OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Experimental Investigation and Parametric Studies of Surface Roughness Analysis in CNC Turning

Ranganath. M. S[1], Vipin[2], Prateek[3], Nikhil[4], Rahul[5], Nikhil Gaur[6]

[1] Associate Professor, [2]Professor, Production and Industrial Engineering, Delhi Technological University, Delhi, India
[3,4,5,6] Student, Mechanical Engineering, Delhi Technological University, Delhi, India

Abstract: *The modern machining industries are focused on achieving high quality, in terms of part/component accuracy, surface finish, high production rate and increase in product life. Surface roughness of machined components has received serious attention of researchers for many years. It has been an important design feature and quality measure in machining process. There are a large number of parameters which affect the surface roughness. The typical controllable parameters for the CNC machines include cutting tool variables, work piece material variables, cutting conditions etc. The desired output is surface roughness, material removal rate, tool wear, etc. Optimization of machining parameters needs to determine the most significant parameter for required output. Many techniques are used for optimization of machining parameters including Taguchi, RSM and ANOVA approach to determine most significant parameter.*

The present work is therefore in a direction to integrate effect of various parameters which affect the surface roughness. This paper investigates the parameters affecting the surface roughness and / or material removal rate with CNC turning process studied by researchers. It also discusses some other parameters such as cutting force and power consumption in different conditions.

Keywords: *Surface Roughness, CNC Turning, Parametric studies, Optimization*

I. Introduction

The drastic increase of consumer needs for quality metal cutting related products (more precise tolerance and better surface finish) has driven the metal cutting industry to continuously improve quality control of the metal cutting processes. The quality of surface roughness is an important requirement of many work pieces in machining operations. Within the metal cutting processes, the turning process is one of the most fundamental metal removal operations used in the manufacturing industry. Surface roughness, which is used to determine and evaluate the quality of a product, is one of the major quality attributes of a turned product. Surface roughness of a machined product could affect several of the product's functional attributes such as contact causing surface friction, wearing, light reflection, heat transmission, ability of distributing and holding a lubricant, coating and resisting fatigue. Therefore, surface roughness is one of the important quality aspects in turning operations. [10]

In addition to the surface finish quality, the material removal rate (MRR) is also an important characteristic in turning operation and high MRR is always desirable. Hence, there is a need to optimize the process parameters in a systematic way to achieve the output characteristics/responses by using experimental methods and statistical models. [16]. Therefore, in order to obtain better surface roughness and high material removal rate, the proper setting of cutting parameters is crucial before the process takes place. As a starting point for determining cutting parameters, technologists could use the hands on data tables that are furnished in machining data handbooks. Previously the trial and error approach could be followed in order to obtain the optimal machining conditions for particular operations. Recently, a Design of Experiment (DOE) has been implemented to select manufacturing process parameters that could result in a better quality product. [10-12]. This paper investigates the parameters affecting the surface roughness and / or material removal rate with CNC turning process studied by researchers. It also discusses some other parameters such as cutting force and power consumption in different conditions. The aim of organization of this paper is to summarize the work done for optimizing the process parameters in CNC turning process.

II. LITERATURE REVIEW

AmanAggarwalet. al. [1] have presented the paper on the title "Optimizing Power Consumption for CNC Turned Parts Using Response Surface Methodology and Taguchi's Technique—A Comparative Analysis".This paper presented the findings of an experimental investigation into the effects of cutting speed, feed rate, depth of cut, nose radius and cutting environment on the power consumption in CNC turning of AISIP-20 tool steel. The cutting tool selected was TiN coated tungsten carbide. Design of experiment techniques, i.e. response surface methodology (RSM) and Taguchi's technique; have been used to accomplish the objective of the experimental study. L27 orthogonal array and face centered central composite design have been used for conducting the experiments. In order to quantify the influence of process parameters and interactions on the selected machining characteristic, analysis of variance (ANOVA) was performed. The analysis of the results for power consumption showed that the techniques, RSM and Taguchi methodology, gave similar results. Taguchi's technique revealed that cryogenic environment was the most significant factor followed by cutting speed and depth of cut. The 3D surface plotsof RSM also revealed that cryogenic environment has very significant effect in reducing power consumption. They also found that RSM technique can model theresponse in terms of significant parameters, their interactions and square terms whereas, this facility is not provided by Taguchi's technique. Also 3D surfaces generated by RSM can help in visualizing the effect of parameters on response in the entire range specified whereas Taguchi's technique givesthe average value of response at given level of parameters. Thus RSM can better predict the effect of parameters on response and is a better tool for optimization.C. X. (Jack)Feng and X. Wang [2] have focused on developing an empirical model for the prediction of surface roughness in finish turning. The model considered work piece hardness (material); feed; cutting tool point angle; depth of cut; spindle speed; and cutting time as the working parameters. Nonlinear regression analysis along with logarithmic data transformation was applied in developing the empirical model. The values of surface roughness predicted by this model were then verified with extra experiments and compared with those from some of the representative models in the literature. To establish the prediction model, regression analysis was conducted with MINITAB. Hypothesis testing was done using t-test, F-test and Levene's test. They assumed that the three-, four-, and five-factor interactions are negligible, because these higher-order interactions are normally assumed to be almost impossible in practice. Therefore, a 2^{5-1} factorial design was selected. To consider system variations, such as tool wear and vibration in particular, the cutting time and a replicate number of three were selected, respectively. The experiments were conducted on a production type YAM CK-1 CNC Lathe with a FANUC OT10 controller. They concluded that the tool point angle had a significant impact on the surface roughness, in addition to feed, nose radius, work piece hardness, and cutting speed. The other factors do not significantly contribute to these smaller roughness values.

HasanGokkaya and MuammerNalbant[3] investigated the effects of insert radii of cutting tools, depths of cut and, feed rates on the surface quality of the work pieces depending on various processing parameters. The AISI 1030 steel work piece was processed on a digitally controlled Johnford T35 Industrial type CNC lathe machine using cemented carbide cutting tools, coated with three layer coating materials TiN, Al_2O_3, TiC (outermost is TiN) applied by the chemical vapour deposition (CVD) technique. It was seen that the insert radius, feed rate, and depth of cut have different effects on the surface roughness. In the range of importance, the effective parameters on the average surface roughness were determined as the following: speed rate, insert radius, and depth of cut. Thus a good combination among the insert radius, speed rate and depth of cut can provide better surface qualities.H. K. Dave et. al. [4] presented an experimental investigation of the machining characteristics of different grades of EN materials in CNC turning process using TiN coated cutting tools. MINITAB statistical software was used for the analysis of the experimental work. Batliboi-make CNC turning centre was used to carry out the experimentation. Different materials like EN-8 and EN-31 were used as work piece. Five parameters viz. speed, feed, depth of cut, insert and work piece material were taken as input process factors. Initial and final weights of work piece and Machining time were recorded. Following equation was used to calculate the Material Removal Rate (MRR):

$$MRR\left(\frac{mm^3}{min}\right) = \frac{[Initial\ Weight\ of\ workpiece(gm) - \ Final\ Weight\ of\ workpiece(gm)]}{[Density\left(\frac{gm}{mm^3}\right) * Machining\ Time\ (min)]}$$

Optimal cutting parameters for each performance measure were obtained employing Taguchi technique by using an L8 orthogonal array. The signal to noise ratio and analysis of variance were employed to study the performance characteristics in dry turning operation.It was seen that with increase in all three parameters speed, feed and depth of cut, MRR would increase, remarkably, i.e. speed, feed and depth of cut are directly proportional to MRR. In addition, they concluded that positive inserts were better than the negative inserts and EN-31 materials were superior to EN-8 for MRR. ANOVA shows that depth of cut is the most significant factor for material removal rate. Effect of feed was insignificant as compared to other cutting parameters for material removal rate.

Ranganath M S et. al. [17] have presented a paper on "Surface Finish Monitoring in CNC Turning Using RSM and Taguchi Techniques". This paper presented the findings of an experimental investigation into the effects of speed, feed rate and depth of cut on surface roughness in CNC turning of Aluminium (KS 1275). Response surface methodology and Taguchi techniques were used to accomplish the objective of the experimental study. L27 orthogonal array was used for conducting the experiments. For the design of RSM, central composite design (CCD) was used. The three factors speed, feed rate, depth of cut, which were selected in the screening experiment, were used in CCD. Minitab 15 was used to develop the experimental plan for Taguchi and response surface methodology. The same software was also used to analyze the data collected. The experiments were carried out on Aluminium workpiece using brazed diamond cutting insert using a CNC turning center (Fanuc 0i mate - TD/Siemens 828D Basic T).

Fig.1CNC Turning Machine [19]

Fig.2FANUC Series Oi Mate –TD [19]

The analysis of the results for surface roughness showed that the techniques - Taguchi technique and Response surface methodology, gave similar results. Taguchi's technique revealed that feed is the most significant factor followed by depth of cut and speed. The 3D surface plots of Response surface methodology also revealed that feed has very significant effect in surface roughness. Significance of interactions and square terms of parameters was more clearly predicted in Response surface methodology. The Response surface methodology showed significance of all possible combinations of interactions and square terms, whereas, in Taguchi's technique only three interactions are normally studied. This is because of the fact that the interactions between control factors were aliased with their main effects .Response surface methodology technique required almost double time for conducting experiments as that needed for Taguchi technique. Response surface methodology technique could model the response in terms of significant parameters, their interactions and square terms. This facility was not provided by Taguchi's technique. 3D surfaces generated by Response surface methodology could help in visualizing the effect of parameters on response in the entire range specified whereas Taguchi's technique gave the average value of response at given level of parameters. Optimization plot as shown in fig.3obtained from Response surface methodology was not a feature of Taguchi technique. Thus Response surface methodology is a better tool for optimization and can better predict the effect of parameters on response.

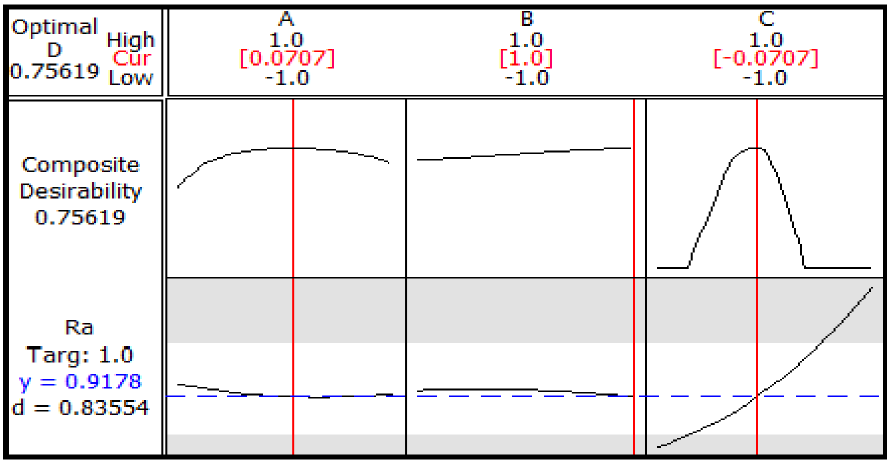

Fig.3 Optimization Plot [17]

Harish Kumar et. al. [5]carried out experimental work for the optimization of input parameters for the improvement of quality of the product of turning operation on CNC machine.Feed Rate, Spindle speed & depth of cut were taken as the input parameters and the dimensional tolerances as output parameter. MS1010 work piece was dry turned using HSS tool on a CNC lathe. Three levels of each cutting parameters were selected. And L9 Array was used in design of experiment for optimization of input parameters. Taguchi parameter design and ANOVA were used to analyze the results. It was found that most important parameter affecting surface roughness was spindle speed, followed by feed and DOC. Ilhan Asiltürk.et.al. [6], have presented a paper on "Determining the Effect of Cutting Parameters on Surface Roughness in Hard Turning Using the Taguchi Method". The study focused on optimizing turning parameters based on the Taguchi method to minimize surface roughness (Ra and Rz). Experiments were conducted using the L9 orthogonal array in a CNC turning machine. Dry turning tests were carried out on hardened AISI 4140 (51 HRC) with coated carbide cutting tools. The statistical methods of signal to noise ratio (SNR) and the analysis of variance (ANOVA) were applied to investigate effects of cutting speed, feed rate and depth of cut on surface roughness. S/N ratios and level values were calculated by using Eq. ''the smaller-the better'' in the MINITAB 14 Program. Results of this study indicated that the feed rate has the most significant effect on Ra and Rz. In addition, the effects of two factor interactions of the feed rate-cutting speed and depth of cut-cutting speed appeared to be important. JakhalePrashant P. andJadhav B. R. [7] haveinvestigated the effect of cutting parameters (cutting speed, feed rate, depth of cut) and insert geometry (CNMG and DNMG type insert) on surface roughness in the turning of high alloy steel. Al_2O_3, TiCN and TiN coated cemented carbide inserts were used as the cutting tool material. The turning experiments were carried out in dry cutting conditions using TACCHI CNC lathe. The Taguchi method and L9 Orthogonal Array were used to reduce variance for the experiments with optimum setting of control parameters.The optimum combination of the cutting parameters was determined by the help of ANOVA and S/N ratios. Finally, confirmation experiments were done using the optimum machining parameters which were found by Taguchi optimization technique and thereby validation of the optimization was tested.A multi-response optimization problem was solved by obtaining an optimal parametric combination, capable of producing high surface quality turned product in a relatively lesser time. Best surface finish (lowest Ra) was obtained at a cutting speed of 100 m/min, feed rate of 0.24 mm/revolutions and a depth of cut of 1mm.Best surface roughness at high cutting speed (i.e. 150 m/min) was obtained from DNMG (12 06 08) insert.The results of ANOVA for surface roughness showed that depth of cut was most significant parameter which affects the surface finish as compared to other cutting parameters. The cutting speed and feed rate were least significant parameters.

M. Kaladharet.al. [8],havefocused on Taguchi method to determine the optimum process parameters for turning of AISI 304 austenitic stainless steel on CNC lathe. A CVD coatedcemented carbide cutting insert was used. The influence of cutting speed, feed, depth of cut were investigated on the surface roughness and material removalrate (MRR). The Analysis Of Variance (ANOVA) was also used to analyze the influence of cuttingparameters during machining. A multiple linear regression model was developed for surface roughness and MRR using Minitab-14 software. The predictors were: Cutting speed, Feed, Depth of cut and Nose radius.The ANOVA and F-test revealed that the cutting speed was the dominant parameter followed by nose radius for surface roughness. In case of MRR response, the depth of cut was the dominant one followed by the feed.A number of multiple linear regression models were developed for surface roughness and MRR. The developed models were reasonably accurate and could be used for prediction within limits. The Optimal range of surface roughness and MRR of the work piece was also predicted.The regression equation forRa was

$$Ra = 2.78 - 0.064 * Speed + 0.239 * Feed - 0.025 * depth\ of\ cut - 0.817 * Nose\ radius$$

Whereas the regression equation for MRR was

$$MRR = 15486 + 1154 * Speed - 294 * Feed + 12095 * depth\ of\ cut - 12416 * Nose\ radius$$

M.Kaladharet. al.[9] have published a paper "Application of Taguchi approach and Utility Concept in solving the Multi-objective Problem when turning AISI 202 Austenitic Stainless Steel". In this, a multi-characteristics responseoptimization model based on Taguchi and Utility concept was used to optimize process parameters, such as speed, feed, depthof cut, and nose radius on multiple performance characteristics, namely, surface roughness (Ra) and material removal rate(MRR) during turning of AISI 202 austenitic stainless steel using a CVD coated cemented carbide tool. Taguchi's L8 orthogonal array was selected for experimental planning. The ANOVA and F-tests were used to analyze the results. The experiments were conducted on ACE Designer LT-16XL CNC lathein dry working environment. In first stage (single response), optimal settings and optimal values of Ra and MRR were obtained individually, and from their corresponding ANOVA results. It was found that the feed (61.428%) was the most significant parameter followed by cutting speed (20.697%) for Ra, the depth of cut (63.183%) was the most significant parameter followed by cutting speed (20.697%) for MRR response. In second stage (multi-response), the analysis of means established that a combination of higher levels of cutting speed, depth of cut, nose radius and lower level of feed was necessary for obtaining the optimal value of multiple performances. Based on the ANOVA and F-test analysis, the most statistical significant and percent contribution of the process parameters for multiple performances were depth of cut, cutting speed, whereas feed and nose radius were less effective.M. Kaladharet. al. [10], have investigated the effect of process parameters on surface finish and Material Removal Rate to obtain the optimal setting of these parameters. They used ANOVA to analyze the influence of cutting parameters during machining. The machining tests were carried out by two layer (TiCN-TiN) PVD coated cermet insert of two different nose radii on Parishudh TC-250 CN, India, CNC lathe. The analysis was made with the help of a software package MINITAB 14.The ANOVA and F–test revealed that the feed was the dominant factor followed by the nose radius for surface roughness. In case of MRR response, the depth of cut was the dominant one followed by feed. It was observed that feed plays an important role both in minimization of surface roughness and maximization of MRR. Error contribution (0% for surface roughness and 0.0001% for MRR) indicates the absence of the interaction effects of process parameters.M. Kaladharet. al. [11] have analyzed the optimization of machining parameters in turning of AISI 202 austenitic stainless steel using CVD coated cemented carbide tools. During the experiment, process parameters such as speed, feed, depth of cut and nose radius were used to explore their effect on the surface roughness (Ra) of the work piece. Commonly available (CVD) of Ti (C, N) +Al_2O_3 coated cemented carbide inserts were used in dry turning the work piece using ACE Designer LT-16XL CNC lathe. The experiments were conducted using full factorial design in the Design of Experiments (DOE). Further, the analysis of variance (ANOVA) was used to analyze the influence of process parameters and their interaction during machining. This analysis was carried out for a significant level of α=0.05 (confidence level of 95%). The effect of feed (the most significant parameter) and nose radius were to be significant. The optimal machining parameters for AISI 202 was obtained for the minimum value (Ra= 0.70 μm) of surface roughness.The correlation among the factors i.e. cutting speed, feed, depth of cut and nose radius and performance measure (Ra) were obtained. The polynomial model obtained was as follows:Ra=1.4731+ 0.4294 * C - 0.2819 * D. R^2 = 94.18% confirms the suitability of models and the correctness of the calculated constants. Also, it was observed that the predicted values and measured values were close to each other. Thus, the experiments were validated.So, in order to obtain a good surface finish on AISI 202 steel, higher cutting speed, lower feed rate, lower depthof cut and higher nose radius have to be preferred.

Ranganath M S, Vipin [18] carried out experimental investigation and parametric analysis of surface roughness in CNC turning using design of experiments. Their work integrated the effect of various parameters which affect the surface roughness. The important parameters discussed were cutting speed, feed, depth of cut, nose radius and rake angle Experiments were carried out with the help of factorial method of design of experiment (DOE) approach to study the impact of turning parameters on the roughness of turned surfaces. Secondly, a mathematical model was formulated to predict the effect of machining parameters on surface roughness of a machined work piece. Model was validated with the experimental data and the reported data of other researchers. Further, the performance of wiper insert tools was analyzed. Several statistical techniques were used to analyze the data. To develop the first order models (log transformed) for predicting the surface roughness values, a regression modeling was done. For establishing the second-order predictive models a full factorial design was used. Experiments were carried out on Aluminium 6061 alloy using cemented carbide inserts on a CNC Turning Machine. The geometry of tools selected was used with the combinations of Nose radius: 0.4mm, 0.8mm, 1.2 mm and Rake angles 16°, 18°, 20°. Minitab 13 was used for analyzing the results. The following conclusions have been made on the basis of results obtained and analysis performed: Increase in cutting speed improved the surface finish, thus the average surface roughness value decreased. Increase in depth of cut affected the surface finish adversely to a small extent, but as depth of cut increased beyond a certain limit surface finish deteriorated to a large extent. Small increase in feed rate deteriorated surface finish to a large extent as compared to same amount of increase of depth of cut. Surface roughness also decreased as the nose radius increased hence surface finish increased. With increase in back rake angle the surface roughness decreased and improved the surface finish. The ANOVA and F-test revealed that the feed is dominant parameter followed by depth of cut, speed, nose radius and rake angle for surface roughness.

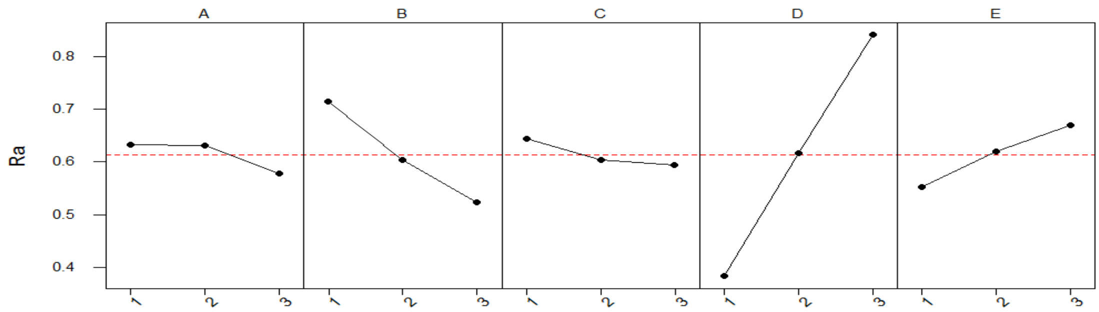

Fig.4 Main effect plots for Ra [18]

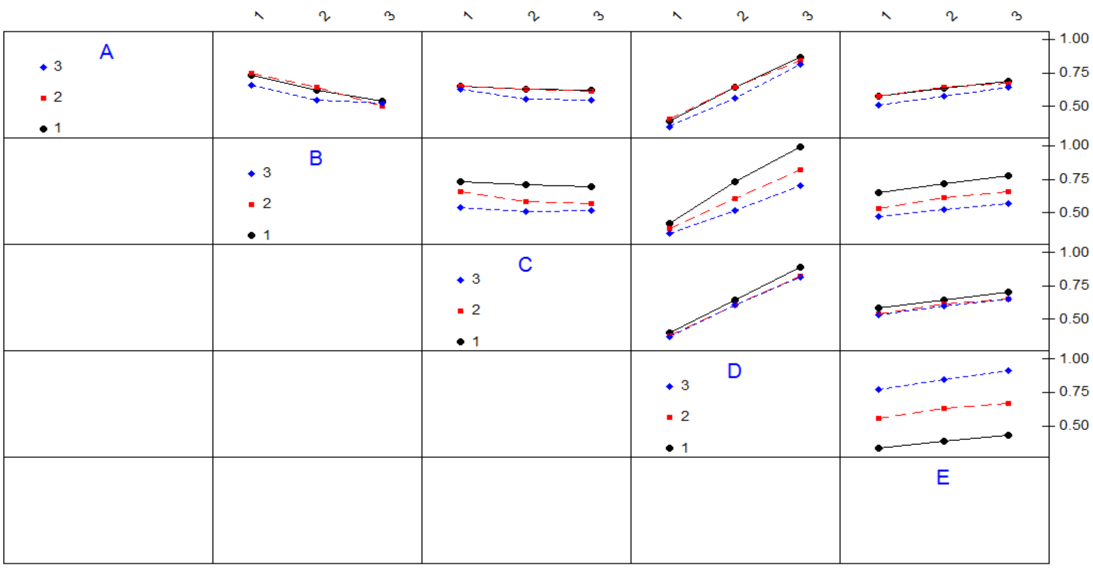

Fig.5 Interaction plots for Ra [18]

M. Nalbantet.al [12] investigated to find the optimal cutting parameters for surface roughness in turning using Taguchi method. The orthogonal array, the signal-to-noise ratio, and analysis of variance were employed to study the performance characteristics in turning operations. An L9 orthogonal array was used. Three cutting parameters namely, insert radius, feed rate, and depth of cut, were optimized with considerations of surface roughness. The cutting experiments were carried out on a Johnford T35 CNC lathe using TiN coated tools with the grade of P-20 for the machining of AISI 1030 steel bars. Inserts used were TNMG160404-MA, TNMG160408-MA and TNMG160412-MA.They concluded that the parameter design of the Taguchi method provides a simple, systematic, and efficient methodology for the optimization of the cutting parameters also the insert radius and feed rate were the main parameters among the three controllable factors (insert radius, feed rate and depth of cut) that influence the surface roughness. The confirmation experiments were conducted to verify the optimal cutting parameters. The percentage contributions of insert radius, feed rate and depth of cut are

48.54, 46.95 and 3.39, respectively.In turning, use of greater insert radius (1.2 mm), low feed rate (0.15 mm/rev) and low depth of cut (0.5 mm) were recommended to obtain better surface roughness for the specific test range.

N.E. Edwin Paul et al. [13] have described the Taguchi method based robust design philosophy for minimization of surface roughness in facing. Experimental works were conducted on CNC Lathe based on L9 orthogonal array. Based on the signal to noise ratio analysis, the optimal settings of the process parameters were determined. Three operating factors, viz., depth of cut, feed and cutting speed were selected for parametric optimization. The effect of different parameters in affecting variation in surface roughness while machining EN8 steel with TNMG 160404 EN-TF CTC 2135 insert was that the feed had greater influence on the surface roughness followed by the cutting speed. From the analysis it was revealed that the feed, cutting speed and depth of cut were prominent factors which affect the facing operations.TugrulOzelet. al. [14] have studied the effects of cutting edge geometry, work piece hardness, feed rate and cutting speed on surface roughness and resultant forces in the finish hard turning of AISI H13 steel using four factor two level factorial design. CBN inserts with two distinct representative types of edge preparations were investigated in this study. These edge preparations include “chamfered” (T-land) edges and “honed” edges.

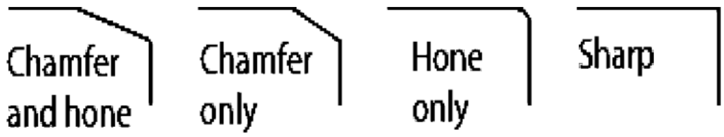

Fig.6 Type of edge preparations used in CBN cutting tools [14]

The response variables were the work piece surface roughness and the cutting forces. Longitudinal turning was conducted on a rigid, high-precision CNC lathe (RomiCentur 35E).The results indicated that the effect of cutting edge geometry on the surface roughness was remarkably significant. The cutting forces were influenced not only by cutting conditions but also the cutting edge geometry and work piece surface hardness. This study showed that the effects of work piece hardness, cutting edge geometry, feed rate and cutting speed on surface roughness were statistically significant. The effects of two-factor interactions of the edge geometry and the work piece hardness, the edge geometry and the feed rate, and the cutting speed and feed rate were also appeared to be important. Especially, honed edge geometry and lower work piece surface hardness resulted in better surface roughness. Cutting edge geometry, work piece hardness and cutting speed were found to be affecting force components. The lower work piece surface hardness and small edge radius resulted in lower tangential and radial forces.

Ranganath M S et. al. [15] have investigated the effect of the cutting speed, feed rate and depth of cut on surface roughness and material removal rate (MRR), in conventional turning of Aluminium (6061) in dry condition. The effect of cutting condition (cutting speed and feed rate) on surface roughness and MRR were studied and analyzed. Design of experiments (DOE) were conducted for the analysis of the influence of the turning parameters on the surface roughness by using Taguchi design and then followed by optimization of the results using Analysis of Variance (ANOVA) to find minimum surface roughness and the maximum MRR.MINITAB software was used for Taguchi’s method and for analysis of variance (ANOVA). Strong interactions were observed among the turning parameters. Most significant interactions were found between work materials, feed and cutting speeds. A Systematic approach was provided to design and analyze the experiments, and to utilize the data obtained to the maximum extent. The following conclusions were drawn based on the experimental investigation conducted at three levels by employing Taguchi technique to determine the optimal level of process parameters.From the data collection it was observed that the increase in cutting speed tended to improve the finish, thus the average surface roughness value decreased.The increase in depth of cut influenced the finish slightly, but greater depth of cut marked the finish poor.Speed was the most critical parameter when finish was the criterion.Finish got poor as the feed increased, thus the average surface roughness value increased with increase in feed.The ANOVA and F-test revealed that the speed and depth of cut were dominant parameters followed by feed for surface roughness.Ranganath M S, Vipin have presented a paper on “Optimization of Process Parameters in Turning Operation Using Taguchi Method and ANOVA: A Review” [16]. This paper investigated the parameters affecting the roughness of surfaces produced in the turning process for the various materials studied by researchers. Design of experiments, mainly Taguchi’s parametric design, were conducted for the analysis of the influence of the turning parameters such as cutting speed, feed rate and depth of cut on the surface roughness. The results of the machining experiments were used to characterize the main factors affecting surface roughness by the Analysis of Variance (ANOVA) method. In this paper Taguchi’s (DOE) approach used by many researchers to analyze the effect of process parameters like cutting speed, feed, and depth of cut on Surface Roughness and to obtain an optimal setting of these parameters that may result in good surface finish, have been discussed.On the basis of the experimental results and derived analysis, one can conclude that cutting speed had the most dominant effect on the observed surface roughness, followed by feed rate and depth of cut, whose influences on surface roughness were smaller. The surface roughness was continuously improved with the increase in cutting speed, but increase in feed rate and depth of cut caused a significant deterioration of surface roughness. The results obtained using the Taguchi optimization method revealed that cutting speed should be kept at the highest level, while both feed rate and depth of cut should be kept at the lowest level. The response graphs and ANOVA results showed that the effects of two-way interactions of these cutting parameters were statistically insignificant, that is, can be neglected. Thus, the Taguchi method provides a systematic, efficient and easy-to-use approach for the cutting process optimization.

Ranganath M S, Vipin [19] have investigated the effect of rake angle on surface roughness in CNC turning of Aluminium (6061) while keeping other machining parameters such as cutting speed, feed rate and depth of cut as constant. Three positive rake angled tools were selected to study and analyze the effect of cutting conditions on surface roughness. Design of experiments were conducted for the analysis of the influence of the turning parameters on the surface roughness by using Taguchi design and then followed by optimization of the results using Analysis of Variance to find minimum surface roughness. Experiments were carried out on a CNC turning machine using cemented carbide insert type cutting tool. The geometry of tools selected was with the combinations of Nose radius: 0.4mm, 0.8mm, 1.2 mm and Rake angles 16°, 18°, 20°. Surtronic 3+ surface roughness measuring instrument was used for the measurement of surface texture.

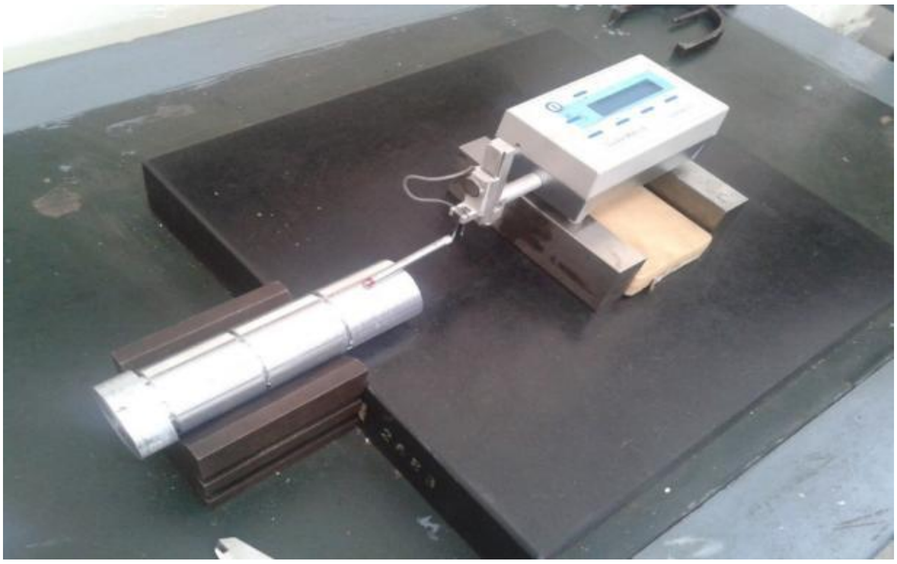

Fig. 7 Roughness Measuring Instrument [19]

It was observed that the surface roughness decreases with increase in rake angle. Strong interactions were observed among the turning parameters. Most significant interactions were found between work materials, feed and cutting speeds. A systematic approach was provided to design and analyze the experiments, and to utilize the data obtained to the maximum extent.

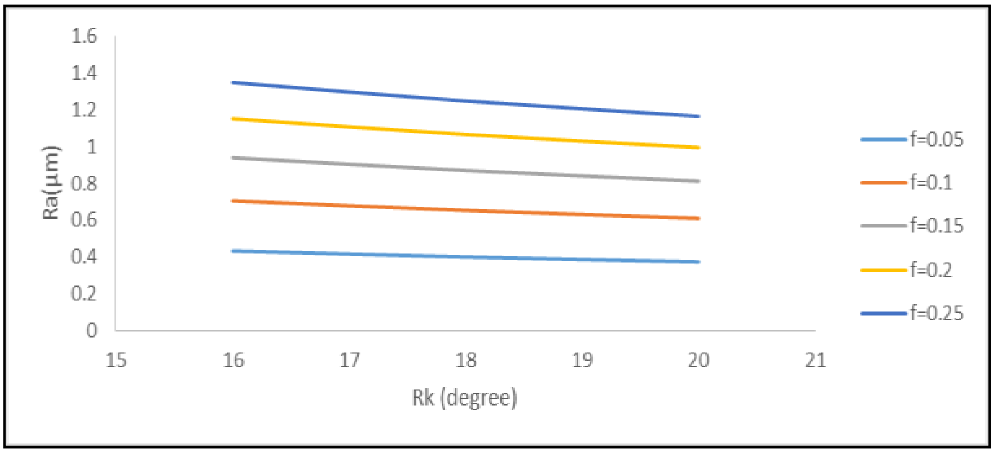

Fig.8 Graph between Surface Roughness and Rake angle at Nr 1.2, V 225, d 0.1 [19]

Upinder Kumar Yadav et.al.[20],have investigated the effect and optimization of machining parameters (cutting speed, feed rate and depth of cut) on surface roughness. An L27 orthogonal array, analysis of variance (ANOVA) and the signal-to-noise (S/N) ratio have been used in this study.The effect of three machining parameters i.e. Cutting speed, feed rate and depth of cut and their interactions were evaluated using ANOVA and with the help of MINITAB 16 statistical software. The purpose of the ANOVA in this study was to identify the important turning parameters in prediction of Surface roughness.The conclusions showed that Surface roughness was mainly affected by feed rate and cutting speed. With the increase in feed rate, the surface roughness also increased and as the cutting speed decreased the surface roughness increased.From ANOVA analysis, parameters making significant effect on surface roughness were feed rate and cutting speed. The optimum setting of cutting parameters for high quality turned parts were as: Cutting speed 264 m/min, Feed rate 0.1 mm/rev, Depth of cut 1.5 mm.The optimum value of the surface roughness (Ra) came out to be 0.89. It was also concluded that feed rate was the most significant factor affecting surface roughness followed by depth of cut. Cutting speed was the least significant factor affecting surface roughness.

III. CONCLUSIONS

The following conclusions have been made on the basis of results obtained and analysis performed by previous researchers:

- CNC Turning gives better results, as speed and feed can be set at any value within a specified range, according to the requirement, compared to a conventional machine in which only some fixed values can be selected.
- Better results have been obtained in terms of DOE techniques such as Taguchi and RSM using MINITAB software.
- Increase in cutting speed improves the surface finish, thus the average surface roughness value decreases.
- Increase in depth of cut affects the surface finish adversely to a small extent, but as depth of cut increases beyond a certain limit, surface finish deteriorates to a large extent.
- Small increase in feed rate deteriorates surface finish to a large extent.
- ANOVA and F-tests reveal that the feed is dominant parameter followed by other parameters for surface roughness.

REFERENCES

[1] AmanAggarwal, Hari Singh, Pradeep Kumar &Manmohan Singh, "Optimizing power consumption for CNC turned parts using response surface methodology and Taguchi's technique - A comparative analysis", Elsevier Journal, Journal of materials processing technology, pp. 373–384, 2008

[2] Feng C. X. & Wang X., "Development of Empirical Models for Surface Roughness Prediction in Finish Turning, International Journal of Advanced Manufacturing Technology," Vol. 20, 348-356, 2002

[3] Gökkayaa H. &Nalbant M., "The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel", Materials & Design, vol. 28(2), 717-721, 2007

[4] H. K. Dave, L. S. Patel & H. K. Raval, "Effect of machining conditions on MRR and surface roughness during CNC Turning of different Materials Using TiN Coated Cutting Tools – A Taguchi approach", International Journal of Industrial Engineering Computations 3, pp. 925-930, 2012

[5] Harish Kumar, Mohd. Abbas, Aas Mohammad, HasanZakirJafri, "Optimization of cutting parameters in CNC Turning", International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 3, pp. 331-334, 2013

[6] IlhanAsilturk&HarunAkkus, "Determining the effect of cutting parameters on surface roughness in hard turning using the Taguchi method", Elsevier Journal, Measurement 44, pp. 1697–1704, 2011

[7] JakhalePrashant P, Jadhav B. R., "Optimization Of Surface Roughness Of Alloy Steel By Changing Operational Parameters and Insert Geometry in The Turning Process", International Journal of Advanced Engineering Research and Studies, II/ IV, pp. 17-21, 2013

[8] M. Kaladhar , K. VenkataSubbaiah& Ch. SrinivasaRao, "Parametric optimization during machining of AISI 304 Austenitic Stainless Steel using CVD coated DURATOMICTM cutting insert", International Journal of Industrial Engineering Computations 3, pp. 577–586, 2012

[9] M. Kaladhar, K. V. Subbaiah, Ch. SrinivasaRao& K. NarayanaRao, "Application of Taguchi approach and Utility Concept in solving the Multi-objective problem when turning AISI 202 Austenitic Stainless Steel", Journal of Engineering and Technology Review (4), pp. 55-61, 2011

[10] M. Kaladhar, K. VenkataSubbaiah& Ch. ShrinivasaRao, "Determination of Optimum Process Parameter during turning of AISI 304 Austenitic Stainless Steels using Taguchi method and ANOVA", International Journal of Lean Thinking, Volume 3,Issue 1, 2012

[11] M. Kaladhar, K. VenkataSubbaiah, Ch. SrinivasaRao and K. NarayanaRao, "Optimization of Process Parameters in Turning of AISI202 Austenitic Stainless Steel", ARPN Journal of Engineering and Applied Sciences, VOL. 5, NO. 9, pp. 79-87, 2010

[12] M. Nalbant, H. Gokkaya& G. Sur, "Application of Taguchi method in the optimization of cutting parameters for surface roughness in turning", Elsevier Journal, Materials and Design 28, pp. 1379–1385, 2007

[13] N. E. Edwin Paul, P. Marimuthu&R.VenkateshBabu, "Machining Parameter Setting For Facing EN8 Steel with TNMG Insert" American International Journal of Research in Science, Technology, Engineering & Mathematics, 3(1), pp. 87-92, 2013

[14] Özel T., Hsu T.K., &Zeren, E., "Effects of cutting edge geometry, workpiece hardness, feed rate and cutting speed on surface roughness and forces in finish turning of hardened AISI H13 steel", International Journal of Advanced Manufacturing Technology, 25(3-4), 262-269, 2005

[15] Ranganath M S, Vipin, R S Mishra, "Optimization of Surface Roughness and Material Removal Rate on Conventional Dry Turning of Aluminium (6061)", International Journal of Advance Research and Innovation, Volume 1, pp 62-71, 2014

[16] Ranganath M S, Vipin, "Optimization of Process Parameters in Turning Operation Using Taguchi Method and Anova: A Review", International Journal of Advance Research and Innovation, Volume 1, pp 31-45, 2013

[17] Ranganath M S, Vipin, Nand Kumar, R Srivastava, "Surface Finish Monitoring in CNC Turning Using RSM and Taguchi Techniques", International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 9, September 2014

[18] Ranganath M. S, Vipin, "Experimental Investigation and Parametric Analysis of Surface Roughness in CNC Turning Using Design of Experiments", International Journal of Modern Engineering Research, Vol. 4, Issue 9, September 2014

[19] Ranganath. M. S, Vipin, "Effect of Rake Angle on Surface Roughness in CNC Turning", International Journal of Advance Research and Innovation, Volume 2, 2014

[20] Upinder Kumar Yadav, Deepak Narang&Pankaj Sharma Attri, "Experimental investigation and Optimization of machine parameters for surface roughness in CNC turning by Taguchi method", International Journal of Engineering Research and Application", vol. 2, Issue 4, pp 2060-2065, 2012.