Study of Effect of Turning Process parameters for machining EN-19

Sachin D. Munde[1], Prof. G. P. Ovarikar[2]
[1] PG Research Scholor, Shree Tuljabhavani College of Engineering, Tuljapur, Maharashtra, India
[2]Head of Department,Mechanical Engineering Shree Tuljabhavani College of Engineering, Tuljapur, Maharashtra, India

Abstract: In present research work the effect of machining parameters including cutting speed, feed rate and depth of cut on material removal rate (MRR) % Rise in tool tip temperature and surface roughness (Ra) in a turning of EN-19 material are investigated using the Taguchi method and ANOVA. A three level, three parameter design of experiment, L9 orthogonal array was used to perform experiment. The analysis of variance (ANOVA) is applied to study the contribution of each machining parameters. Optimization of process parameter is carried out by GRA). The present investigation indicates that speed and feed rate are the most significant factors in case of material removal rate and surface roughness

Index Terms—**Turning, EN-19, GRA**

I. INTRODUCTION

EN-19 It has drawn special attention due to its excellent properties. From few years, the technology of CNC turning machine has been advanced significantly, in order to meet the advance requirements in various manufacturing fields, particularly in the precision turning metal cutting industry. It is widely used for a variety of products to manufacturing in the industries. Material removal rate (MRR) % RTTT and Surface roughness (Ra) are an important responses of machining operation. MRR and Ra contribute to machining cost and quality of the machining component respectively. In order to reduce the machining time and characteristics, effort to maximize the value of MRR and to minimize Ra by selecting optimal machining process parameters like cutting speed, feed rate, depth of cut are required to be study in details.

Zhou Jinming M. et al [1] used a pressurized coolant in a precision hard turning of bore, with polycrystalline cubic boron nitride as the tool materials, to reduce the thermal distortion of the machined part such as form error and to improve its waviness. The pressurized coolant jet was directly delivered under the chip on the rake face. Experimental result indicated that form error induced by the heat has been reduced, and waviness of the bore was improved with use of pressurized coolant. Crater wear is smaller under pressurized coolant compared to dry cut due to lower rake face temperature and shorter contact length between chip and work-piece. Functions of pressurized coolant include breaking the chips to reduce the chip and machined surface contact area, thereby decreasing the crater wear; breaking the path way of heat from chip to work-piece; and continuously dissipating heat from the freshly machined surface in order to reduce the thermal distortion of work-piece and improve the product quality. Both waviness and surface roughness in the machined part are improved remarkably with use of pressurized coolant.

Tamizharasan T. et al [2] described the various characteristics in terms of component quality, tool life, tool wear, and effects of individual parameters on tool life and material removal, and economics of operation. The newer solution, a hard turning operation, is performed on a lathe. In this study, the PCBN tool inserts are used. The hardened material selected for hard turning is commercially available engine crank pin material. Volume of material removed (MRR) in cm3/min is calculated as V=f*s*d* t where, t = cutting time in minutes, f = feed rate in cm/rev, d = depth of cut in cm, s = cutting speed in cm/min & the surface roughness value depends mainly on feed rate and nose radius of the tool. The theoretical value of surface roughness is calculated as, Ra = f2/32R, where f is feed rate and R is nose radius of tool.

Prasad Balla Srinivasa et al [3] presented an investigation of a tool condition monitoring system, which consists of a fast Fourier transform pre-processor for generating features from an online acousto-optic emission (AOE) signals to develop a database for appropriate decisions. A fast Fourier transform (FFT) can decompose AOE signals into different frequency bands in the time domain. In this work they used a laser Doppler vibrometer for online data acquisition and a high-speed FFT analyser used to process the AOE signals. In this research work the results obtained from the analysis of acousto-optic emission sensor employs to predict flank wear in turning of AISI 1040 steel of 150 BHN hardness using Carbide insert and HSS tools. The continuous demand for higher productivity and product quality asks for better understanding and control of the machining process. A better understanding can be achieved through experimental measurement and theoretical simulations and modelling of the process and its resulting product.If the vibration signal can indirectly monitor the tool wear growth, it is also able to monitor surface roughness growth and, consequently, to establish the end of tool life in this kind of operation.One of the main difficulties of monitoring the tool life through vibration signal is to identify the frequency range that is actually influenced by the tool wear, since the machining process has a lot of factors that produces vibration, many of them not correlated with the wear and breakage processes.

Satish Chinchanikar and S.K. Choudhury [4] discussed effect of work material hardness and cutting parameters on performance of coated carbide tool when turning hardened steel with an optimization approach. Insert used for turning is Coated tungsten based cemented carbide inserts Kennametal KC9110 (CVD with TiCN/Al2O3/TiN coating layer sequence 80° diamond shape with 0.8 mm nose radius) and work piece AISI 4340 steel 35 (33–35) and 45 (45–47) HRC. Cutting forces are low at higher cutting speed when coupled with higher feed and higher depth of cut. Cutting forces get affected mostly by depth of cut followed by feed. Surface roughness gets affected significantly at higher feed and depth of cut.

Hamdi Aouici et al [5] used CBN7020 insert having standard designation SNGA12 04 08 S01020 manufactured by Sandvik company. Analysis of surface roughness and cutting force components in hard turning with CBN tool Prediction model and cutting conditions optimization on AISI H11 hot work steel work piece was the objective. The optimized surface roughness (Ra) and cutting force components (Fa, Fr and Fv) are (0.327–0.340) lm, [(33.91–38.78); (90.12–102.38) and (63.85–77.57)] N, respectively. Influenced by the depth of cut on feed force (Fa) and the cutting force (Fv) are (56.77%) and (31.50%) respectively. Whereas the cutting speed has a very small influence of only (0.14%).

M.Y. Noordin et al [6] performed cutting tests with constant depth of cut and under dry cutting conditions on AISI 1045 steel bars by CVD coated carbide Insert CNMG 120408-FN. The factors investigated were cutting speed, feed and the side cutting edge angle (SCEA) of the cutting edge. The main cutting force, i.e. the tangential force and surface roughness were the response variables investigated. The experimental results indicate that the feed is the most significant factor that influences the surface roughness and the tangential force.

Ashok Kumar et al [7] done experimental investigations on machinability aspects in finish hard turning of AISI 4340 steel using uncoated and multilayer coated carbide insert. They used CNMG 120408 inserts coated with four layers of (TiN, TiCN, Al2O3 and TiN). During machinability study in hard turning, It is observed that, the tool life for multilayer TiN coated carbide insert is higher. The tool life are respectively TiN coated - 19 min, Multilayer ZrCN – 8 min, uncoated carbide -1 min. The study of chip morphology reveals color transformation from golden to burnt blue during the span of tool life. It is revealed that the rise of cutting temperature is higher for multilayer ZrCN coated carbide insert compared to TiN coated carbide insert and wears the tool faster

M.M.A. Khana, Mithua and N.R. Dharb [8] did experiments to find If the cutting oil is used in very minimum quantity with pressure then what could be the results. They observed the effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oil-based cutting fluid. They used uncoated carbide SNMG 120408 insert under minimum quantity lubrication (MQL) condition food-grade vegetable oil having viscosity 84 cP at 20◦C; moisture content 5.5% and flash point: 340 ◦C. They concluded that surface finishes improved mainly due to reduction of wear and damage at the tool-tip by the application of MQL. The present MQL system enabled reduction in average chip–tool interface temperature up to 10% as compared to wet machining.

Raghuraman S. et al. [9] investigated the optimal set of process parameters for Electrical Discharge Machining (EDM) process for machining Mild Steel IS 2026 using copper electrode. Input parameter were current, pulse on time and pulse off time. Response parameters were material removal rate, tool wear rate, and surface roughness. Based on the experiments conducted on L9 orthogonal array, analysis has been carried out using Grey Relational Analysis. It was concluded that the multi-response characteristics were improved with GRA.

G. Rajyalakshmi et al. [10] mathematical models were derived by the regression analysis to represent the process behavior of wire electrical discharge machining (WEDM) operation for machining Inconel825 using brass wire. Experiments were conducted with eight input parameters: pulse on time, pulse off time, corner servo voltage, wire feed, wire tension, dielectric flow rate, spark gap voltage and servo feed to be varied in three different levels. Response parameters were material removal rate (MRR), surface roughness (Ra) and spark gap (G). Grey relational analysis was adopted to convert multi-objective criterion into an equivalent single objective function. It was concluded that the Grey-Taguchi Method, was most ideal and suitable for the parametric optimization of the Wire-Cut EDM process, when using the multiple performance characteristics.

II. EXPERIMENTAL SET-UP

The turning operation is carried out in dry environment i.e. without coolant. These experiments were conducted using the hardware on CNC lathe machine as shown in Figure 1. at Sahayog Engineering, B-43, MIDC, Chikalthana, Aurangabad - 431210. A Cylindrical bar of EN-19 (length 105 mm, diameter 78 mm) was used as workpiece to carry out experiments on CNC lathe by a TNMG 160408 MC TT5100 carbide insert as cutting tool without a coolant.

Figure1: Experimental Set-up

Table: 1 Levels of Parameters

	1	2	3
Speed (rpm)	1753	1984	2215
Feed (mm/rev)	0.02	0.03	0.04
Depth of cut (mm)	0.7	1.2	1.7

III. RESULT AND ANALYSIS

A. Analysis for material removal rate:

The MRR results obtained shows that, the experiment number 3 provided the highest MRR, equal to 1.65 gram/sec, while the test number 1 provided the lowest 0.24 gram/sec. In order to find the reasons for this variation ANOVA was carried. Analysis of variance technique (ANOVA) is carried with Minitab 16. Value of P is used to determine whether a factor is significant; typically compare against an alpha value of 0.05. If the p-value is lower than 0.05, then the factor is significant.

ANOVA table show the analysis of variance (ANOVA) for MRR, which used for identifying the factors significantly affecting the performance measures. This analysis was carried out for significance level of α=0.05 i.e. for a confidence level of 95%. Table 4.7 shows that the significant parameter for the MRR is feed followed by the next largest contribution comes from depth of cut and then speed which is not statistically significant.

The regression equation is

MRR = - 1.21 + 0.000065 Speed + 32.3 Feed + 0.843 DOC ………….. (1)

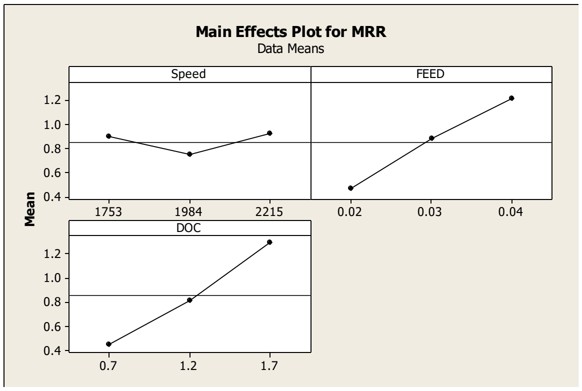

Figure 2: Main Effect Plot for MRR

Main effect plot for MRR is shown in Fig 2 The results show that with the increase in the feed and depth of cut there is a continuous increase MRR that means the MRR is an increasing function of feed and depth of cut. However, with the increase in speed there is a decrease in MRR up to 1984 rpm and increase in MRR was observed. A feed 0.04 mm/rev gives a highest MRR and 0.02 mm/rev show the lowest MRR. Based on the analysis using Fig. 4.3, high MRR was obtained at cutting speed (2215 rpm), depth of cut (1.7 mm) and feed (0.04 mm/rev).

B. Analysis for % rise in tool tip temperature

The % RITT results obtained shows that, the experiment number 3 provided the highest MRR, equal to 75.980c, while the test number 8 provided the lowest 10.240c. In order to find the reasons for this variation ANOVA was carried. Analysis of variance technique (ANOVA) is carried with Minitab 16. Value of P is used to determine whether a factor is significant; typically compare against an alpha value of 0.05. If the p-value is lower than 0.05, then the factor is significant. ANOVA table show the analysis of variance (ANOVA) for %RITT, which used for identifying the factors significantly affecting the performance measures. This analysis was carried out for significance level of α=0.05 i.e. for a confidence level of 95%. Table 4.4 shows that the significant parameter for the %RITT is DOC followed by the next largest contribution comes from feed and then speed. All the parameters are relatively less significant for %RITT.

The regression equation is

%RTTT = 58.5 - 0.0439 Speed + 966 FEED + 23.7 DOC ………….. (2)

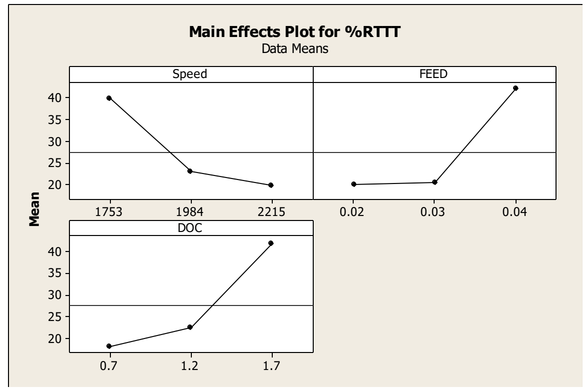

Figure 3: Main Effect Plot for %RTTT

Main effect plot for %RITT is shown in Fig 4. The results show that with the increase in the feed and depth of cut there is a continuous increase %RITT that means the %RITT is an increasing function of feed and depth of cut. However, with the increase in speed there is a decrease in %RITT. A feed 0.07 mm/rev gives a lowest %RITT and 0.04 mm/rev show the highest %RITT. Based on the analysis using Fig. 4.4, high %RITT was obtained at cutting speed (2215 rpm), depth of cut (0.7 mm) and feed (0.02 mm/rev).

C. Analysis for surface roughness

The Ra results obtained shows that, the experiment number 3 provided the highest Ra, equal to 2.12 µm, while the test number 8 provided the lowest 0.11 µm. In order to find the reasons for this variation ANOVA was carried. Analysis of variance technique (ANOVA) is carried with Minitab 16. Value of P is used to determine whether a factor is significant; typically compare against an alpha value of 0.05. If the p-value is lower than 0.05, then the factor is significant. Table shows the results of ANOVA for surface roughness. It was observed that, the cutting speed is the most significant parameter followed by the DOC. However, the insignificant parameter (feed) has the least effect in controlling the surface roughness.

The regression equation is

Ra = 12.1 - 0.00589 Speed + 11.5 FEED + 0.893 DOC ………….. (3)

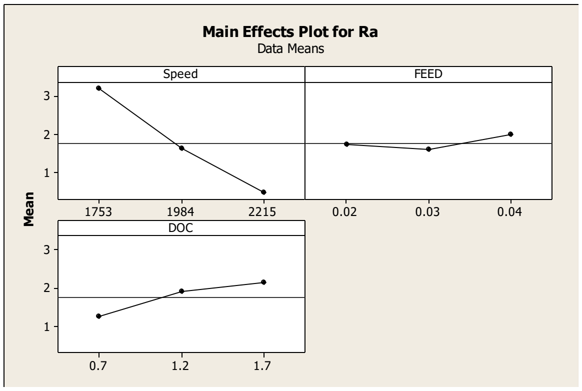

Figure 4: Main Effect Plot for Ra

Main effect plot for surface roughness (Ra) is shown in Fig 4. Result shows increase in surface roughness with decreasing cutting speed. The surface roughness appears to be an almost linear increasing function of feed. According to this main effect plot, the conditions for good surface finish are: cutting speed at (2215 rpm), feed at (0.03 mm/rev) and depth of cut at (0.7 mm).

VII. CONCLUSION

In this work, experimental investigation has been reported for CNC turning of En-19 material. An overview of the principle of CNC turning, its experimental set-up and machining process is discussed. The report focuses on optimization of process parameters to improve machine characteristics. Based on the results of the experiments and statistical analysis carried out, the following general conclusions were drawn.

1] In CNC turning it was found that the parameters like speed feed and depth of cut are significant and has strong effect on process characteristics.

2] All individual graphs for Speed, feed and depth of cut from chapter no 4 show increasing trend for MRR. With feed and DOC %RTTT increases bur with increase in speed it decreases. Ra decreases with speed and increases with DOC but with change in feed there is no significant effect.

3] Process parameters were optimized for stable machining condition. The optimized values are speed = 1753 rpm, feed = 0.04 mm/rev and DOC = 1.7 mm.

4] Grey relation theory has been found efficient to convert multiple responses into an equivalent single objective function. Thus, a multi-objective optimization problem has been converted into a single objective function optimization problem which can be solved by Taguchi method.

5] Optimum values of cutting parameters for machining of AISI 4140 workpiece material using a TNMG 160408 MC TT5100 carbide insert as cutting tool under dry condition are, speed= 1753 rpm, feed= 0.04 mm/rev and depth of cut= 1.7 mm.

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