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# COMPUTER NUMERICAL CONTROLLED (CNC) TURNING OPERATION FOR MRR ON ALUMINIUM ALLOY: A REVIEW

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Many manufacturing industries involve machining operations. Machining is one of the most widely spread metal machining process in mechanical manufacturing industry. The main objective of today's manufacturing industries is to produce low cost, high quality products in short time. In metal cutting the turning process is one of the most fundamental cutting processes used. The selection of optimal cutting parameters is a very important issue for every machining process in order to enhance the quality of machining products and reduce the machining costs. The purpose of this paper is to review the past literatures on optimization of cutting parameters in turning on aluminium alloy. On studying the past literatures it was noticed that cutting parameters like spindle speed (rpm), feed rate (mm/rev), depth of cut (mm) and cutting speed (m/min) are important parameters which regulates the required output.



## 1. INTRODUCTION

CNC Machining is a process used in the manufacturing sector that involves the use of computers to control machine tools. Tools that can be controlled in this manner include lathes, mills, routers and grinders. The CNC in CNC Machining stands for Computer Numerical Control. Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, workpiece, fixture, and cutting tool. The workpiece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating workpiece and cuts away material in the form of small chips to create the desired shape. Turning is used to produce rotational, typically axi-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces.

## 2. LITERATURE REVIEW

**R.A.MULEY at al. [1]** studied the use of engineering materials that has increased to a great extent in the industries. To increase the quality of the machined parts during turning process is considered as the main challenge of industries. So it is required to find the optimum parameters in order to have easy and economical machining. Material removal rate affects the productivity and in turn the cost of manufacturing. This paper presents the optimization of material removal rate (MRR) and surface roughness for a given range of cutting parameters in turning operation. AISI D2, high chromium high carbon steel was selected for this study owing to its major applications in dies and tool industries. Optimum values were obtained and the effect of cutting speed on surface roughness and MRR was studied.

**Sujit Kumar Jha et al. [2]** focussed to utilize Taguchi methods to optimize the material removal rate for machining operation and the effects of CNC machining processes on aluminium samples. There are three important cutting parameters namely, cutting speed, feed rates and depth of cut, which has been considered during the machining of aluminium alloy. This research examines the effects of process parameters on Material Removal Rate (MRR) during machining on CNC. An Orthogonal array has been selected and constructed to find the optimal levels and to analyse the effect of the turning parameters. The signal-to-noise (S/N) ratio has been calculated to construct the analysis of variance (ANOVA) table to study the performance characteristics in dry turning operations. ANOVA has shown that depth of cut has significant role in producing higher MRR. The optimal results have been verified through conformation experiments with minimum number of trials as compared with full factorial design. The best cutting parameters for material removal rate has been found as cutting speed 1000 RPM, feed 0.20 mm/rev and depth of cut 1.5 mm on the basis of ANOVA analysis.

**Saurabh Singhvi et al. [3]** discussed the challenges in machining industries is reduce lead time and increase production rate in order to maintain their competitiveness. This paper investigates the machinability of mild steel in turning process perform on conventional lathe machine. Two parameters like tool rake angle and feed are varied to investigate their effect on material removal rate. An attempt has been made to model the one response variable using Taguchi an ANOVA method. These are techniques of great practical importance in a lot of applications of statistical conclusion in a reliable way. Taguchi L9 orthogonal array is used for experimental design. The main aim of this work is save power and useful production time during manufacturing of product.

**S. Dinesh et al [4]** machined EN-24 alloy steel work pieces were turned on Computer Numerical Controlled (CNC) lathe by using Cemented carbide tool (coated). The influence of four cutting parameters, cutting speed, feed rate, depth of cut, and tool nose radius on minuscule surface roughness and material removal rate (MRR) were analysed on the basis of Response Surface Methodology approach. The experimental results were collected by following the Taguchi's L16 mixed Orthogonal Array design.

**Saini & Pradhan [5]** aimed for selection of optimum machining parameters, Tool geometry and cutting condition etc. for the variety of materials is an important and complicated task for the manufacturing industries in providing best quality at less cost to the customers. In this research work CNC turning operation is carried out using L27 Taguchi orthogonal arrays on aluminium alloy 8011with carbide insert and influence of CNC turning process parameters like Cutting Speed, Feed and Depth of Cut are analysed for two output objectives like material removal rate and surface roughness. The optimum sets of turning process parameter as well as combined effect of considered response are estimated using Taguchi-Fuzzy application. In this analysis it is found that feed is the most significant process parameter followed by depth of cut and cutting speed on the selected response parameters.

**Krishnamurthy & Venkatesh [6]** discussed the utilization of TiB2 particles reinforced aluminium (Al6063) metal matrix composite materials in many different engineering fields has undergone a tremendous increase. Accordingly, the need of accurate machining of composites has increased enormously; an attempt has been made to assess the factors influencing surface roughness and material removal rate on machining the composite. The orthogonal array, the signal to-noise ratio, and analysis of variance were employed to study the performance characteristics in turning operations of 5 and 10 wt. % TiB2 particles reinforced aluminium (Al6063) metal matrix composites. Taguchi method was used to find the optimal cutting factors for surface roughness (Ra) and material removal rate (MRR). Three cutting factors namely speed; feed and depth of cut were optimized with considerations of Ra and MRR. The experimental plan and analysis was based on the Taguchi L27 orthogonal array with three cutting factors using carbide tool (K20). The optimal parametric combination for K20 carbide insert was found to be feed, speed and depth of cut. The analysis of variance (ANOVA) result shows that feed the most significant process parameter on surface roughness followed by speed. The depth of cut was found to be insignificant from the study. For MRR result show that the speed and the feed are the most significant parameters followed by the composition of composite material.

**Sayak Mukherjee [7]** used Taguchi method with L25 (5^3) Orthogonal Array for three parameters namely Speed, Feed and Depth of cut. For each of these parameters five different levels have been identified and used to perform the turning parameters for maximization of material removal rate on an EMCO Concept Turn 105 CNC lathe. The material selected for machining was SAE 1020 with carbide cutting tool. The MRR is observed as the objective to develop the combination of optimum cutting parameters. This paper proposes an optimization approach using orthogonal array for the maximized MRR and the result from this study confirms the same. This study also produced a predictive equation for determining MRR with a given set of parameters in CNC turning. Thus, with the proposed optimal parameters it is possible to increase the efficiency of machining process and decrease production cost in an automated manufacturing environment.

**Dinesh et al. [8]** investigated the response of EN-24 alloy steel work pieces which was turned on Computer Numerical Controlled (CNC) lathe by using Cemented carbide tool (coated). The influence of four cutting parameters, cutting speed, feed rate, depth of cut, and tool nose radius on minuscule surface roughness and material removal rate (MRR) were analyzed on the basis of Response Surface Methodology approach. The experimental results were collected by following the Taguchi's L16 mixed Orthogonal Array design.

**Sonowal et al. [9]** focused to review the literature on optimization of cutting parameters for minimum surface roughness in turning. The cutting parameters like spindle speed (rpm), feed (mm/rev) and depth of cut (mm) are taken into consideration.

**JohnJushua and Rajkumar [10]** aimed at the analysis of cutting parameters in CNC machine of Al6063 alloy. This paper explains the effective approach based on the optimization of turning parameters with response to the surface methodology (RSM) is proved. This article is about minimizing adequate surface roughness and maximizing the material removal rate in machining Al6063 alloy using Tungsten carbide tool. Cutting Speed, Feed rate and

Depth of Cut are the machining parameters selected to explain the process parameters. To study the performance characteristics in CNC various analysis like turning operation, the orthogonal array, signal to noise ratio are employed. In terms of cutting parameters, mathematical model is proved using response surface model.

**Kaldhone and Anuse [11]** dealt with the optimization of turning process by the effect of machining parameters applying ANOVA and Taguchi methods to improve the quality of manufactured goods and engineering development of designs for studying variation. In this work, Austenitic stainless steel AISI 316L was considered as work piece while spindle speed, feed rate and depth of cut are considered as cutting parameters. The results of analysis showed that depth of cut and spindle speed has the most significant contribution on the material removal rate and feed rate has less significant contribution on the material removal rate.

**Rajpoot et al. [12]** used Response Surface Methodology method to scrutinize the effect of cutting parameters like cutting speed, feed and depth of cut on average surface roughness and material removal rate during turning of Al 6061 alloy. To find out the effect of each factor independently on surface roughness faced centered design based on RSM was implemented. The roughness was measured at three different locations. The results of 20 experiments were further analyzed in Design Expert 8.0.4.1 software to find out the surface roughness and material removal rate. A regression model was developed for evaluating surface roughness considering actual factors. ANOVA was performed to examine the significance of the regression model for a confidence level of 95%. Among the three cutting parameters depth of cut was found to be the significant factor for both surface roughness and MRR.

**Vishnu et al. [13]** presented a work performed by turning of EN-36 steel alloy which was carried out in order to optimize the turning process parameters using Taguchi approach. The present paper deals with the optimization of selected process parameters, i.e. Speed, Feed rate, Depth of cut and type of tool. Taguchi orthogonal array is designed with three levels of machining parameters and different experiments are done using L9 (34) orthogonal array. Taguchi method stresses the importance of studying the response variation using the signal to noise (S/N) ratio, resulting the minimization of quality characteristic variation due to uncontrollable parameter. The material removal rate is considered as the quality characteristic in the concept of "the larger the better". The material removal values measured from experiment and their optimum value for material removal rate are calculated. The S/N ratio of predicted value and verification test values are valid when compared with the optimum value. It is found that S/N ratio value of verification test is within the limits of predicted value and the objective of the work is fulfilled.

**Chopra et al. [14]** studied the intelligent methods based on fuzzy logic, artificial neural network (ANN), adaptive neuro fuzzy inference system (ANFIS) and genetic algorithms (GA) for tuning a PID controller. The controller tuned by the given methods has been used for concentration control of a continuous stirred tank reactor (CSTR). Simulation results reveals that intelligent methods provide better performance than the conventional Zeigler Nichols (ZN) method in terms of various performance specifications.

**Ranganath et al. [15]** performed a work 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. He also discussed some other parameters such as cutting force and power consumption in different conditions.

**Saraswat et al. [16]** took the cutting parameters (depth of cut, feed rate, spindle speed) and optimized them for turning of mild steel and as a result of that the combination of the optimal levels of the factors was obtained to get the lowest surface roughness. The Analysis of Variance (ANOVA) and Signal-to-Noise ratio were used to study the performance characteristics in turning operation. The analysis also shows that the predicted values and calculated values are very close, that clearly indicates that the developed model can be used to predict the surface roughness in the turning operation of mild steel.

**Bhuiya and Ahmed [17]** presented an experimental study of cutting force in turning of AISI 1040 steel and developed a model of the cutting force during turning using Response surface Methodology (RSM) and also performed optimization of machining parameters using Genetic Algorithm (GA). The second order empirical model of the main cutting force in terms of machining parameters have been developed based on experimental results. The experimentation has been carried out considering three machining parameters: cutting speed, feed rate and depth of cut as independent variables and the main cutting force as the response variable. The formulated model has been validated against new set of experimental values using Mean Absolute Percent Error (MAPE) method. The Genetic Algorithm approach is also used to optimize the cutting parameters to keep the main cutting force to a minimum.

**Dhameliya et al. [18]** presented a single characteristic response optimization model based on Taguchi Technique to optimize process parameters such as spindle speed, feed and depth of cut. Taguchi's L9 orthogonal array is selected for experimental planning. The Analysis of experimental result showed that the combination of optimum levels of cutting speed, feed and depth of cut is essential to achieve simultaneous maximization of material removal rate and minimization of surface roughness. This project also aims to determine Analysis of Variance.

**Borse [19]** investigated the optimization of surface roughness and material removal rate in dry turning of SAE52100 steel. Carbide inserts were used for machining of SAE 52100 to study effects of process parameters [Cutting speed (S), Feed (F) and depth of cut (d)]. These models can be effectively used to predict the surface roughness (Ra) and material removal rate of the workpiece. Paper presents work of an investigation of turning process parameters on SAE 52100 material, for optimization of surface roughness, material removal rate. The experiment is carried out by considering three controllable input variables namely cutting speed, feed rate, and depth of cut. The design of experiment and optimization of surface roughness, material removal rate is carried out by using Taguchi L9 orthogonal array.

**Parthiban et al. [20]** studied the effect of process parameters on Aluminium alloy 6061-T6 surface, and to develop the mathematical model for Material removal rate and surface roughness on milling process. The quadratic model is best agreement with experimental data; finally the numerical optimization technique has been used to find out best optimum milling parameters. The optimal set of process parameters has also been predicted to maximize the MRR and minimize the surface roughness.

**Francis et al. [21]** optimized the cutting parameters of mild steel (0.18% C) in turning to obtain the factors effecting the surface roughness and MRR. To study the influence of cutting parameters they applied ANOVA and Signal to Noise ratio. The cutting parameters like spindle speed, feed and depth of cut were taken into consideration. A total of 27 experiments were done which were designed according to Taguchi method. The experiments were performed by using HSS cutting tool in dry condition. For MRR the most significant factor was spindle speed whereas feed was the most significant factor for surface roughness.

**Prasad [22]** conducted full factorial design consisting of 243 experiments considering three machining parameters and two tool geometrical parameters to determine the impact of these parameters on surface roughness. The machining parameters were speed, feed and depth of cut whereas the tool geometrical parameters were back rake angle and side rack angle with three levels each. The metal used for turning was mild steel with HSS cutting tool. It was found that feed is the only significant factor during this experiment.

**Saravanakumar et al.[23]** This paper was aimed at conducting experiments on Inconel 718 and investigating the influence of machining process parameters such as cutting speed (X1, m/min), feed rate(X2, mm/rev), and depth of cut (X3, mm) on the output parameters such as material removal rate and surface roughness. Several techniques are available for optimizing the input parameters to get optimized output parameters and in this research genetic algorithm is used. The chemical composition and hardness test are carried out for Inconel 718 material. Number of experiments had been conducted with suitable combinations of input parameters. Relationship between material removal rate and input parameters and between surface roughness and input parameters are arrived through Minitab software. These regression equations are solved using genetic algorithm tool called user interface method and the optimum combinations of input parameter for input parameters for maximum material removal rate (MRR) and minimum surface roughness (Ra) had been arrived using mat lab software.

**Hasan et al. [24]** investigated the effects of process parameters on Material Removal Rate (MRR) in turning of C34000. The single response optimization problems i.e. optimization of MRR was solved by using Taguchi method. The optimization of MRR was done using twenty seven experimental runs based on L'27 orthogonal array of the Taguchi method are performed to derive objective functions to be optimized within the experimental domain When the MRR was optimized alone the MRR comes out to be 8.91. The optimum levels of process parameters for simultaneous optimization of MRR have been identified. Optimal results were verified through confirmation experiments.

## 3. CONCLUSION

On studying the past literatures it is seen that the material removal rate is mainly affected by spindle speed, cutting speed, depth of cut and feed rate and by increasing any one, the material removal rate is increased. Further use of optimising techniques helps to determine the optimal value of process parameters to obtain the required response.

## 4. REFERENCE

1. R.A.Muley, A.R.K Ulkarni, R.R.Deshmukh, (2016), Optimization Of Surface Roughness and Material Removal Rate In Turning Of AISI D2, Mechanical Engineering Department, JNEC, Aurangabad, International Journal of Mechanical And Production Engineering, pp. 46-48.
2. Sujit Kumar Jha And Pramod K Shahabadkar, (2015), Experimental Investigation Of Cnc Turning Of Aluminum Using Taguchi Method, Engineering Department, IBRA College Of Technology, IBRA, Sultanate Of Oman, International Research Journal Of

Engineering And Technology (IRJET), Pp. 1524-1534.

3. Saurabh Singhvi, M.S.Khidiya, S.Jindal, M.A.Saloda, (2016), Investigation of Material Removal Rate in Turning Operation, M.Tech Scholar, Department of Mechanical Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India, International Journal of Innovative Research in Science Engineering and Technology, pp. 2890-2895.
4. S. Dinesh, K. Rajaguru, V. Vijayan, A. Godwin Antony , (2016), Investigation and Prediction of Material Removal Rate and Surface Roughness in CNC Turning of EN24 Alloy Steel, Department of Mechanical Engineering K. Ramakrishnan College of Technology Tiruchirapalli, Tamil Nadu, India, Department of Mechanical Engineering Shivani College of Engineering and Technology Samayapuram, Trichy, Tamilnadu, India, Mechanics and Mechanical Engineering Vol. 20, No. 4 (2016) 451–466 © Lodz University of Technology, pp. 452-466.
5. Surendra Kumar Saini, Sharad Kumar Pradhan, (2014), Optimization of Multi-Objective Response during CNC Turning using Taguchi-Fuzzy Application, M.E. Student ,Mechanical Engineering Department, NITTTR Bhopal, Madhya Pradesh, India 12th GLOBAL CONGRESS ON MANUFACTURING AND MANAGEMENT, GCMM 2014, pp. 142-149.
6. K.Krishnamurthy, J.Venkatesh, (2013), Assessment of Surface Roughness and Material Removal Rate on Machining of TIB2 Reinforced aluminium 6063 Composites: A Taguchi's Approach, Department of Mechanical Engineering, Adichunchangiri Institute of Technology, Chikmagalur-577102, INDIA, Department of Automobile Engineering, PES College of Engineering, Mandya-571401, INDIA, International Journal of Scientific and Research Publications, pp. 1-5.
7. Sayak Mukherjee, Anurag Kamal, Kaushik Kumar, (2014), Optimization of Material Removal Rate During Turning of SAE 1020 Material in CNC Lathe using Taguchi Technique, Student, Birla Institute of Technology, Mesra, Ranchi-835215, INDIA, ELSEVIER.
8. S .Dinesh, K. Rajaguru, V. Vijayan, A. Godwin Antony, (2016), Investigation and Prediction of Material Removal Rate and Surface Roughness in CNC Turning of EN24 Alloy Steel, Mechanics and Mechanical Engineering Vol. 20, No. 4, pp. 451–466.
9. Dharindom Sonowal, Thuleswar Nath, Dhrupad Sarma, (2015), A Review on Optimization of Cutting Parameters on Turning, International Journal of Engineering Trends and Technology (IJETT), pp.54-60.
10. C. JohnJoshua, N.Rajakumar, (2016), Effect of Spindle Speed and Feed Rate on Surface Roughness and Material Removal Rate of AA6063A in CNC Turning Using Response Surface Methodology, IJRMET, pp. 7-11.
11. Prof. Kaldhone S.Y. Prof. Anuse U.L. ,(2015), Optimization Of Metal Removal Rate For SS316l In Dry Turning Operation Using Taguchi Method, International Journal Of Innovations In Engineering Research And Technology [IJIERT], pp. 1-10.
12. Bheem Singh Rajpoot, Dharma Ram Moond and Shrivastava, Sharad, (2015) Investigating the Effect of Cutting Parameters on Average Surface Roughness and Material Removal Rate during Turning of Metal Matrix Composite Using Response Surface Methodology,‖ International Journal on Recent and Innovation Trends in Computing and Communication, pp. 241 – 247.

13. A.Venkata Vishnu, G.Guruvaiah Naidu, K.B.G.Tilak, J.Ramakrishna, (2015), Application of Taguchi Method in the Optimization of Turning Parameters for Material Removal Rate of En-36 Material, International Journal of Advance Engineering and Research Development, pp. 54-62.
14. Vikram Chopra, Sunil K. Singla, Lillie Dewan, (2014), Comparative Analysis of Tuning a PID Controller using Intelligent Methods, Acta Polytechnica Hungarica, pp.235-249.
15. M Ranganath, S, Vipin, Prateek, Nikhil, Rahul, Nikhil Gaur (2014), Experimental Investigation and Parametric Studies of Surface Roughness Analysis in CNC Turning, International Journal Of Modern Engineering Research (IJMER), pp. 49-58.
16. Neeraj Saraswat, Ashok Yadav , Anil Kumar and Bhanu Prakesh Srivastava, (2014), Optimization of Cutting Parameters in Turning Operation of Mild Steel, International Review of Applied Engineering Research. ISSN 2248-9967 Volume 4, Number 3 (2014), pp. 251-256.
17. Tanveer Hossain Bhuiyan and Imtiaz Ahmed, (2014), Optimization of Cutting Parameters in Turning Process, BUET, SAE International, pp. 1-08.
18. Kishan Dhameliya, Jignesh Desai, Mohit Gandhi1, Divyesh Dave, (2014), Experimental investigation of process parameters on MRR and Surface roughness in turning operation on CNC Lathe machine for Mild Steel – E250: IS 2062, International Journal of Engineering Research and Technology (IJERT), pp- 744-750.
19. Sachin C Borse, (2014), OPTIMIZATION OF TURNING PROCESS PARAMETER IN DRY TURNING OF SAE52100 STEEL, International Journal of Mechanical Engineering and Technology (IJMET), pp-01-08.
20. A Parthiban, R Pugazhenthi, R Ravikumar and P Vivek,(2013), Experimental Investigation of Turning Parameters on AA 6061-T6 Material, International Conference on Emerging Trends in Engineering Research, pp- 1-8.
21. Vishal Francis, Ravi. S. Singh, Nikita Singh, Ali. R. Rizvi and Santosh Kumar, (2013) Application of Taguchi Method and ANOVA in Optimization of Cutting Parameters for Material Removal Rate and Surface Roughness in Turning Operation,‖ International Journal of Mechanical Engineering and Technology, Vol 4, pp.47-53.
22. D.V.V. Krishan Prasad, (2013), Influence of Cutting Parameters on Turning Process Using ANOVA Analysis, ‖ Research Journal of Engineering Sciences, Vol. 2, pp. 1-6.
23. K. Saravankumar, Dr A.K. Shail Dawood, M.R. Pratheesh Kumar, (2012), Optimization of CNC Turning Process Parameters on INCONEL 718 Using Genetic, IRACST – Engineering Science and Technology: An International Journal (ESTIJ), ISSN:2250-3498,Vol.2,No.4,pp.532-537.
24. Kamal Hassan, Anish Kumar, M.P.Garg, (2012), Experimental investigation of Material removal rate in CNC turning using Taguchi, International Journal of Engineering Research and App, pp. 1582-1590.