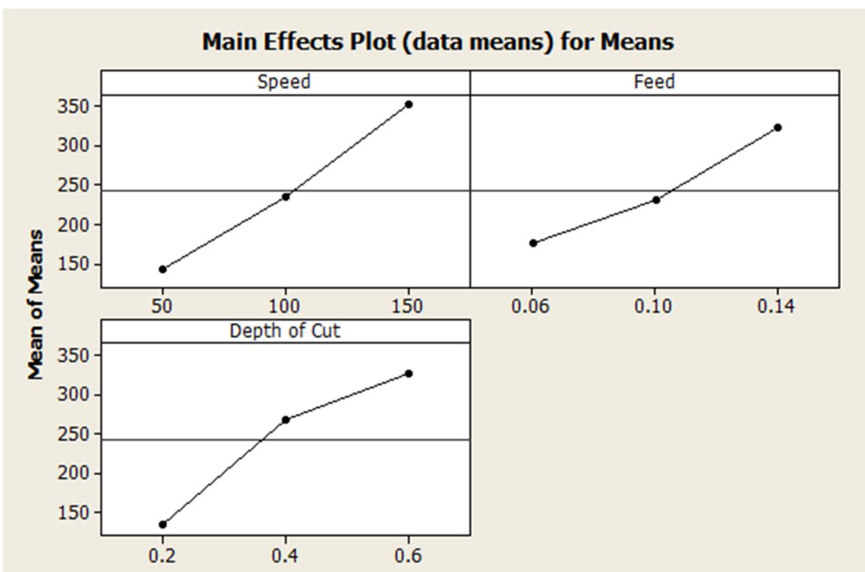

Fig. 2 Main effect plot for MRR

The figure 2 clears that as we increase the cutting speed, the MRR tends to increase. As the cutting speed increases, the material is removed at a faster rate and hence MRR increases. The cutting speed is the most significant factor for MRR. MRR increases with increase in feed but at a slower pace as compared to that of cutting speed. As we increase the feed, the thickness of material to be removed increases. This reduces lead time and hence increases material removal rate. In case of depth of cut, as the level of depth of cut is increased, material removal is observed to get increased. Depth of cut is the distance of newly machined surface to the uncut surface. Thus as it is increased, the thickness of material to be removed increases and hence it will increase the material removal rate. It can be seen from the three graphs shown above that all the three machining parameters viz. cutting speed, feed per revolution and depth of cut directly affect the MRR and increases with the increase in value of parameters. Maximum MRR is obtained at 150 RPM speed, 0.14 mm feed rate and 0.6 mm depth of cut.

B. Surface Roughness

With present set of experiments, the value of surface roughness lied between 6.73µm to 8.01µm.

The following table III shows the ANOVA for Surface Roughness. It's clear from the table that the major influencing parameter for surface roughness of machined EN-24 is cutting speed followed by depth of cut. The contribution of speed and depth of cut are 62.19% and 26.94% respectively. The feed rate is the least influencing parameter and has negligible influence on surface roughness. Its contribution is 1.79%.

Table III: Anova For Surface Roughness

Source	DOF	SS	Adj MS	F Value	Contribution
Speed	2	0.94516	0.47258	6.85	62.19
Feed	2	0.02722	0.01361	0.20	1.79
Depth of Cut	2	0.40949	0.20474	2.97	26.94
Error	2	0.13796	0.06898		9.08
Total	8	1.51982			100%

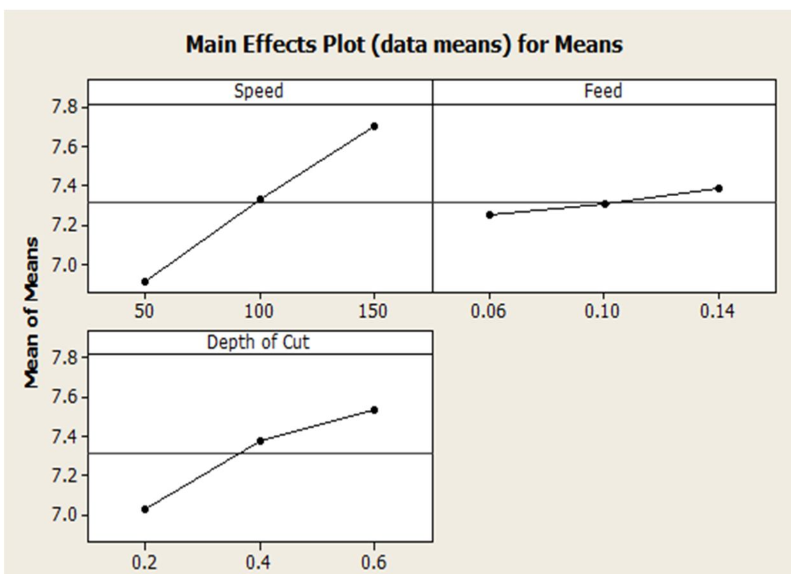

Fig. 3 Main effect plot for WLT

The above graph shows the effect of input parameters on surface roughness. From all the three graphs it is seen that the surface finish degrades with increasing the level of machining parameters. By increasing the cutting speed the surface roughness increases and the surface finish starts to degrade. Very rough surface is generated as we increase the cutting speed to the higher levels. In case of feed rate, it also affects the surface roughness in similar fashion. The surface degrades with the increase in feed rate as thicker layer of material is removed which will roughen the new exposed machined surface. Increase in depth of cut also degrades the surface finish of EN-24. The most influential factor for surface roughness is the cutting speed followed by depth of cut and lastly by feed rate. Lowest surface roughness is obtained at 50 RPM cutting speed, 0.06 mm/rev feed rate and 0.2 mm depth of cut.

IV. CONCLUSIONS

This experimental study described the optimization of input machining parameters viz. cutting speed, feed rate and depth of cut in plain turning of EN-24 using L9 orthogonal array of Taguchi method. Factors with different levels were found to play significant role in plain turning operation for maximization of MRR and minimization of Surface Roughness. Following conclusions are made:

A. As we increase the cutting speed, the MRR tends to increase. As the cutting speed increases, the material is removed at a faster rate and hence MRR increases. The cutting speed is the most significant factor for MRR. MRR increases with increase in feed but at a slower pace as compared to that of cutting speed.

B. As we increase the feed, the thickness of material to be removed increases. This reduces lead time and hence increases material removal rate.

C. In case of depth of cut, as the level of depth of cut is increased, material removal is observed to get increased. Depth of cut is the distance of newly machined surface to the uncut surface. Thus as it is increased, the thickness of material to be removed increases and hence it will increase the material removal rate.

D. Maximum MRR is obtained at 150 RPM speed, 0.14 mm feed rate and 0.6 mm depth of cut.

E. The surface finish degrades with increasing the level of machining parameters. By increasing the cutting speed the surface roughness increases and the surface finish starts to degrade. Very rough surface is generated as we increase the cutting speed to the higher levels.

F. In case of feed rate, it also affects the surface roughness in similar fashion. The surface degrades with the increase in feed rate as thicker layer of material is removed which will roughen the new exposed machined surface. Increase in depth of cut also degrades the surface finish of EN-24.

G. The most influential factor for surface roughness is the cutting speed followed by depth of cut and lastly by feed rate. Lowest surface roughness is obtained at 50 RPM cutting speed, 0.06 mm/rev feed rate and 0.2 mm depth of cut.

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