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A Review on Optimization of Process Parameter for Surface Roughness and MRR during Turning Operation

Sandeep R. Jadhav[1], Arun B.Degaonkar[2]
[1]M.E. (Mechanical-Production) Student, Department of Mechanical Engineering, Karmaveer Bhaurao Patil College of Engineering & Polytechnic, Satara, Maharastra, India
[2]Professor, Department of Mechanical Engineering, Karmaveer Bhaurao Patil College of Engineering & Polytechnic, Satara, Maharastra, India

Abstract— Turning is one of the widely used machining processes for various purposes. The purpose of turning operation is to produce low surface roughness of the parts. In a global competitive environment every industry are trying to reduce the cutting cost and improved the quality of machined parts/components. So, it required focusing on material removal rate and surface roughness .Critical quality measure and surface roughness in mechanical parts depends on process parameter during machining parameter. In turning operation; extend significant influence of process parameter like speed, feed, depth of cut, tool geometry, and work piece material etc different for different response. Therefore, optimization of surface roughness is a multi-factor, multi-objective optimization problem. This paper reviews the various literatures on the optimization of turning process by studying the influence of various process parameters (spindle speed, feed rate, depth of cut, tool geometry, work piece material, lubricant etc.) on the performance parameters (surface roughness, material removal rate, machining time, etc) during turning process.
Keywords — Turning process, SR, MRR, cutting parameter, optimization

I. INTRODUCTION

Turning is very important machining process in which a single point cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. The cutting tool is fed linearly in a direction parallel to the axis of rotation. Turning is carried on a CNC lathe that provides the power to turn the work piece at a given rotational speed and to feed to the cutting tool at specified rate and depth of cut. Therefore three cutting parameters namely cutting speed, feed and depth of cut need to be determined in a turning operation. The turning operations are accomplished using a cutting tool; the high forces and temperature during machining create a harsh environment for the cutting tool. Therefore tool life is important to evaluate cutting performance. The purpose of turning operation is to produce low surface roughness of the parts. Surface roughness is another important factor to evaluate cutting performance. Proper selection of cutting parameters and tool can produce longer tool life and lower surface roughness

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact . Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy .Surface roughness has become the most considerable technical requirement and it is an index of product quality. In order to get better the tribological properties, fatigue strength, corrosion resistance and aesthetic appeal of the product, a reasonably good surface finish is desired. Nowadays, the manufacturing industries specially are focusing their attention on dimensional accuracy and surface finish. In order to obtain optimal cutting parameters to achieve the best possible surface finish, manufacturing industries have resorted to the use of handbook based information and operators' experience. This traditional practice leads to improper surface finish and decrease in the productivity due to sub-optimal use of machining capability. This causes high manufacturing cost and low product quality .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 stastical models.

II. LITERATURE REVIEW

K. P. Warhode et al. [1] have optimized process parameter for material remove rate, power consumption and machining time using response surface methodology. The work piece material used for present investigation is Al6063 aluminium alloy. The experiments were conducted by using Taguchi L27 orthogonal array by considering the machining parameter such as speed, feed and depth of cut. The result has indicated that it is feed rate which has significant influences both MRR and machining time and for power consumption speed is most significant parameter.

Madhav Murthy A et al. [2] has studied the effect of varying cutting parameter on surface finish using Taguchi method. In this study the selected cutting parameter are cutting speed, feed, depth of cut and nose radius. Taguchi method with L16 orthogonal array (four factors and two levels) was used for experimentation and Analysis was done by Analysis of variance and regression equation has been adopted for predicting the surface roughness. Result show that, the factor feed rate is the most significant in influencing the surface roughness while the remaining three factors considered are not significant. It was found that minimum surface roughness obtained at minimum nose radius, feed rate and maximum cutting speed.

Ravindra Thamma [3] have developed and comparing multi regression models by collecting data pertaining to depth of cut, nose radius, feed rate, surface roughness and cutting speed during turning of AL6061 aluminium alloy. Full factorial design of experiment procedure was used to develop the surface roughness regression model, within the range of selected parameter. The study reveals that cutting speed, feed and nose radius have major impact on surface roughness. Also depth of cut has significant impact on surface roughness in an interaction with other parameter.

K. krishanamurthy et al. [4] performed experiment to investigate the effect of machining parameter on surface roughness and material remove rate of TiB2 particles reinforced aluminum (Al6063) metal. Four parameter namely cutting speed, feed, depth of cut and material are varied to study their effect on surface roughness and material remove rate. Experiment were conducted based on Taguchi L27 orthogonal array and then followed by optimization of the result using Analysis of variance to find out maximum material remove rate and minimum surface roughness. The optimum MRR was obtained when setting the cutting speed and feed rate at high values but low surface roughness obtained at high cutting speed and low feed rate.

A. kannan et al. [5] has developed mathematical model to predict the temperature influence and surface quality. The material used for experiment is (320mm long and 60 mm diameter) of Al 6063 aluminium alloy. A L27 Orthogonal Array (OA) based Design of Experiments (DOE) approach and Response Surface Methodology (RSM) was used to analyze the effect of cutting speed, feed, and depth of cut on work piece material. The mathematical model for cutting temperature, surface roughness and cutting force component were developed using RSM. Result shows that cutting temperature is influenced principally by the depth of cut on other hand feed rate and depth of cut have statistical significance on surface roughness and cutting force. For minimum surface roughness of turned profile as well as minimum cutting temperature and cutting force obtained at higher cutting speed lower feed rate and depth of cut.

S.Hari Vignesh et al. [6] has developed mathematical model for correlating the interactive and higher order influences of various turning parameter on surface roughness. The Present work is attempt to develop a force ,surface roughness and tool wear prediction model during finish machining of Al 7075 aluminium alloy to analyze the combination of machining parameter for better performance within selected range of machining parameter. Design of experiment with L27orthogonal array used for conduct the experiment and Response surface methodology used to developed mathematical model. result shows that the cutting force are influenced principally by the depth of cut on other hand both feed rate and depth of cut have statistical significance on surface roughness and tool wear.

Mihir T. Patel et al. [7] performing the experiment to investigate the effect of process parameter like spindle speed, feed, depth of cut, nose radius on material removal rate and surface roughness. They developed a surface roughness and material removal rate prediction model for machining of Al6068 aluminium alloy. The experiments have been conducted using L8 orthogonal array with mixed level design on conventional lath machine. To test the quality of fit data, the ANOVA analysis was undertaken. The result shows that material removal directly influenced by cutting speed and depth of cut while the nose radius and cutting speed have significance on surface roughness. For MRR nose radius is least significant and for surface roughness depth of cut is least significant.

N. B. Doddapattar et al.[8] has optimize the machinability of aluminium alloy Al7075 and cutting tool parameter like cutting speed, feed, depth of cut and tool nose radii by using Taguchi technique. It is found that for turning and milling of aluminium alloy the feed rate is most significant factor on surface roughness. Also the interaction between speed and feed gives minimum surface roughness compare to interaction between cutting speed and depth of cut and the feed rate and depth of cut.

P. Jayaraman et al. [9] have used grey relational analysis to performed multi-objective optimization of surface roughness and material removal rate. It investigate the effect of cutting speed, feed and depth of cut on surface roughness and material removal rate in turning of Al6063aluminium alloy using uncoated carbide insert under dry condition. Experiment were conducted based on Taguchi design of experiment with orthogonal L9 array and then followed by optimization of result using ANOVA to find out maximum MRR and minimum surface roughness. From this study it is revealed that feed rate is most influencing factor in grey relation grade followed by depth of cut. Lower cutting speed, lower feed rate and medium depth of cut gives minimum surface roughness and maximum material removal rate.

H.M. Samashekara [10] has developed regression model during machining of Al 6351-T6 aluminium alloy using uncoated carbide insert to analyze the combination of machining parameter for better performance within selected range of machining parameter. A full factorial design of experiment with orthogonal L9 array was used to develop the surface regression model. Developed model shows that surface roughness on machining parameter are significant; hence it could be used for making prediction for surface roughness. Analysis of variance is also used to analysis the influence of cutting parameter during machining and it is found that speed has greater influence on surface roughness followed by feed.

H.R.Ghan et al. [11] has developed surface roughness and material removal rate prediction model far machining (turning and milling) of Al-alloy (KM-26) using multi regression analysis for optimization machining parameter. Design of experiment with orthogonal L9 array (3 factors with 3 levels) has been used for conduct the experiment. The experimental data was analyzed by using Minitab16 software. The regression model was postulated in obtaining the relation between surface roughness, material removal rate, machining time and input process parameter (speed, feed and depth of cut). From this study it is concluded that most significant parameter on surface roughness are speed and depth of cut while in case MRR speed is most influencing parameter followed by feed but in case of machining time speed is most influencing parameter followed by depth of cut.

M. D. Tayab [12] has optimize cutting parameter like spindle speed, feed, depth of cut to minimization surface roughness and maximization of material removal rate in CNC turning of aluminium alloy(AL 6063-T6) using carbon insert tool in dry condition. Taguchi design of experiment with L9 orthogonal array was used for experiment and minitab17 statistical software used to analysis the experimental data. The ANOVA is used to investigate which design factor and their interaction affects the response significantly. The result show that significant factor for surface roughness are feed rate and spindle speed while for MRR depth of cut and spindle speed are most significant factor.

C. Ramudu et al. [13] has optimized the process parameter for surface roughness and material removal rate by using design of experiment. In this study mathematical model was developed for optimization of machining parameter like speed, feed, depth of cut and material on surface roughness and MRR is investigated. Mathematical model developed by using response surface methodology. Aluminium alloy and resin used as work piece for machining with H.S.S cutting tool. The experiment is conducted using three levels of speed, feed, depth of cut and two levels for material. The analysis of data was done by using done by using statistical tool DESIGN EXPERT-8(software). Result of this study shows that, the surface roughness & MRR greatly depends on work piece material. Feed rate have the greatest effect on surface roughness and is followed by spindle speed, and DOC. For MRR, the parameter that had the most influence is DOC and is followed by spindle speed and feed rate

Z. karim et al. [14] has studied the effect of positive and negative rake angle on tool wear and surface finish during machining of Al 6061 aluminium alloy. In this study machining parameter were kept constant while rake angle varied from positive to negative rake angle. Higher value of rake angle causes high wear of flank while surface roughness value reduces with increases of rake angle. The result of this study is used to assist machine operator to assist them in considering the optimum value of rake angle to get best result.

Tejinder pal singh [15] has investigated influence of cutting tool parameter such as tool rake angle, nose radius, and clearance angle on surface roughness in turning operation using single point cutting tool. Aluminium was used for experimentation. The mathematical models were developed to predict the effect of various tool parameters on surface roughness. Coefficient and adequacy of the developed model has been checked using student's't' and 'f' test respectively at 95%. From this study it was found that surface roughness decreases with the increases in rake angle and also increase with increases in the nose radius.

D.V.V. Krishan Prasad [16] has investigates the effect of machining parameter (Cutting speed, depth of cut, and feed rate) and tool geometry (back and side rake angle) on surface finish. In this work mild steel is selected as the specimen. Experiments were conducted using design of experiment with full factorial design and analysis done by using ANOVA. It is found that feed is the significant parameter Influencing surface roughness and side rake angle is having comparatively less effect on surface roughness.

M. Kaladhar [17] has optimize process parameters on multiple performance characteristics such as, surface roughness (Ra) and material removal rate(MRR) during turning of AISI 202 austenitic stainless steel using a CVD coated cemented carbide tool. They investigate the effect of process parameter like cutting speed, feed, depth of cut and tool nose radius on surface finish and material removal rate to obtain the optimal setting of these process parameter. And the ANOVA and F-tests are used to analyse the influences of cutting parameter during machining. It is found that higher levels of cutting speed, depth of cut, and nose radius and lower level of feed is essential to achieve simultaneous maximization of material removal rate and minimization of surface roughness.

L.B.Abhang et al. [18] has performed the experiment on EN-31 steel alloy to optimize surface roughness with considering influential process parameters feed rate, depth of cut and lubricant temperature. Experiment were conducted based on Taguchi method with orthogonal L9 array, and then followed by optimization of result using analysis of variance. Experimental result shows that feed rate and lubricant temperature are main parameter which influences surface roughness. Better surface finish obtained by applying cooled lubricant. This research demonstrates how to use Taguchi parameter design for optimization machining performance with minimum cost and time to industrial readers.

Ravinder Tonk et al.[19] has studied the effect of turning process parameters like cutting tool, cutting fluid, cutting speed, feed and depth of cut, while machining EN31 steel to optimizing thrust and feed force. Experiments were conducted on conventional lathe machine and Taguchi's robust design methodology has been used for statistical planning of the experiment. For this study two type of tools and three types of coolant were used with three different values of machining parameters (speed, feed and depth of cut).from this study ,It is found out that depth of cut and cutting oil are most significant parameter for feed force and feed, depth of cut are most significant parameter for thrust force.

S. Thamizhmanii et al. [20] has investigates the effect of process parameter to get lowest surface roughness in turning SCM 440 alloy steel. They investigate the effect of process parameters like Cutting speed, depth of cut, and feed rate on surface roughness. Experiment was designed and conducted using Taguchi method with orthogonal L18 array and Analyzed by using ANOVA. Result found that depth of cut has significant role to play in producing lower surface roughness followed by feed and The Cutting speed has less significant role on surface roughness from the tests.

K. Adarsh Kumar et al. [21] has carried out experiment on face turning operation in machining of En-8 to optimize surface roughness .As case study, the turning process of En-8 is examined considering three input parameter: Cutting speed, depth of cut, and feed rate. Experiments were based on Taguchi design of experiments with orthogonal L27 array. A multiple regression analysis (RA) using analysis of variance is conducted to determine the performance of experimental measurements. A multi regression analysis has been carried out for establish correlation between cutting speed, feed rate and depth of cut to optimize surface roughness. It is found that factors which have great influence on surface roughness are feed rate followed by cutting speed.

M. Nalbant et al. [22] has studied the effect of cutting parameter on surface roughness in machining AISI 1030 steel bars using TiN coated tools. The experimental result corresponding to effect of different tool nose radii of cutting tool, various depths of cut and different feed rates on surface roughness has been investigated by using Taguchi approach and analysis of variance. It is found that insert Radius and feed rate are the main parameters among the three controllable factors (insert radius, feed rate and depth of cut) that influence the surface roughness.

Satyanarayana Kosaraju et al. [23] have studies the effect of rake angle and feed rate on cutting forces in orthogonal turning process. Experiment were carried out on GEDEE WIELER lathe using high speed steel cutting tool for machining EN8 hollow cylindrical work piece. Experimental result shows that cutting force increases with increases in feed rate while decreases with increases rake angle.

Tian –syung Lan [24] present the optimization of cutting parameter –speed, feed, depth of cut and nose radius in order to improve surface finish and MRR orthogonal array has been adopted for planning of experiment and multi objective optimization by using TOPSIS. It was observing that higher cutting speed, feed, depth of cut and minimum nose radius gives better surface finish and higher MRR. The result achieved by proposed multi objective optimization technique, show that surface roughness and MRR increases about 27.80 %and 21.45 % respectively.

Arun Kumar Parida et al. [25] has utilized TOPSIS method to optimize multi response like MRR and surface roughness where Taguchi approach was used to analyse the effect of parameter such as speed, feed and depth of cut in turning of GFRP. Also statistical Analysis of variance (ANOVA) is performed to judge the significant of factor for response. It was observed that this approach gives much more reliable solution as exact experimental values are used to represent the process. Result shows that depth of cut is a factor which has great influence on increasing MRR and decreasing surface roughness by speed and feed.

III. DISCUSSION AND FUTURE TRENDS

After an elaborate scrutiny of the published work, the following conclusion can be drawn:

Most of researchers had taken input parameter speed, feed, and depth of cut and in some case other parameter such as nose radius, rake angle, lubricant, work piece material etc. and facing output parameters surface roughness(SR), material removal rate(MRR), cutting force, power consumption.

For surface roughness the most significant parameters are speed, feed, rake angle, nose radius and least significant parameter is DOC (Depth of Cut) and for MRR the most significant parameter is DOC, feed and least significant parameter is nose radius.

Most of researcher used response surface methodology, Regression analysis, Taguchi method, TOPSIS, Grey relational analysis for multi response optimization.

In case of aluminium alloy AL 6063 as work piece material, optimization of turning process is carried out by considering input parameter as cutting speed, feed, depth of cut and nose radius and surface roughness, material removal rate, cutting temperature, power consumption as output parameter. The rake angle is input parameter has effect on surface roughness is consider in case

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of Al6061 and aluminium as work piece material but it is not consider in case of Al6063.

From the above discussion hence, problem statement can be stated as, to find out the optimum parameter in order to get minimum surface roughness and to analyse the effect of machining parameter and rake angle on surface finish for Al 6063 aluminium alloy as work piece material. To optimization, Taguchi and TOPSIS method has been employed to determine the best combination of machining parameter such as cutting speed, feed, depth of cut and rake angle to attain the minimum surface roughness, machining time and maximum dimensional accuracy.

IV. CONCLUSIONS

A review of the research work on ferrous and non ferrous with turning process is presented in this paper .Turning is extensively used in industry for machining of ferrous and non ferrous. This is reflected in number of publication concerned with these processes. In turning, process parameter i.e. cutting speed, feed and depth of cut the number of other inter-related factor affected metal cutting are properties of work material, properties and geometry of cutting tool, working condition.

The above survey is done on optimization of turning process with different work piece material by considering different input parameter and output response and correlating relation between them in order to optimize the process parameter so that desired value of performance parameters are obtain. For making turning process cost effective along with the assurance about quality there is need to optimize the process parameter in a systematic way by using experimental method and statistical models. For each and every method introduced and employed in machining process, the objective are same to enhance the capability of machining performance like better surface finish high material removal rate to get better output product.

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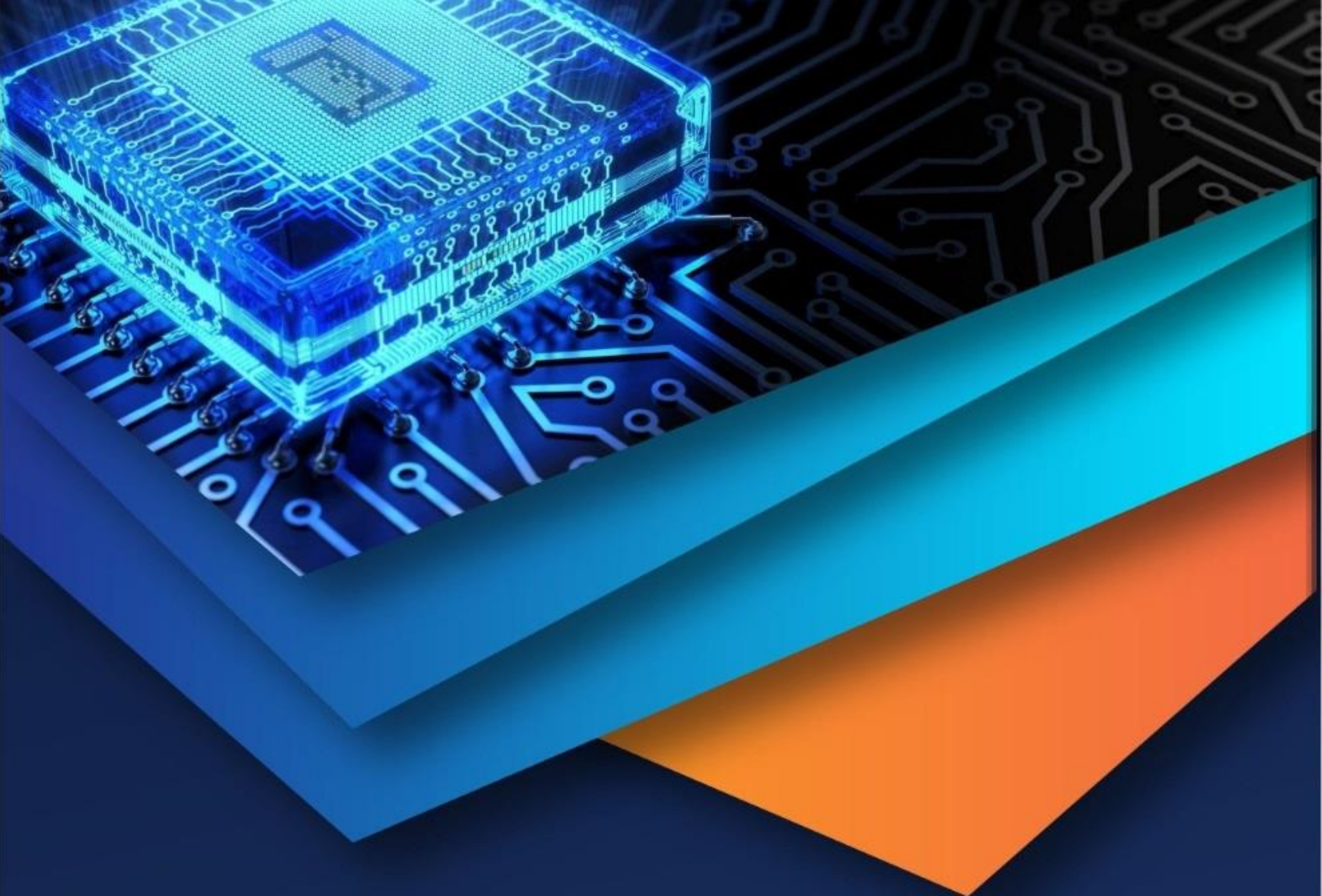

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