IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
6th National Conference on Science, Technology and Communication Skills – NCSTCS 2K23
Narula Institute of Technology, Agarpara, Kolkata, India
Vol. 10, Special Issue 3, September 2023

Experimental Investigation of the Effect of Process Parameters on MRR in CNC Turning Operation

Akhtarujjaman Sarkar[1], Arghya Gupta[2] and Arijit Sarkar[3]

Faculty, Department of Mechanical Engineering, Narula Institute of Technology, Kolkata, India[1,2]

Student, Department of Mechanical Engineering, Narula Institute of Technology, Kolkata, India[3]

Abstract: The turning process is a widely used machining operation for creating cylindrical parts in various industries. One of the most critical factors in turning operations is the Material Removal Rate (MRR), which directly affects the productivity and efficiency of the process. The MRR is influenced by several process parameters such as cutting speed, feed rate, and depth of cut. Therefore, it is crucial to optimize these parameters to achieve a higher MRR and enhance the process efficiency. The present study focuses on the experimental investigation of the impact of process parameters on material removal rate (MRR) and surface roughness in turning operation on a CNC machine for brass materials using the Taguchi method. The Taguchi design of experiments is used to identify the optimal cutting conditions for the turning operation. The cutting parameters, namely cutting speed, feed rate, depth of cut, tool temperature, are considered for the study. The experiments were conducted based on an L9 orthogonal array of Taguchi design with three levels for each parameter. The results are analysed using S/N Ratio and the analysis of variance (ANOVA) method to identify the significant parameters and their optimal levels. The findings reveal that the feed rate is the most significant factor affecting the MRR, followed by the cutting speed and depth of cut. Moreover, the optimum levels of the cutting parameters for maximizing the MRR is identified. The study provides valuable insights for optimizing the turning process parameters for brass materials, which can lead to improved productivity and quality in manufacturing industries. In conclusion, the Taguchi method was successfully used to optimize the process parameters for turning operations on brass materials, and the results obtained could be used to enhance the efficiency and productivity of the turning process. The study also highlights the importance of process optimization in manufacturing operations, and the usefulness of statistical approaches like the Taguchi method in achieving optimization. Further research could be carried out to investigate the effect of other process parameters on MRR in turning operations.

Keywords: Depth of Cut, Spindle Speed, Feed Rate, MRR, Taguchi Method

I. INTRODUCTION

In the manufacturing industry, CNC (Computer Numerical Control) turning operations play a vital role in producing precision components with high efficiency. The Material Removal Rate (MRR) is a key performance metric that directly affects the productivity and cost-effectiveness of CNC turning processes. Maximizing MRR is crucial for achieving higher production rates and reducing manufacturing costs. Therefore, understanding the factors that influence MRR and optimizing the process parameters are of significant importance. Brass, an alloy of copper and zinc, is widely used in various industries due to its excellent machinability, corrosion resistance, and aesthetic appeal. CNC turning is commonly employed for brass component manufacturing. However, achieving an optimal balance between MRR and other machining characteristics, such as surface finish and tool life, requires a comprehensive understanding of the effect of process parameters on MRR specifically for brass material. The objective of this research is to experimentally investigate the effect of process parameters on MRR in CNC turning operations for brass material. By studying the influence of cutting speed, feed rate, depth of cut, and tool geometry, this study aims to provide insights into the optimal parameter settings for maximizing MRR in brass component manufacturing.

The investigation of process parameters on MRR in CNC turning has been extensively studied for various materials. However, brass, with its unique material properties, warrants a dedicated investigation to understand the specific effects of process parameters on MRR in this context. The findings of this research will contribute to the body of knowledge regarding the machining of brass material and provide practical guidance to manufacturers for optimizing CNC turning operations. The objective of this experimental investigation is to analyse the effect of process parameters on Material Removal Rate (MRR) in CNC turning operations specifically for brass material.

II. EXPERIMENTAL SET UP

The experimental setup for the "Experimental Investigation of the Effect of Process Parameters on MRR in CNC Turning Operation" for brass material is as follows:

CNC Lathe Machine: A CNC lathe machine with the necessary controls and capabilities to adjust process parameters such as cutting speed, feed rate, and depth of cut was used. The machine should have high precision and stability to ensure accurate and repeatable results.

Workpiece Material: Brass material of specific dimensions and composition was selected as the workpiece for the experiments. The brass material should be representative of the typical brass components used in industrial applications. The workpiece was securely mounted in the lathe chuck to ensure stability during the turning operation.

Cutting Tool: A suitable cutting tool specifically designed for CNC turning operations was chosen. The tool material and geometry were selected based on their compatibility with brass machining, taking into account factors such as tool wear resistance and heat dissipation. The cutting tool was securely mounted in the tool holder of the lathe.

Process Parameters: The process parameters investigated included cutting speed, feed rate, depth of cut. A range of parameter values was chosen based on pre-experimental analysis and industry standards. The specific parameter values for each experimental run were carefully selected and recorded.

Measurement Equipment: To measure the MRR during the experiments, suitable measurement equipment was used. This typically involved weighing the workpiece before and after the turning operation using a precision scale to calculate the weight of the removed material. Additionally, cutting forces may be measured using a dynamometer or force sensor to analyze the impact of process parameters on cutting forces.

Experimental Procedure: A detailed experimental procedure was followed for each experimental run. This included setting up the CNC lathe machine with the appropriate process parameters, mounting the workpiece and cutting tool, and executing the turning operation. Throughout the experiment, relevant data such as cutting forces and weight measurements were recorded. Replication of experiments was performed to ensure statistical significance and reliability of the results.

By following the experimental setup and procedure described above, the researchers were able to conduct the "Experimental Investigation of the Effect of Process Parameters on MRR in CNC Turning Operation" for brass material. The setup ensured accurate data collection and facilitated the analysis of the experimental results, providing valuable insights into the optimal parameter settings for maximizing MRR in brass component manufacturing.

Fig. 1 CNC lathe machine

III. DESIGN OF EXPERIMENT

For the experimental design, the Taguchi method was employed to reach more comprehensive a result with lesser experiments. The objective of the Design of the experiment is to determine the variables in a process that are the critical parameters and their target values and so on the basis of selected parameters, experimental design is carried out.

Taguchi method is a powerful tool for the design of high-quality systems which provides a simple, efficient, and systematic approach to optimize designs for performance, quality, and cost. Taguchi method is an efficient method for a designing process that operates consistently and optimally over a variety of conditions. The Taguchi experimental design is done for L8 Orthogonal array (OA) for mixed-level design for four parameters which are spindle speed, feed, depth of cut, and nose radius. Minitab16 software was used to analyse the data.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

6th National Conference on Science, Technology and Communication Skills – NCSTCS 2K23

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 10, Special Issue 3, September 2023

TABLE1 TURNING PARAMETERS AND LEVELS

Symbol	Turning parameters	Level 1	Level 2	Level 3
A	Cutting speed	1000	2000	3000
B	Depth of cut	0.2	0.4	0.6
C	Feed rate	210	300	400

TABLE2 EXPERIMENTAL DATA

Sl. No.	Speed RPM	Feed Rate (mm/rev)	Depth of Cut (mm)	Tool Temperature (°C)	MRR (mm^3/min)
1	1000	210	0.2	39	49.14
2	1000	300	0.4	40	67.58
3	1000	400	0.6	40	91.52
4	2000	210	0.4	40	22.89
5	2000	300	0.6	40	34.03
6	2000	400	0.2	39	45.6
7	3000	210	0.6	43	16.04
8	3000	300	0.2	39	22.6
9	3000	400	0.4	39	29.49

Signal-to-nose ratio (S/N Ratio): Taguchi uses the loss function to measure the performance characteristic deviating from the desired value. The value of loss function is then further transformed to S/N ratio. Usually, there are three categories of the performance characteristic in the analysis of the S/N ratio, i.e., the lower-the-better, the higher-the-better, and the nominal-the-better.

Based on the S/N analysis, the S/N ratio for each level of control parameters is computed, and the higher the S/N ratio, the better the Material Removal Rate (MRR). As a result, the optimal process parameter level is the one with the highest S/N ratio. The S/N ratio was calculated to determine the effect of control parameters on MRR and to determine the optimal control parameter setting for maximum MRR. In this paper, we analysed the S/N ratio using "Larger-the-Better" type performance characteristics.

TABLE3 S/N RATIO CALCULATION

Sl. No.	Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)	Tool Temperature (°C)	MRR (mm^3/min)	S/N Ratio for larger the better
1	1000	210	0.2	39	49.14	33.82
2	1000	300	0.4	40	67.58	36.61
3	1000	400	0.6	40	91.52	39.24
4	2000	210	0.4	40	22.89	27.21
5	2000	300	0.6	40	34.03	30.63
6	2000	400	0.2	39	45.6	33.18
7	3000	210	0.6	43	16.04	24.20
8	3000	300	0.2	39	22.6	37.09
9	3000	400	0.4	39	29.49	39.42

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

6th National Conference on Science, Technology and Communication Skills – NCSTCS 2K23

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 10, Special Issue 3, September 2023

Response Table for Signal to Noise Ratios

Larger is better

Level	Speed	Feed rate	DOC
1	36.55	28.38	31.36
2	30.34	31.44	31.06
3	26.86	33.93	31.32
Delta	9.69	5.56	0.30
Rank	1	2	3

Response Table for Means

Level	Speed	Feed rate	DOC
1	69.41	29.36	39.11
2	34.17	41.40	39.99
3	22.71	55.54	47.20
Delta	46.70	26.18	8.08
Rank	1	2	3

Fig. 2 Response table

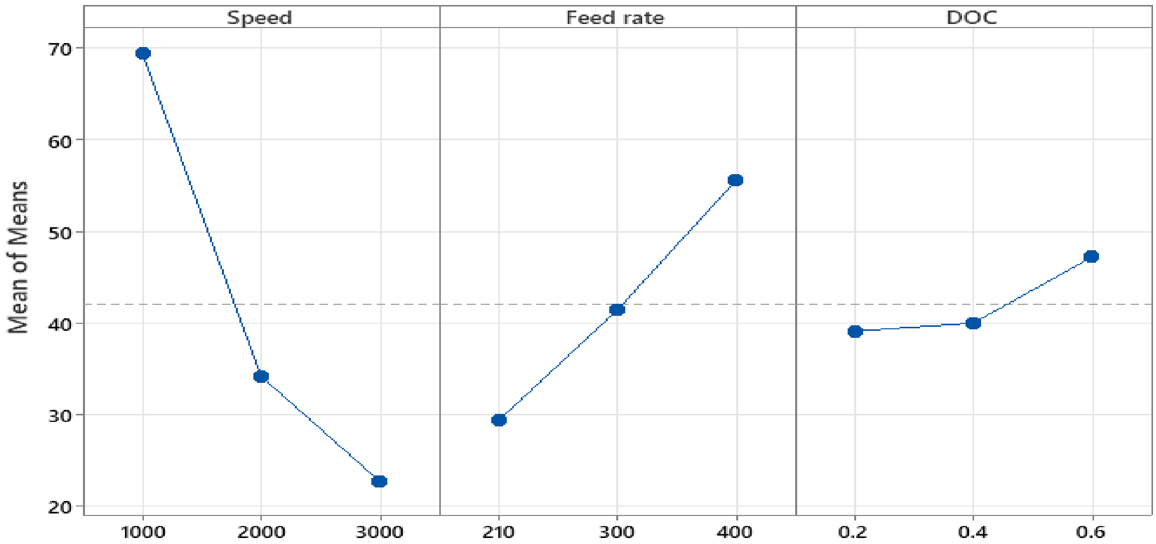

Fig. 3 Main effects plots for means

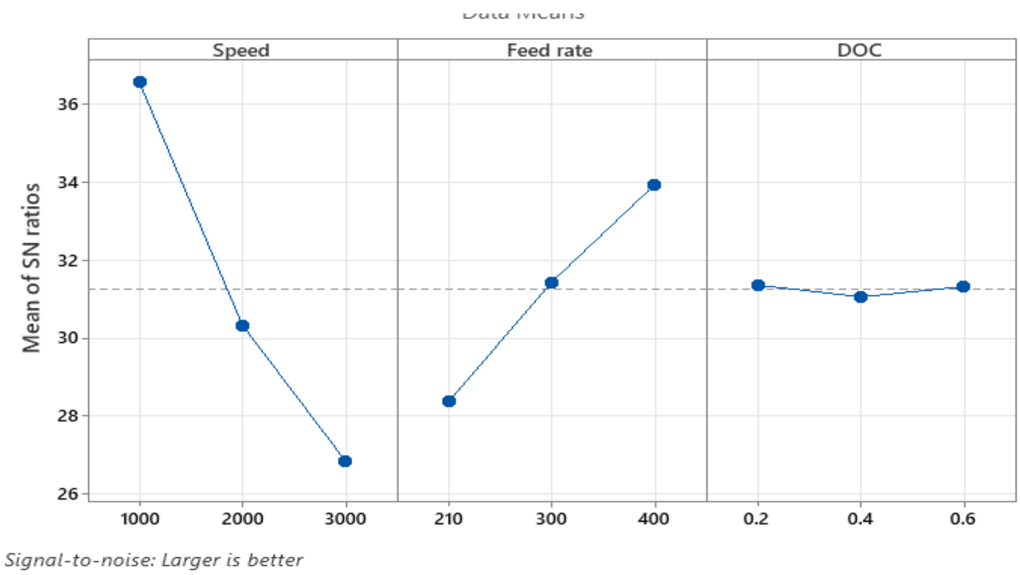

Fig. 4 Main effects plots for S/N ratios

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	3	4399.83	91.55%	4399.83	1466.61	18.06	0.004
Speed	1	3271.80	68.08%	3271.80	3271.80	40.28	0.001
Feed rate	1	1030.01	21.43%	1030.01	1030.01	12.68	0.016
DOC	1	98.01	2.04%	98.01	98.01	1.21	0.322
Error	5	406.09	8.45%	406.09	81.22		
Total	8	4805.91	100.00%				

Fig. 5 Analysis of variance

IV. CONCLUSION

This experimental study has been done to find out the best combination of work piece and electrode which gives maximum MRR. Taguchi Method has been applied in this work for getting optimal setting of control parameters and ANOVA technique is used to identify the effect of control parameter on MRR. From the analysis of the results following conclusions can be drawn. In this experimental work it has been observed that the Material removal rate varies with each control parameter. From ANOVA analysis it can be concluded that Speed is the most influencing control parameter on MRR at 95% confidence level. Results obtained from both S/N Ratio and polynomial regression analysis are also bearing same trend.

REFERENCES

[1]. Deresse N. C, Deshpande V. and Taifa I. W. (2020, April). Experimental investigation of the effects of process parameters on material removal rate using Taguchi method in external cylindrical grinding operation. Engineering Science and Technology, an International Journal, 23(2), 405-20.
[2]. Roy D. and Sarkar A. (2015). A comparative study to maximize MRR in electro discharge machining process by variation of control parameters using Taguchi analysis. International Journal of Engineering Research and Applications, 5(3), 59-66.
[3]. Seçgin Ö. (2021, March). Multi-objective optimization of Ms58 brass machining operation by multi-axis CNC lathe. Arabian Journal for Science and Engineering, 46(3), 2133-45.
[4]. Sahoo P., Barman T. K. and Routara B. C. (2008). Taguchi based fractal dimension modelling and optimization in CNC turning. Advances in Production Engineering & Management, 3(4), 205-17.
[5]. Kumar M. V., Kumar B. K. and Rudresha N. (2018, January). Optimization of machining parameters in CNC turning of stainless steel (EN19) by Taguchi's orthogonal array experiments. Materials Today: Proceedings, 5(5), 11395-407.