



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 11, November 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Determination of Optimal Metal Removal Rate in Dry Turning of AISI 1029 Steel with Carbide Insert Tool Using Taguchi's Method

Dr. T.N. Guma¹, Victor A. Onoja²

Department of Mechanical Engineering, Nigerian Defence Academy, Kaduna, Nigeria¹

P.G. Student, Department of Mechanical Engineering, Nigerian Defence Academy, Kaduna, Nigeria²

ABSTRACT: Machining is essentially a finishing production process and an economic activity that requires maximization of productivity and quality of products at minimal costs. In this paper, an experimental investigation of cutting variables for optimal metal removal rate (MRR) as a measure of optimal productivity in the turning process has been conducted with 125, 250, and 500-m/min cutting speeds; 0.1, 0.2, and 0.3-mm/rev feed rates; and 0.5, 1, and 1.5-mm depths of cut. Taguchi's L-9 Latin squares orthogonal arrays were designed with the cutting variables. Turning operations were conducted on the XL 400 lathe with a 79.6-mm diameter and 200mm-length solid cylindrical AISI 1029 steel rod using the array variables as inputs and MRR as the response variable. The input variables and the MRR values obtained from the experimental turning process were analyzed with the Minitab-17 software using generated Signal-to-Noise ratios, main effect plots, contour plots, surface plots, and analysis of variance by imbibing Taguchi's concept of The-Larger-The-Better. Results obtained from the analyses jointly showed that 500-m/min cutting speed, 1.5-mm depth cut, and 0.3-mm/rev feed rate were conditions for optimal MRR in the turning operation. Further analysis of variance of collated data showed that, feed rate had the highest contribution of 45.634%, followed by depth of cut with 23.0234%, and cutting speed with 22.0033% in the MRR. Confirmation test at optimal conditions indicated 225-cc/min MRR against the 222.41-cc/min value obtained from the Minitab-17 predictive regression equation. This put the experimental value in error by only 1.2%. The confirmation tests and percentage errors revealed accuracy of the conducted turning experiments at 95% confidence level.

KEYWORDS: Machining, Finishing production process, Productivity and quality control, Complexity of process variables, Optimal MRR cutting conditions

I. INTRODUCTION

Machining is a fast and efficient process of producing components into desired shape and dimensions with fine surface finish [1]. Machining is achieved by removing unwanted excess surface material from the component or part using power-operated machine tool. However, machining process requires much control of complex variables with the ultimate target to achieve consistent product quality with high productivity at affordable cost. The process is therefore an economic activity that requires maximization of production and quality of products at minimal costs. One of the major factors in machining economics is time. The longer it takes to machine a part to finishing specifications, the more it costs. The cost of machining can be great if the part is large or several parts are to be machined in batches. Maximization of machining productivity with a given metal (material) is achieved by maximization of its MRR [2, 3]. Maximization of MRR is particularly desirable at the initial stage of machining called roughening operation in production of large batches before settling for the smoothing cutting variables to get the best surface finish and dimensions of products.

Turning is the most common machining process in metal cutting industry. Turning is especially used in manufacturing industries for producing cylindrical parts to required specifications in dimensions and surface finish. Many turning processes can involve cutting speeds as low as a few centimeters per second to as high as 1000m/s and depths of cut as low as less than one millimeter to as much as over 10mm and feed rates as low as less than one millimeter to as high as over 5mm/rev [4, 5, 6]. This wide range of machining conditions make it difficult for many machinists and engineers to know the best values of the cutting variables at which to operate with given materials and tool types to achieve requisite product types and qualities in the shortest possible time, and to resolve to trial and error approaches during machining process in

producing the target components or parts. However, in our volatile and fiercely competitive product requirements, traditional trial-and-error alone is no longer sufficient in choosing such wide range of cutting variables to meet the challenges of optimal MRR and other machining requirements. It is much economical and faster for the machinist or engineer to just select from available experimentally established machining conditions for given machinable materials that will yield optimal productivity and quality of products.

The mostly used material in turning operations is low carbon steel due to its outstanding usage as a structural material in engineering and good machinability properties [1, 7]. However, no two different types of steel are equally machinable. The machinability of steel is greatly determined by many factors, such as the feed rates, cutting speeds, depths of cut, the choice of cutting fluid, cutting tool material; and properties of the steel type such as its chemical composition, strength or hardness, and ductility level [8]. The AISI 1029 steel, which is also designated as UNS G10290, ASTM A29, ASTM A510, ASTM A576, SAE J403, and SAE J412 is a carbon steel type that is on the boundary between low and medium carbon steels. This steel type is resistant to heat and stress corrosion and maintains high strength at elevated temperatures. The AISI 1029 steel is a suitable material for marine engineering, chemical processing plants, furnaces and gas turbines, boilers and pressure vessels, and nuclear power plants. The steel type is also used for the manufacture of forged components that are subjected to low stresses, for automotive and general engineering. This type of steel frequently requires turning processes to produce components or parts such as bolts, nuts, washers, threaded rods, studs, stud bolts, and other fasteners to desired accuracy specifications for various engineering applications [9, 10]. Application of optimization techniques in turning processes with AISI 1029 carbon steel is a strategic way of increasing machining productivity and quality of products with the steel at reduced cost.

Taguchi's optimization method can be easily used rather than using any other conventional methods in modern day engineering approaches and other fields to find the required optimal output parameter over a set of given inputs [11, 12, 13]. Application of Taguchi's method to optimize MRR as a measure of machining productivity involves selecting the MRR solution over the set of given input cutting speed, feed rate, and depth of cutting variables that will reduce cost and increase quality. The so-obtained optimal MRR is least affected by any outside disturbances such as the noise and other environmental conditions. Taguchi's method has wide variety of applications in different fields of human activities because of its easiness to use to optimize target parameters against input variables. The method is a great quality control approach used in product design and development in engineering for reducing occurrence of defects and failures in manufactured products [14]. However, in as much as the method has a lot of advantages; the major setback in the method is that results obtained from it are only relative to the levels of the selected input variables and do not exactly indicate the effect of entire range of each variable on the performance characteristic value. The method also does not test the output for all possible combinations of input variables as the combination of the selected inputs is limited [14].

The aim of this paper is to exemplify the use of Taguchi's method in determining some cutting variables for optimal MRR to improve productivity in orthogonal dry turning of AISI 1029 carbon steel on the lathe with carbide insert tools under various selectable sets of cutting conditions.

II. MATERIALS AND METHODOLOGY

A. Materials

The material used in carrying out this research work was AISI 1029 steel. The material was obtained in rod form of diameter 79.6mm and length 2000mm from Hartzog Nig. limited at Kakuri in Kaduna metropolis, Nigeria. The information regarding the carbon content and other constituent elements present in the metal were not provided at the point of sale but with words from the seller that the material was the AISI 1029 carbon steel.

1. Ascertainment of the procured AISI 1029 steel

The chemical composition of the procured AISI 1029 carbon steel was determined using the handheld S1 TITAN 500 Alloy Analyzer. The analyses showed the steel was indeed an AISI carbon steel with 0.3%-C, 0.10%-Si, 0.790%-Mn, 0.040%-P, 0.050%S, and 98.72%-Fe contents by cross-checking with the AISI standard specifications of 0.25-0.31%-C, 0.07-0.6%-Si, 0.6-0.9%-Mn, 0.0-0.040%-P, 0.0-0.050%S, and 98.7-99.15%-Fe for the steel [9, 10]. Other basic properties of AISI 1029 steel that make it a distinct machinable material as obtained from the literatures are given in Table 1 [9, 10].

Table 1: Basic mechanical and physical properties of AISI 1029 steel [9, 10]

Property	Value
Density	7850kg/m ³
Ultimate Tensile Strength at room temperature	992.85MPa
Yield Strength at 0.2% offset at room temperature	579.16MPa
Brinell Hardness Number (BHN)	145
Young's modulus	190-210GPa
Poisson ratio	0.27-0.3
Elongation	44%

2. Cutting tool specifications

Unused tungsten carbide cutting tool inserts of ISO – CNMG 12 04 08-QM specifications were used with a single point cutting tool of inscribed circle diameter (IC) = 12.7mm, cutting edge effective length (LE) = 12.7mm, corner radius (RE) = 0.794mm, insert thickness = 4.763mm, grade = 25, and clearance angle = 0 degree for the turning machining. The inserts were available in the Department of Mechanical Engineering, Nigerian Defence Academy workshop where the study turning experiments were conducted

B. Methodology

1. Experimental design

Machining variables of 125, 250, and 500-mm/min cutting speeds; 0.1, 0.2, and 0.3-mm/rev feed rates; and 0.5, 1, and 1.5-mm depths of cut were chosen, and each variable was designed to have three levels, denoted as L1, L2, and L3 as shown in Table 2 with MRR as the response factor. The experimental design was according to Taguchi's L-9 Latin squares orthogonal arrays The Taguchi orthogonal array shown in Table 3 provided the number of experiments to be carried out.

Table 2: Turning process variables with their values at 3 levels

Variable	Levels		
	L1	L2	L3
Cutting Speed (mm/min)	125	250	500
Feed Rate (mm/rev)	0.1	0.2	0.3
Depth of Cut (mm)	0.5	1.0	1.5

Table 3: Coded and actual experimental process design variables using Taguchi's L-9 design with 3 levels and 3 factors

Experiment No	Coded process variable			Actual process variable		
	Cutting speed (mm/min)	Feed rate (mm/rev)	Depth of cut (mm)	Cutting speed (mm/min)	Feed rate (mm/rev)	Depth of cut (mm)
1	1	1	1	25	0.1	0.5
2	1	2	2	125	0.2	1.0
3	1	3	3	125	0.3	1.5
4	2	1	2	250	0.1	1.0
5	2	2	3	250	0.2	1.5
6	2	3	1	250	0.3	0.5
7	3	1	3	500	0.1	1.5
8	3	2	1	500	0.2	0.5
9	3	3	2	500	0.3	1.0

2. The turning experimentation

Orthogonal turning of AISI 1029 steel was conducted on the XL 400 lathe using a single point cutting tool. The cutting tool used in the study was inserted with CNMG 12 04 08-QM 425 standard carbide inserts with four cutting edges. The work-piece was of length 200mm and diameter 79.6mm. One end of the work-piece was rigidly fixed in the chuck of the lathe and its other end supported by the tail stock. The cutting tool shank was firmly clamped on the tool holder. The lathe was set to the selected set of cutting speed, feed rate and depth of cut according to the experimental design with Taguchi's L-9 orthogonal arrays shown in Table 3. The work-piece was first faced to prepare it for length accuracy requirement in the



turning operation. For each experimental array, the appropriately selected cutting speed, feed rate and depth of cut were used to conduct turning process under dry condition with the lathe switched on in operation. The machined length for each experiment was 140mm. For uniformity in the experimental conditions, one insert cutting edge was used for each set of experiment and the insert replaced with new ones after all the four insert edges had been used in the turning operations. For each set of cutting variable as per Table 3, the MRR was evaluated in cubic centimeters (cc) using equation 1 given as.

$$MRR = f \cdot d \cdot v \dots \dots \dots (1)$$

Where f was the feed rate in mm/rev, d the depth of cut in mm, and v the cutting speed in m/min of the turning operation.

The cutting speed was evaluated by equation 2 given as,

$$v = \frac{\pi DN}{1000} \dots \dots \dots (2)$$

Where, D was the diameter of the work-piece in millimeters (79.6mm), and N the spindle speed in revolutions per minute (rpm). The experimentation was conducted using the cutting speeds of 125, 250, and 500m/min at spindle speeds of 500, 1000, and 2000rpm respectively.

The collated input cutting variables and the response MRR values obtained from the turning process were analyzed with the Minitab-17 software using generated Signal-to-Noise ratio ($\frac{S}{N}$), main effect plots, contour plots, surface plots, and analysis of variance by imbibing Taguchi’s concept of the ‘Larger-the-Better’ according to equation 3 [15].

$$\frac{S}{N} = -10 \log_{10} \left[\frac{1}{n} \sum \frac{1}{y^2} \right] \dots \dots \dots (3)$$

Where, y was the measured value of MRR, and n was the number of measurements.

The relative importance for each turning variable was also given in the order of its percentage contribution in the turning process by analysis of variance (ANOVA) using the Minitab-17 software at a level of significance $\alpha = 0.5$, that is at 95% confidence level.. After data analysis to determine optimum cutting condition for MRR, a confirmation experiment was carried out using the set of cutting variables for optimum MRR obtained from the analysis. Results obtained from the Minitab-17 generated regression equation using the Minitab-17 software was compared with the results obtained from the confirmation experiment.

III. RESULTS

Results of the experimentally determined MRRs on the XL 400 lathe are shown in Table 4. Results of Signal to Noise ratio, main effects for MRR as obtained with Minitab17 software are presented in Table 5, and Fig.1 respectively. The contour plots of the MRR for various cutting speed, depth of cut, and feed rate variations using the Minitab-17 software are presented in Figs. 2a, 2b, and 2c respectively. The displayed results of the surface plots for MRR by varying the cutting speed and feed rate, cutting speed and depth of cut, and depth of cut and feed rate as obtained using Minitab-17 software are shown in Figs, 3a, 3b, and 3c respectively. Results of the analysis of variance (ANOVA) are presented in Table 6 while that of the confirmation test is in Table 7.

Table 4: Experimentally determined MRR

Run	Cutting speed (m/min)	Feed rate (mm/rev)	Depth of cut (mm)	MRR (cc/min)
1	125	0.1	0.5	6.25
2	125	0.2	1.0	25.00
3	125	0.3	1.5	56.25
4	250	0.1	1.0	25.00
5	250	0.2	1.5	75.00
6	250	0.3	0.5	37.50
7	500	0.1	1.5	75.00
8	500	0.2	0.5	50.00
9	500	0.3	1.0	150.00



Table 5: Signal to Noise ratio for the MRR

Run	MRR (cc/min)	Signal to Noise Ratio
1	6.25	15.9176
2	25.00	27.9588
3	56.25	35.0025
4	25.00	27.9588
5	75.00	37.5012
6	37.50	31.4806
7	75.00	37.5012
8	50.00	33.9794
9	150.00	43.5218

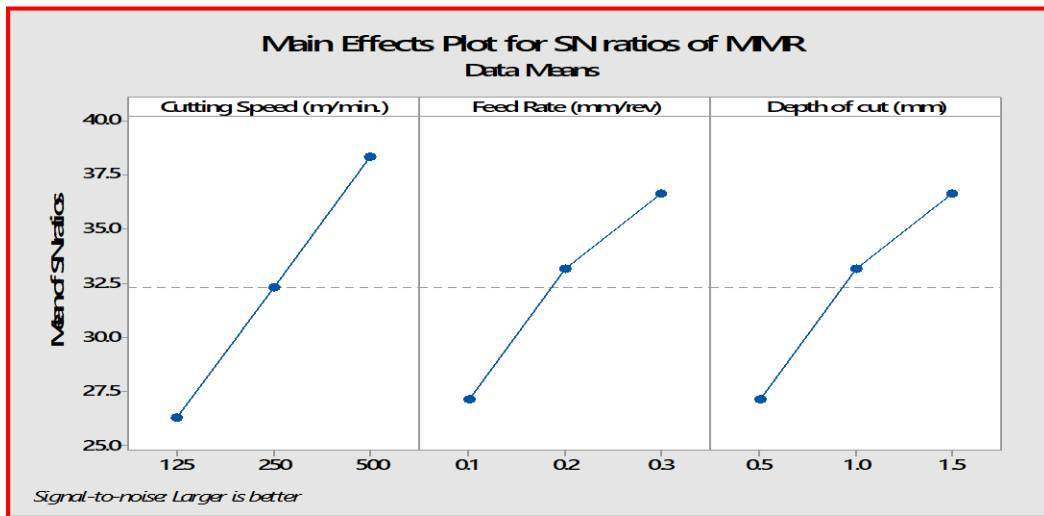


Fig 1 Main effect plots for MRR

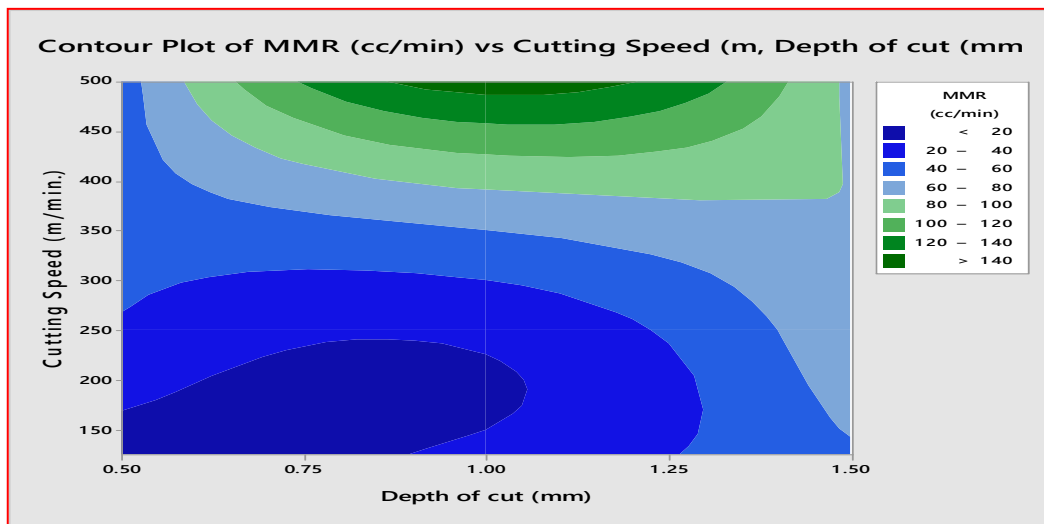


Fig. 2a: Contour plots of MRR as obtained by varying cutting speed and depth of cut

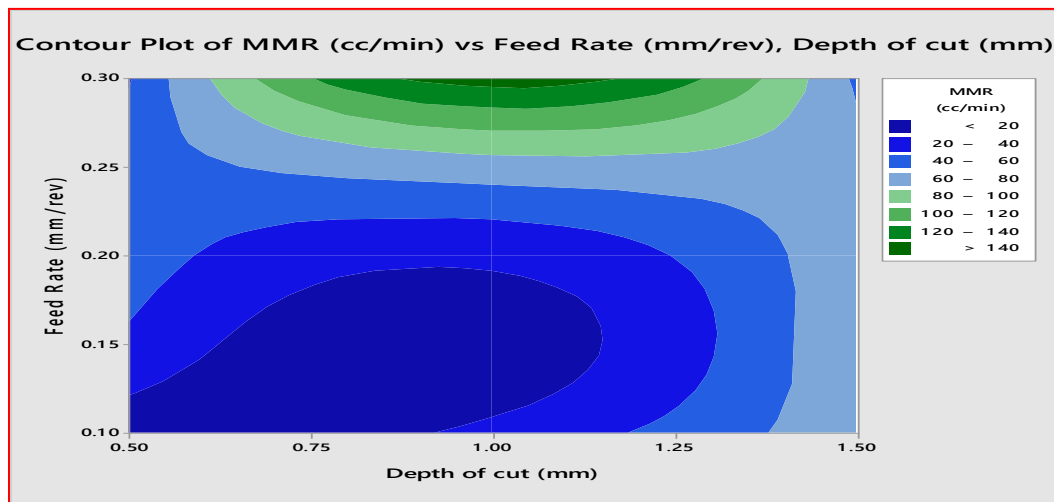


Fig. 2b: Contour plot of MRR as obtained by varying the feed rate and depth of cut

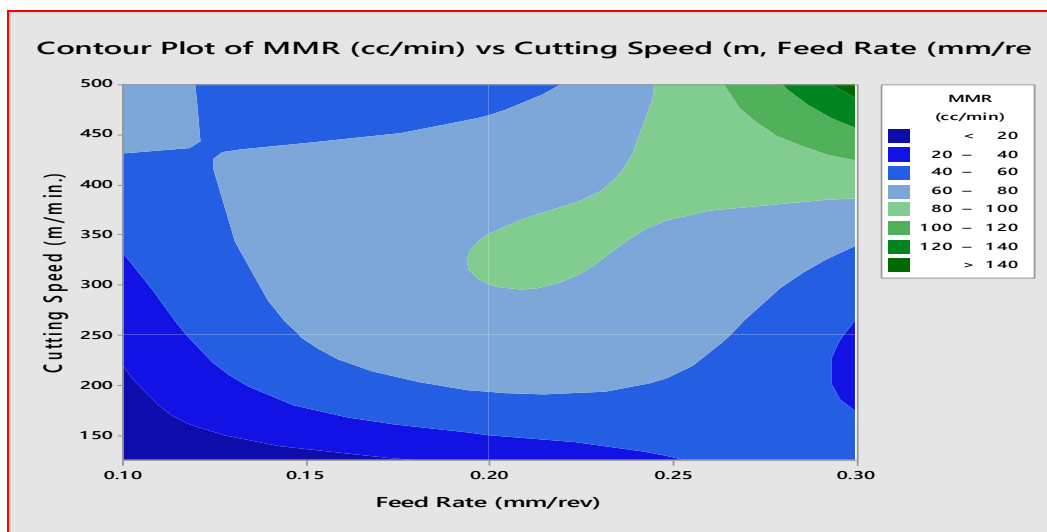


Fig. 2c: Contour plots of MRR (cc/min) as obtained by varying cutting speed and feed rate

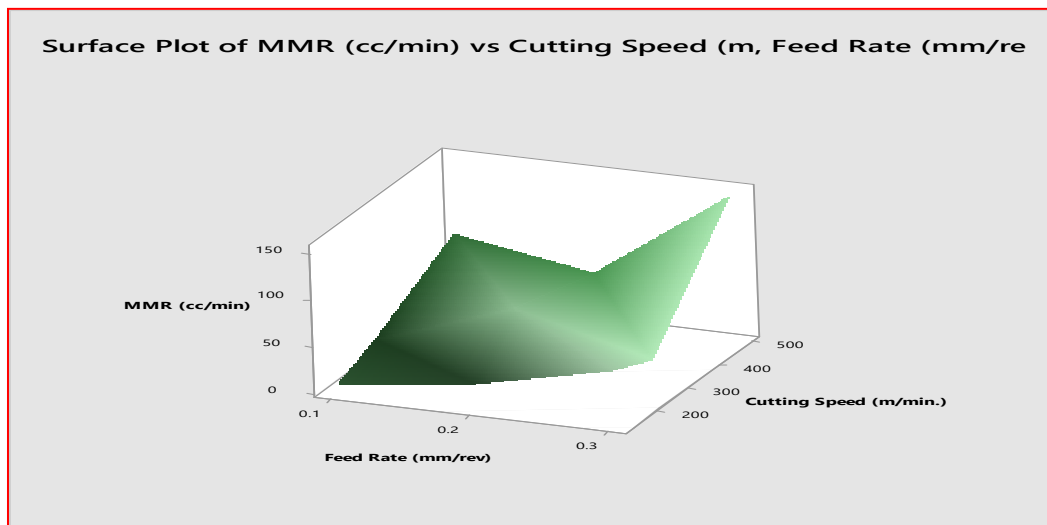


Fig. 3a: Surface plots for MRR as obtained by varying the cutting speed and feed rate

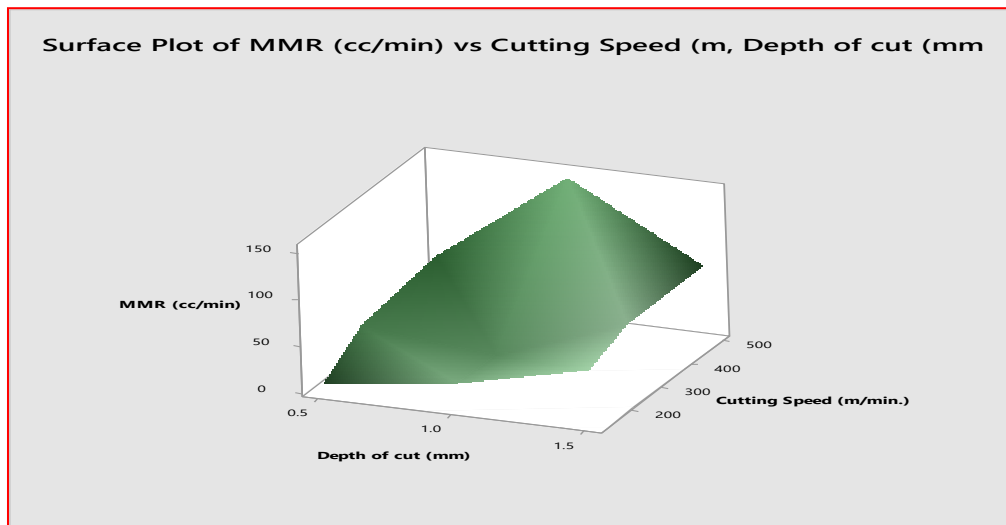


Fig. 3b: Surface plots for MRR as obtained by varying the cutting speed and depth of cut

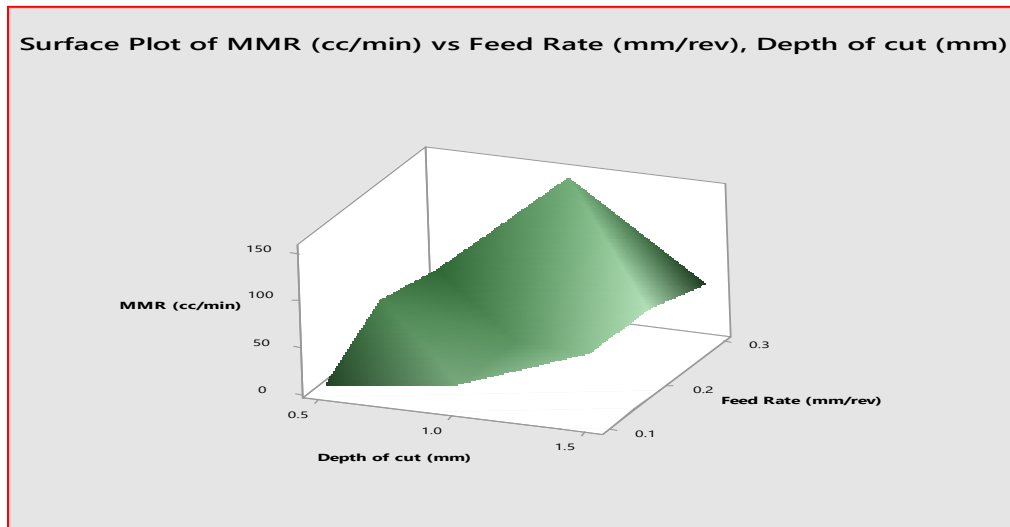


Fig.3c: Surface plots for MRR as obtained by varying the depth of cut and feed rate

Table 6: ANOVA for MRR

Factor	DOF	SS	MS	F	P
Cutting speed	2	6521	6251.2	6.80	22.0033
Feed rate	2	3151	3151.0	11.08	45.634
Depth of cut	2	2109	2109.4	5.59	23.0234
Error	2	2820	564.0	3.74	9.229
Total	8	14332	12 075.6	27.21	1.00

SS = sum of squares, DOF = degree of freedom of overall data, MS = mean square, F = The Minitab-evaluated degree freedom, and P = percentage contribution values

Table 7: Confirmation test

Parameter	Estimated value	Experimental Value	Percentage error (%)
MRR (cc/min)	222.41	225	1.2

Discussion of Results

From the results presented in Table 4; it can be seen that the metal removal rate increases with increase in all cutting conditions of cutting speed, feed rate, and depth of cut of the dry turning operation on the lathe. This trend of behavior was also observed by Guma [1] in non-circular boring on the engine lathe.

From results of the Minitab-17 generated Signal to Noise ratios under various runs of the experiment presented in Table.5, it can be seen that, the third level of experiment that is run 9 gives the highest Signal to Noise ratio of 43.5218 for the MRR. On the basis of Taguchi’s concept of the Larger the Better which applies to MRR; this Signal to Noise ratio corresponds to 500-m/min cutting speed, 1.5-mm depth cut, and 0.3-mm/rev as can be seen in Table 4.

From results of the main effects plots presented in Fig.1, it is evident that the 500-m/min cutting speed, 1.5-mm depth of cut, and 0.3-mm/rev feed rate gave the highest Signal to Noise ratios for the cutting speed, depth of cut, and feed rate variations respectively. Therefore by the main effect plots analysis of the MRR, the cutting conditions for optimal MRR are 500-m/min cutting speed, 1.5-mm depth of cut, and 0.3-mm/rev feed rate. This is seen to correlate well with analysis of results from Table 5.

The empirically generated regression equation for metal removal rate (MRR) using the Minitab-17 is given by equation 1 as.

$$MRR = -77.1 + 0.1690CS + 229.2FR + 97.5DOC \dots \dots \dots (1)$$

Where; *CS* was the cutting speed, *FR* was the feed rate, and *DOC* was the depth of cut.

Substitution of values of the cutting variables for optimal MRR as obtained from analyses of results in Table 5 and main effect plot for MRR in Fig 1 into equation 1, gave;

$$MRR = -77.1 + 0.1690(500) + 229.2(0.3) + 37.5(1.5) = 222.41\text{cc/min, as the optimal value.}$$

Fig 2a shows that for maximum MRR which must exceed 140cc/min, the depth of cut has to range from about 0.9 to 1.1mm and feed rate from about 0.29 to 0.3mm/rev as can be observed from Fig. 2a. On the other hand, Fig 2b shows that for maximum MRR which must be greater than 140cc/min, the depth of cut must range from about 0.9 to 1.1mm and cutting speed from 400 to 500m/min. Finally, Fig 2c shows that for maximum MRR, which should be at least 140cc/min, the feed rate must range from about 0.29 to 0.3mm/rev and cutting speed from 400 to 500m/min.

Fig 3a shows that the surface's peak point corresponds with the highest MRR value and the predictor values are 0.3mm/rev for feed rate, and 500m/min for cutting speed. Fig. 3b shows that the surface's peak point corresponds with the highest MRR value and the predictor values are 500-m/min cutting speed, and 1.0-mm depth cut. Fig. 3c shows that the surface peak plot corresponds with the highest MRR value and the predictor values are 1.0mm for depth of cut and 0.3mm/rev for feed rate.

From the ANOVA result for MRR with Minitab 17 presented in Table 6, it can be seen that the feed rate has the highest effect on the MRR. Feed rate with cutting speed and depth of cut have much greater effect on MRR. At 90.7% confidence level, the percentage contributions of cutting speed, feed rate, and depth of cut to MRR in the turning operation were 22.0033%, 45.634% and 23.0234% respectively.

Confirmation tests were conducted to verify the estimated result against experimental value. From the confirmation test for the optimal MRR presented in Table 7, it is evident that the estimated value of MRR using equation 1 was 222.41cc/min against the 225cc/min value obtained by experimentation. This depicted the experimental value in error by only 1.2% as can be seen from Table 7. The confirmation tests and percentage errors revealed accuracy of the performed turning experiment at 95% confidence level.

IV. CONCLUSION

- [1]. An experimental study of cutting variables in orthogonal turning of AISI 1029 steel on XL 400 lathe under dry condition within the scope of 125, 250, and 500-m/min cutting speeds; 0.1, 0.2, and 0.3-mm/rev feed rates; and 0.5, 1, and 1.5-mm depths of cut using Taguchi's method has been conducted. The study results show that: 500-m/min cutting speed, 1.5-mm depth of cut, and 0.3-mm/rev feed rate were conditions for optimal MRR in the turning operation. Feed rate had the highest contribution of 45.634%, followed by depth of cut with 23.0234%, and cutting speed with 22.0033% in the MRR. Confirmation test at optimal conditions indicated 225-cc/min MRR against the 222.41-cc/min value obtained from the Minitab-17 predictive regression equation. This put the experimental value in error by only 1.2%. In totality, all the confirmation tests and percentage errors revealed accuracy of the performed turning experiment at 95% confidence level. The work exemplifies how Taguchi's method can be similarly employed using any other selectable 3 level 3 factor cutting conditions on the lathe for determination of cutting conditions for optimal MRR in dry-turning of AISI 1029 carbon steel to improve the machining productivity.

REFERENCES

1. Guma, T.N. (1990). Non-Circular Boring on the Lathe Using Chain Drive for Power Transmission, M,Sc Thesis, Department of Mechanical Engineering, Ahmadu Bello University, Zaria.
2. Nalbant, M., Gokkaya, H., and Sur, G. (2007). Application of Taguchi method in the optimization of cutting parameters for surface roughness in turning. *Materials and Design*, 28(4), pp. 1379-1385 DOI: [10.1016/j.matdes.2006.01.008](https://doi.org/10.1016/j.matdes.2006.01.008)
3. Shaw, M.C. (2005). *Metal Cutting Principles*, Oxford Science Publishers, pp. 170 – 175.
4. Guma, T.N. (2009). Surface Finish Analysis of Non-circular Bores Produced on the Lathe Using a Servo-controlled Attachment. *International Journal of Science and Technological Research*, Development Universal Consortia, Ikot Ekpene, Nigeria, 6(1&2). pp. 94-106.
5. Guma, T.N. (2010). Applicable Technique for Dimensional and Form Accuracy of Non-circular Bores Produced on the Lathe Using a Servo-Controlled Attachment. *Journal of Science and Technology Research*, International Research and Development Institute (IRDI), Uyo, 9(2), pp. 71-75.
6. Sahoo, P. (2011). Optimization of Turning Parameters for Surface Roughness using RSM and GA. *Advances in Production Engineering and Management*, 6, pp. 197 – 208.



7. Wakjira, M.W., Altenbach, H., and Perumalla, J.R. (2019). Analysis of CSN 12050 Carbon Steel in Dry Turning Process for Product Sustainability Optimization Using Taguchi Technique. Journal of Engineering, Vol. 2019, Article ID 7150157, 10 pages, 2019. <https://doi.org/10.1155/2019/7150157>
8. Abu, J. O. (2000). Comparative Machinability Evaluation of Heat Treated Carbon Steels. Ph.D Dissertation Submitted to the Department of Mechanical Engineering, Ahmadu Bello University, Zaria.
9. AZO Materials. AISI 1029 Carbon Steel (UNS G10290). Available at: [https://www.azom.com/article.aspx?ArticleID = 6530](https://www.azom.com/article.aspx?ArticleID=6530). Accessed 29/9/2020
10. Medium Carbon Steel AISI 1029-Boltport Fastener. Available at: <https://boltport.com/materials/medium-carbon-steel/aisi-1029/> Accessed 12/8/2020
11. Ajay Mishra Evaluation of the Impact of Taguchi Methods on Product Process Parameters Optimization. Shodhganga: A Reservoir of Indian Theses @ INFLIBNET. Available at: <http://hdl.handle.net/10603/89659> Accessed 23/7/2020.
12. Dehnad, K. (1989) A Geometric Interpretation of Taguchi's Signal to Noise Ratio. In: Dehnad K. (eds) Quality Control, Robust Design, and the Taguchi Method. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-1472-1_13
13. Davim, J. P. (2003). Design of Optimization of Cutting Parameters for Turning Metal Matrix Composites Based on the Orthogonal Arrays. Journal of Material Process Technology, 132, pp.340-344.
14. Mukherjee, S., Kamal, A., and Kumar, K. (2014). Optimization of Material Removal Rate During Turning of SAE 1020 Material in CNC Lathe using Taguchi Technique, Procedia Engineering, 97, 29-35. <https://doi.org/10.1016/j.proeng.2014.12.221>
15. Mgbemena, C., Mgbemena, C., Etebenumeh, G., and Ashiedu, F. (2016). Effect of Turning Parameters on Metal Removal and Tool Wear Rates of AISI 1018 Low Carbon Steel. Nigerian Journal of Technology (NIJOTECH) Vol. 35, No. 4, pp. 847-854.



INNO  **SPACE**
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details