COMPARATIVE ANALYSIS AND OPTIMIZATION OF MACHINING PARAMETERS USING CENTRAL COMPOSITE DESIGN AND BOX BEHNKEN DESIGN OVER STEEL 1018

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Abstract—Surface roughness is a parameter which determines the quality of machined product. Now a days the general manufacturing problem can be described as the attainment of a predefined product quality with given equipment, cost and time constraints. So in recent years, a lot of extensive research work has been carried out for achieving predefined surface quality of machined product to eliminate wastage of over machining. Response surface methodology is used for prediction of surface roughness of machined part.This paper particularly shows the main findings of an experimental investigation into the effects of the cutting speed, feed rate, depth of cut, nose radius and cutting environment in turning. Design of experiment techniques, i.e. Response Surface Methodology (RSM) is going to be used to accomplish the objective of the experimental study.In this research work a new predictive model is proposed which is based on Central composite design and box behnken design. These both the techniques use statistical analysis and quadratic model for optimization of parameters in turning operation. Quadratic model gives best fits for the regression to find the optimal solution of equation and the proposed quadratic equation for predictive model.

***IndexTerms*—Response Surface Methodology (RSM), DOE, CCD, BBD, ANOVA**

I. INTRODUCTION

In this section, we are presenting literature survey which had been carried out by going through various journals and articles. This Section gives brief of all the journals or Articles which provided information about turning parameters, prediction of surface roughness of machined surface, CCD and BBD. Several website which contains information about these things are also referred and listed in the reference section. Idea of research gap obtained from most of the reviewed paper. The identified research gap comparative analysis and optimization of machining parameters using CCD and BBD over AISI 1018 is performed on the basis of various research paper. In section problem statements has been formulated based on research gap.

2. LITERATURE REVIEWED

Various related literature such as transactions, proceeding of various national and international conferences and other journals which available on Google scholar were reviewed.

3. JOURNALS/ARTICLES

Yue Liu (2016)[1] the overall goal of this study is to develop an efficient assembly time estimation method by generating the prediction model from an experimental design.The Box-Behnken design (BBD) is an experimental design to basically support the response surface methodology to illustrate and estimate a prediction model for the securing operations., the results indicate that the predicted value found was in good agreement with experimental data, with an Adjusted R-Squared value of 0.769 for estimated securing time.**Nilrudra Mandal et al (2015)[2]** In this paper researchers investigated the influence of factors such as cutting speed, feed rate and depth of cut on flank wear during hard turning of AISI 4340 steel with newly developed transformed toughened nano-composite Zirconium Toughened Alumina (ZTA) ceramic inserts.by using RSM optimization process it has been investigated that the depth of cut and feed rate has more effect on surface roughness on AISI 4340. Using regression analysis as a function of above mentioned independent variables. The predictive value from the developed model and experimental values are found to 2.17μm.**Mihir thakorbhai patel (2015)[3]**Aluminum alloy has a wide variety of applications in different industries. The Challenge of modern machining industries is to manufacture the low cost and produce high quality product in shorter period of time. So, it is necessary to control the process parameters in any manufacturing practices. The typical process parameters for the CNC lathe machines are speed, feed, depth of cut, tool geometry, wet cutting, dry cutting, tool material, work material, etc. . ANOVA approach helps to determine whether selection of process parameters are appropriate or not. Optimization of machining parameters are also required to determine for given responding characteristics to obtain optimal result.**Sourabh Kumar soni (2015)[4]** High quality and productivity are two important but major criteria in several machining operations. Vertical End Milling process operated by CNC is a broadly accepted material removal process used to manufacture components with complicated shapes and profiles. In this project we're describing milling possibilities of nickel alloy Inconel 718. The lowest surface roughness (Ra) of 0.80 µm was achieved corresponding to: f: 0.12 mm/rev, Vc: 55m/min. and d: 1.6 mm.**K. Rahul Verma (2015)[5]** The present work objective is to find out the optimum cutting parameters in turning of hardened AISI M2 steel using cryogenically treated cutting inserts. The Utility concept coupled with Taguchi approach was employed to optimize both surface roughness and power consumption simultaneously. According to Analysis of variance (ANOVA) results.The necessary optimum conditions for multiple performance characteristics optimization were obtained as cutting speed of 100m/min, feed 0.04 mm/rev and depth of cut of 0.2 mm.the expected range of surface roughness values for manufacturing industries is 0.063-5 µm. The obtained surface roughness values were fallen below the 0.618 µm in the present work.**Madhukar Sorte (2015)[6]** the surface roughness is one of the most commonly used criteria to determine the quality of turned steel. The surface roughness of a turned surface is an important response parameter.. Taguchi's technique has been used to accomplish the objective of the experimental study. L-9 Orthogonal array, Signal to noise (S/N) have been used for conducting the experiments. It can be concluded that the combination of the high level of cutting speed (200m/min) and low level feed of (0.1mm/rev) and a middle value of depth of cut 0.1mm yield the optimum result and Ra is .14469µm.**Afsaneh Morshedi (2014)[7]** The concept of response surface methodology can be used to establish an approximate explicit functional relationship between input random variables and output response through regression analysis and probabilistic analysis can be performed. Response Surface Methodology (RSM) is a set of mathematical and statistical methods useful for the modeling and analysis of problems. It is the process of identifying and fitting an approximate response surface model from input and output data obtained from experimental studies or from the numerical analysis where each run can be regarded as an experiment.**Dipti Kanta Das (2014)[8]**This paper deals with some examination on surface roughness during hard machining of EN 24 steel with the help of coated carbide insert. The experiment has been done under dry conditions. The optimization of process parameters have been done using Grey based Taguchi approach.Feed is considered to be the most dominant parameter for both surface roughness parameters Ra and Rz. The prediction models have high correlation coefficient (R2 = 0.993 and 0.934). This is evident to be better fitting of the model and found to be high significance.**Amit Phogat (2013)[9]**This paper presents the findings of an experimental investigation into the effects of cutting speed, feed rate, depth of cut, nose radius and cutting environment in Lathe turning of mild steel tool. Design of experiment techniques, i.e. response surface methodology (RSM) has been used to accomplish the objective of the experimental study. Though both the techniques predicted near similar results, RSM technique seems to have an edge over the Taguchi's technique.**Harish Kumar (2013)[10]**Many manufacturing industries involve machining operations. In metal cutting the turning process is one of the most fundamental cutting processes used. Surface finish and dimensional tolerance, are used to govern and evaluate the quality of a product, and are major quality attributes of a turned product.For the improvement of quality of the product of turning operation on CNC machine. Feed Rate, Spindle speed & depth of cut are taken as the input parameters and the dimensional tolerances as output parameter. CNC turning process using High Speed Steel cutting tools the optimum set of speed, feed rate and depth of cut and the most affecting parameters having the impact of 59.9% is Speed and surface roughness is 2.186µm.**M.Manohar (2013)[11]**This paper discusses the use of Box Behnken design approach to plan the experiments for turning Inconel 718 alloy with an overall objective of optimizing the process to yield higher metal removal, better surface quality and lower cutting forces. Response Surface methodology (RSM) has been acquired to demonstrate the output parameters (responses) that are decided by the input process parameters.. the variation of Desirability with change in cutting speed and feed when DOC is kept constant at optimum level of 1.7mm and surface roughness is 3.06µm.**M. Aruna and V. Dhanlakshmi (2012)[12]**Inconel 718, a nickel based super-alloy is an extensively used alloy, accounting for about 50% by weight of materials used in an aerospace engine, mainly in the gas turbine compartment. This is owing to their outstanding strength and oxidation resistance at elevated temperatures in excess of 5500 C.This paper is apprehensive with the optimization of the surface roughness when turning Inconel 718 with cermet inserts. The percentage error is calculated based on the difference between predicted value and experimental value for Ra =4.356 to 9.06%.**P. P. Sirpukar (2012)[13]**In this paper an attempt is made to review the literature on optimizing the machining parameters in turning processes by using tool inserts. Various conventional techniques employed for machining optimization include geometric programming geometric plus linear programming, Non-Linear Programming, goal programming, sequential unconstrained minimization technique and dynamic programming etc. the surface roughness i.e. 57.47 %. The second factor which contributes to surface roughness is the feed rate having 23.46 %. The third factor which contributes to surface roughness is the depth of cut having 16.27%. It is recommended from the above results that cutting of 18.30 to 15.78 m/min can be used to get lowest surface roughness.**Sahoo.P (2011)[14]**The paper presents an experimental study of roughness characteristics of surface profile generated in CNC turning of AISI 1040 mild steel and optimization of machining parameters based on genetic algorithm. The three level rotatable central composite designs are employed for developing mathematical models for predicting surface roughness parameters. Response surface methodology is adopted particularly in analyzing the effect of process parameters on different surface roughness parameters. It can be appreciated that the P value is less than 0.05 which means that the model is significant at 95% confidence level. Also the calculated value of the F-ratio is more than the standard value of the F-ratio for Ra. It means the model is adequate at 95% confidence level to represent the relationship between the machining response and the machining parameters and achieve roughness value of Ra=0.937 and Rsm=0.077.**D. Philip Selvaraj (2010)[15]**the present work is concentrated with the dry turning of AISI 304 Austenitic Stainless Steel (ASS). This paper presents the effects of cutting parameters like cutting speed, feed rate and depth of cut on the surface roughness of austenitic stainless steel during dry turning. The model of experiments based on Taguchi's technique has been used to get the data. An orthogonal array, the signal to noise (S/N) ratio and the analysis of variance (ANOVA) are employed to investigate the cutting characteristics of AISI 304 austenitic stainless steel bars implementing TiC and TiCN coated tungsten carbide cutting tool.. ANOVA results gives that feed rate, cutting speed and depth of cut affects the surface roughness by 51.84%, 41.99% and 1.66% respectively. The confirmation experiment was also carried and demonstrated the effectiveness of the Taguchi optimization method. Achieved roughness is 0.65µm.**TugrulOzel and J. Paulo Davim (2009)[16]**presented the paper about effects of design of insert tools in the surface roughness of machined surface. They took AISI 1045 steel and their surface finishing had investigated with wiper insert tool. They found that with help of wiper insert tool surface smoothness increases. They used RSM model as predictive model for prediction of surface roughness.This paper emphasizes the use of different type of inserts to increase in smoothness of machine surface and also discuss the importance of RSM as predictive model. Predicted RMS error of 0.745 obtained in wiper insert and RMS error of around 0.475 obtained in conventional insert.**HasanOktem and Erzurumlu (2006)[17]**worked on optimization of cutting parameters in the machining of mould surfaces of an ortez part used in biomedical instruments. They optimized the parameters with the help of genetic algorithm coupled with Response Surface. A feed forward neural network was developed and trained as well as tested in MATLAB.*They introduced machining tolerance as new cutting parameters in the experiment. They found that RSM along with GA gave more satisfactory results. Percent of error obtained was less* than 1.33%.**Yusuf sahin (2004)[18]** The surface roughness model in the turning of AISI 1040 carbon steel was described in terms of cutting speed, feed rate and depth of cut using response surface methodology. Machining tests were conducted using PVD-coated tools under different cutting conditions. The surface roughness equations of cutting tools when machining the carbon steels were achieved by using the experimental data., it has been seen that the first-order effect of feed rate was significant during cutting speed and depth of cut was insignificant. The predicted surface roughness of the samples was found to lie close to that of the experimentally observed ones with 95% confident intervals.**M. Y. Noordin (2003)[19]** The working capability of a multilayer tungsten carbide tool was described by implementing response surface methodology (RSM) when turning AISI 1045 steel. Cutting tests were performed with constant depth of cut and under dry cutting conditions. The factors investigated were cutting speed, feed and the side cutting edge angle (SCEA) of the cutting edge.The feed is the most significant factor that influences the surface roughness and the tangential force. The percentage error range between the actual and predicted value for Ra and Fc are as follows: Ra ∼ −4.47 to 7.76% and Fc ∼ −0.54 to 2.16%.**Ishan korkut (2003)[20]**High strength, low thermal conductivity, high ductility and high work hardening tendency of austenitic stainless steels are the main factors that make their machinability difficult. In this experiment the determination of the optimum cutting speed isfocused when turning an AISI 304 austenitic stainless steel using cemented carbide cutting tools.Surfaceroughness (Ra) was also decreased with increasing the cutting speed. Correlation was made between the tool wear/surface roughness and the chips obtained at the three cutting speeds of 120, 150 and 180 m/min.surface roughness is 1.6µm at max speed 180m/min.

3. CONCLUSION

Many researchers have developed intelligent systems for prediction of surface roughness for machined surface. From the above literature survey it seems the RSM systems are the most appropriate solution for the quick and precise predictive model. Most of the researchers have worked on fuzzy logic system, Taguchi, regression analysis for prediction and genetic algorithm for optimization of machining parameter in different types of machining. Some of them also suggested to couple two AI technique like fuzzy and ANN or ANN and GA to get most précised and optimized predicted result. But nobody developed predictive model based on CCD and BBD both together. But CCD and BBD was used by various researchers for prediction in biotechnology sector as well as prediction of chemical composition of various compound. This literature survey motivates us to work in the development of combine CCD and BBD based predictive model.

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