Al-Qadisiyah Journal for Engineering Sciences 16 (2023) 096–101

Contents lists available at http://qu.edu.iq

Al-Qadisiyah Journal for Engineering Sciences

Journal homepage: https://qjes.qu.edu.iq

Influence of cutting parameter on surface quality in dry turning of different materials

Zainab Hussein Mohsein*, *Ahmed Basil Abdulwahhab* *, and *Diana Abed Alkareem Noori

Production and Metallurgy Engineering Department, University of Technology, Baghdad, Iraq

ARTICLE INFO

Article history:
Received 15 December 2022
Received in revised form 26 January 2023
Accepted 29 April 2023

Keywords:
Surface Roughens
Cutting Condition
Feed Rate
Dry Turning
DOC

ABSTRACT

In machining operations, surface roughness (Ra) is an essential measure of product quality. It is determined by the cutting settings. The parameters that have been worked on are the Feed (F) (0.72, 0.88, 0.96, 1.12 mm/min), depth of cut (DOC) (0.5mm), and spindle speed (N) (545, 710, 1000, 1400 rpm). Three types of ferrous metals were employed in this study low-carbon steel St 3, medium-carbon steel St 45, and high-carbon steel Y8. According to the data, the optimal operating condition for obtaining the best surface roughness is 1.119 µm for low-carbon steel. St 3 from the product is by employing the following cutting settings for the cutter (feed 0.72 = mm/rev), (DOC= 0.5mm), and (machine speed =1400 rpm). But when using the cutting variables (feed 1.12 = mm/rev), (DOC = 0.5mm), and (machine speed = 545 rpm) for high-carbon steel Y8, gives the highest surface roughness is 4.999 µm. The experimental findings indicate that the surface roughness of turned components is considerably affected by cutting settings and machine equipment. According to the results of this study, increasing spindle speed lowered the Ra of the turned components, but rising feed increased the surface roughness. The value acquired by this approach will benefit other researchers for future work on tool vibrations, cutting forces, and so on.

1. Introduction

In turning operations, surface roughness is an essential criterion for numerous turned components. In terms of quality, among the many important considerations is the geometry of the machined surface. Surface roughness is defined as the variations in height on the machined surface, and it is usually measured in microns. Usually, surface roughness was used to characterize surface quality. Surface roughness is a significant component that must be evaluated not just in traditional tribology disciplines like corrosion, friction, and lubricants but also in domains like sealing, hydrodynamics, and electrical and thermal conductivity. During machining operation, cutting conditions like cutting speed (Vc), feed rate, and a consistent DOC have the greatest effect on the final roughness of the surface. The Ra will rise if these parameters are not selected conveniently. Notch effects lead to fracture initiation, decreased fatigue strength, and decreased corrosion resistance due to this condition. As a result, the characterization and assessment of the roughness of surfaces are crucial in machining operation optimization [1][2]. Surface roughness as a function of turning parameters was studied by a number of authors across a range of materials.

Kassab and Khoshnaw [3] investigated the vibration of the cutting tool and Ra quality, for the turning operation the Vc, DOC, F, and tool overhang were the process variables examined. Experiments were conducted utilizing a lathe and turning (no cutting fluid) operation on medium carbon steel, with varying levels of the mentioned process parameters.

* *Corresponding author.*
E-mail address: ahmed.b.abdulwahhab@uotechnology.edu.iq (Ahmed Basil Abdulwahhab)

https://doi.org/10.30772/qjes.v16i2.850

Nomenclature:

Ra	Surface roughness (µm)
Vc	Cutting speed (m/min)
F	Feed rate (mm/rev)
DOC	Depth of cut (mm)
N	Spindle speed (r.p.m)

In order to regulate the surface quality of the manufactured products, the authors established a strong relationship between the vibration of the cutting tool and the roughness of the surface. Acceleration of the cutting tool was found to have the greatest effect on the workpiece's surface roughness; acceleration increased with cutting tool overhang. Increases in feed rate were observed to enhance the roughness of the surface.

Regression modeling was developed by Thamma [4] to determine the best set of turning operation process parameters for aluminum 6061 workpieces. The findings of the research showed how significantly the speed of cutting, radius of the nose, and feed rate influenced Ra. When the speed of cutting, the radius of the nose, and the feed rate are optimized, smoother surfaces may be machined. Mia M et al. [5] Predictions of surface roughness were made using an artificial neural network (ANN) to turn AISI 1060 steel. The Bayesian regularization approach was used to train the NN model, which was then used to provide surface roughness predictions. Feed rate and lubricant flow rate were discovered to have an effect on the Ra. In order to regulate the surface quality of the manufactured products, the authors established a strong relationship between the vibration of the tool and the roughness of the surface. The acceleration of the cutting tool was found to have the greatest influence on the workpiece's Ra; acceleration increased with the tool overhang. Increases in feed were observed to enhance surface roughness.

The model established by Vikas B. Magdum [6] which incorporates the effect of the speed of the spindle, feed rate, the amounts to which h decreases t, and any two variable interactions, has an accuracy of 91.91 percent. This research facilitates the understanding and optimization of these factors on the quality of the surface machined surfaces during dry turning. P. Kumar et al. [7] performed some experiments on the (AISI H13) as a workpiece by using different tools of (CBN grades). They discovered that work material hardness, speed of cut, and (F) were the most significant factors on (Ra) and forces of cut. In addition, the (CBN10 grade) has also been found to be superior to the (CBN600) and (CBN BNC300 grades).

Machining characteristics of Inconel 718 alloy during turning with PVD coated carbide insert have been reported by Vinothkumar et al. [8] Under dry and atomic spray cutting fluid conditions, They found that, compared to dry methods, tool wear was decreased by roughly 17–34% when using the ASCF approach, and the surface quality was much better. The lubricating effect at the tool contact was cited as the cause of these decreases.

S. Padhan, et al. [9] have investigated how austenitic stainless steel Nitronic 60 performed when it was turned in a dry, compressed air-cooled, flooded, and hardly lubricated machining environment. While SiAlON turned the steel, the wear of the tool, cutting force, cutting temperature, and Ra was measured. They reached the conclusion that MQL technique increased and improved the machining surface quality of their machines. Ra and force of cut decreased as cutting speed increased, but force, surface roughness, and temperature increased as the feed rate increased. Tool wear nevertheless decreased.

The purpose of this investigation is to analyse experimentally the impact of parameters of the machining on the Ra in turning processes in order to create the ideal settings of these parameters to improve the roughness in turning processes.

Abbas F. Ibrahim [10] examines the relationship between surface roughness and process variables (approach angle, tip radius, cutting speed, and feed rate) in a lathe. The tests were carried out using Taguchi's L8 vertical matrix to be evaluated with contrast analysis and signal-to-noise ratio. According to this, it is noted that the surface roughness correlates negatively with the front half of the cutting edge and positively with the approach angle. The analysis of variance revealed that feeding rate was the most important of the variables that affected the least surface roughness, followed by cutting speed, the radius of the front of the cutting edge, and finally the approach angle. Khalid A. Al-Dolaimy [11] conducted practical experiments to find out the effect of cutting conditions on the surface roughness in the machining process in order to determine the optimal settings for these factors to improve the surface roughness in the machining process. The surface roughness of the steel samples was measured after the machining process, which was carried out on a traditional lathe machine and on another machine CNC, using a carbide cutting tool at different cutting conditions such as cutting speed, cutting depth, feeding, and the use of cooling fluids. The results showed that the surface roughness of the samples resulting from the turning process decreased with increasing cutting speed and feeding are reduced when using coolant.

Haider M. Mohammad and Roaa Hameed Ibrahim [12] study the effect of cutting speed and feed rate on the surface roughness of the workpiece and temperature of the cutting tool by predicting mathematical equations, which depend on the practical results during the turning process. These mathematical models were used to study the surface roughness behaviour, which was using (LAB-Fit Data) program. The experiments were carried out on a piece of steel, which is used in many applications due to its ease of machining with AISI 1045 carbon control turning lathe computer and the experiments were carried out without the use of coolant. The results showed that the surface roughness decreases with increasing the cutting speed with the increase in the feed rate, and it is also observed that the temperature of the cutting tool increases with the increase of each speed cutting and feeding rate. Abdullah F. Huayier [13] use the Taguchi experience design technique to analyze the impact of various variables on the surface roughness of (AL-2024) using a computer numerically controlled (CNC) milling machine and a high-speed steel (HSS) tool equipped with a flat-end milling cutter. There are two stages to the cutting procedure: the first involves coolant and dry cutting in the upward cutting direction. The second step involves using coolant and dry cutting techniques while proceeding in the lower direction of the cut. The results demonstrate the optimal working conditions for bottom grinding to achieve the lowest product surface roughness.

Using a CNC Milling machine, Sutar and Gujar [14] conducted research to determine how factors such as cutting speed, feed rate, depth of cut (DOC), and the kinds of coolant affected the surface roughness of stainless steel. It was discovered that the kind of coolant is the most critical parameter among these factors. This was followed by the cutting speed, the feed rate, and the DOC.

2. Experimental method and materials

Experiments were carried out utilizing a turning machine (TOS TRENCLN), model at the University of Technology, as seen in Fig. 1, the speed range n = (14-2800 rpm) with variable speeds of spindle and different feed rates for three materials. Three distinct types of ferrous metals (Low carbon steel.St03, Medium carbon steel St 45, High carbon steel.Y8) were employed, each having the same parameters of 30 cm (length) 40 mm (diameter) 0.5 mm (depth of cut), the materials specifications are shown in Table 1, 2 and 3. It was examined at State Company for engineering rehabilitation and testing with a temperature of (25C°) and a moisture length percentage of (23%). The test specimens (the rod bars) are shown in Fig.2.

Figure 1. Model of a turning machine.

Table 1. Chemical structure of steel 45 material

Material	Cr	S%	P	Mn	Si	C
Weight (%)	0.130	0.0238	0.0132	0.640	0.331	0.555
Material	V	Al	Ni	Mo	Cu	Fe
Weight (%)	0.174	0.0011	0.063	0.0657	0.0119	Balance*

Table 2. Chemical structure of steel 03 material

Material	Cr	S%	P	Mn	Si	C
Weight (%)	5.25	0.0083	0.0085	0.256	1.09	0.313
Material	V	Al	Ni	Mo	Cu	Fe
Weight (%)	0.0857	0.355	0.0259	0.0862	1.24	Balance*

Table 3. Chemical structure of steel Y8 material

Material	Cr	S%	P	Mn	Si	C
Weight (%)	5.23	0.0099	0.0089	0.254	0.108	0.313
Material	V	Al	Ni	Mo	Cu	Fe
Weight (%)	0.0842	0.353	0.0158	0.0884	1.24	Balance*

Figure 2. Depicts the finished product of operations performed on the workpiece.

3. Selecting the proper cutting conditions

The success of the turning operation is governed by the impacts of the surface layer and by the selection of three factors of cutting parameters, namely speed of cut, feed rate, and three distinct materials (of varying hardness) at the same 0.5mm depth of cut:

- Speed of Cut, Vc = 68.48, 89.22, 125.66, and 175.92 m/min.
- Feed rate, f = 0.72, 0.88, 0.96, 1.12 mm/rev.
- Depth of cut, DOC = 0.5 mm.

The roughness of surfaces is a prevalent problem in the products. During production, subtle variations in the surface texture might arise. To assess surface roughness, a product surface roughness (Ra) tester of the "Mar Surf PS1" from the United States, illustrated in Fig. 3, the value of Ra was calculated three times after machining in different positions, and then the mean was determined. The average results were used as a representation of the machined surface's roughness (Ra) [15]. With parameters stated in Table 4.

Figure 3. Surface roughness measurement instrument.

Table 4. Contains the specifications of the (Mar Surf PSI).

Range	0.03 µm to 12.7µm	0.03 µm to 12.7µm
Head of the probe	20µm	20µm
Travel length	1.75-5.6 mm, 17.5 mm	1.75-5.6 mm, 17.5 mm

4. Results and discussion

Results of the roughness measurement equipment on three materials with the same diameter (40 mm), length (30 cm), and feed depth of cut (0.5 mm) were examined. Four different rotational speeds (545, 710, 1000, 1400 rpm) were selected on the lathe machine and converted into a linear speed (68.48, 89.22, 125.66, 175.92 m/min) through the cutting speed law Vc= (π D N) /1000 [16]. Which will be shown in the next tables (5, 6, and 7).

Table 5. Machining conditions used in the experiments for steel 03

Exp.	Cutting depth (mm)	speed of cut (m/min)	Feed rate (mm/rev)	Surface Roughness (µm)
1	0.5	68.48	0.72	3.559
			0.88	3.611
			0.96	3.912
			1.12	4.188
2	0.5	89.22	0.72	2.677
			0.88	2.914
			0.96	3.271
			1.12	3.540
3	0.5	125.66	0.72	2.428
			0.88	2.508
			0.96	3.093
			1.12	3.163
4	0.5	175.92	0.72	1.119
			0.88	2.210
			0.96	2.570
			1.12	2.873

Table 6. Machining conditions used in the experiments for steel 45

Exp.	Cutting depth (mm)	speed of cut (m/min)	Feed rate (mm/rev)	Surface Roughness (µm)
1	0.5	68.48	0.72	2.990
			0.88	3.077
			0.96	3.563
			1.12	3.899
2	0.5	89.22	0.72	2.447
			0.88	2.647
			0.96	2.799
			1.12	2.979
3	0.5	125.66	0.72	2.252
			0.88	2.332
			0.96	2.508
			1.12	2.934
4	0.5	175.92	0.72	1.939
			0.88	2.016
			0.96	2.683
			1.12	2.867

Table 7. Machining conditions used in the experiments for y8 steel

Exp.	Cutting depth (mm)	speed of cut (m/min)	Feed rate (mm/rev)	Surface Roughness (µm)
1	0.5	68.48	0.72	3.073
			0.88	3.823
			0.96	4.507
			1.12	4.999
2	0.5	89.22	0.72	2.242
			0.88	2.331
			0.96	2.841
			1.12	3.047
3	0.5	125.66	0.72	2.511
			0.88	2.762
			0.96	2.888
			1.12	3.084
4	0.5	175.92	0.72	2.277
			0.88	2.623
			0.96	2.759
			1.12	2.933

4.1. Variable feed rate and its impact on the surface roughness

Figures (4, 5, and 6) indicate the average surface roughness increases with an increase in feed rate at a constant speed of cut. The best Ra is measured in the machining surfaces using the following cutting conditions for (steel 03) (feed = 0.72 mm/rev, depth of cut = 0.5 mm), and (speed of cut= 175.92 m/min); the surface roughness (Ra) was (1.119 µm), The results showed the highest degree of the Ra in the same metal at speed of cut (68.48 m/min) and the feed rate was (1.12 mm/rev) with the same depth of (0.5 mm) the surface roughness (Ra) was (4.188 µm). Compared to the results of other measurements performed. In turn, the thickness of the chip will decrease from the beginning of the cut until it touches zero at the end. This stops the edge from rubbing and polishing on the surface prior to cutting. The best surface roughness measured in the machined surfaces using cutting conditions for (steel 45) is (feed = 0.72 mm/rev), (depth of cut = 0.5 mm), and (speed of cut = 175.92 m/min). The (Ra) was (1.939 µm). The results showed the highest degree of Ra of the same metal at the speed of cut (68.48m/min) and the feed of (1.12 mm/rev) with the same cutting depth of(0.5mm) the (Ra) was (3.899 µm). The best surface roughness is measured in the machined surfaces using the following machining parameters for (steel y8) cutter feed is (0.72), cutting depth (0.5 mm), and speed of cut (175.92m/min) the surface roughness (Ra) was (2.277 µm).

The results showed the highest surface roughness of the same metal at cutting speed (68.48 m/min), and the feed rate was (1.12 mm/rev) with the same cutting depth of (0.5mm) the (Ra) was (4.999 µm). By discussing the results for all samples used in the current study and comparing them with previous studies [2][17] it was found that the rate of surface roughness of the sample operated increases with the increase in the feed rate of the machine.

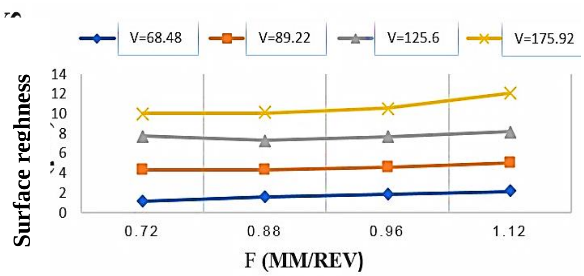

Figure 4. Show the comparison between surface roughness and feed rate for steel 03 at different cutting speeds

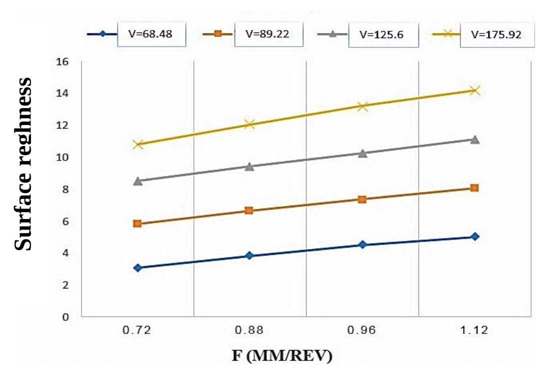

Figure 5. Show the comparison between surface roughness and feed rate for steel 45 at different cutting speeds

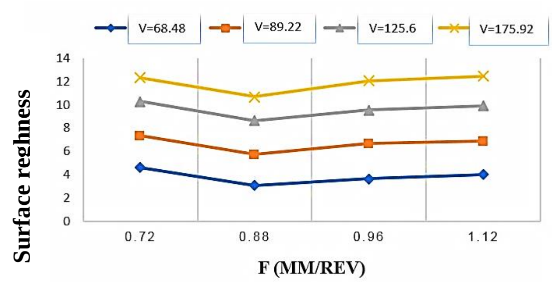

Figure 6. Show the comparison between surface roughness and feed rate for y8 at different cutting speeds

4.2. The effect of cutting speed on the surface roughness

Figures (7, 8, and 9) indicate that the average surface roughness increases with an increased cutting speed at a constant feed rate. The best surface roughness is measured on the surfaces of the sample under cutting conditions for (steel 03) are (feed = 0.72mm/rev), (cutting depth = 0.5mm), and (cutting speed = 175.92 mm/min). The (Ra) was (1.119µm). The highest surface roughness of the same metal at cutting speed was (68.48 m/min) and the feed was (1.12 mm/rev) with the same cutting depth of (0.5mm) The surface roughness (Ra) was (4.188 µm) as compared to the other values that were obtained. The operational surfaces' best-possible surface roughness was assessed using cutting conditions for (steel 45) cutter (feed = 0.72mm/rev), (depth of cut = 0.5mm), and (machine speed = 175.92m/min) the surface roughness (Ra) was (1.939 µm). The results showed the highest degree of surface roughness of the same metal at speed (68.48 m/min), and the feed was (1.12mm/rev) with the same cutting depth of (0.5mm) and the surface roughness (Ra) was (3.899 µm). The best surface roughness is measured in the machined surfaces by utilizing cutting conditions of (steel y8) with a feed rate is (0.72mm/rev), cutting depth of (0.5mm), and speed of (175.92m/min) and the (Ra) was (2.277µm). The results showed the highest degree of surface roughness of the same metal at speed (68.48 m/min), and the feed was (1.12mm/rev) with the same depth of (0.5mm) and the surface roughness (Ra) was (4.999 µm). These findings were quite similar to the research that had been done before [18][19].

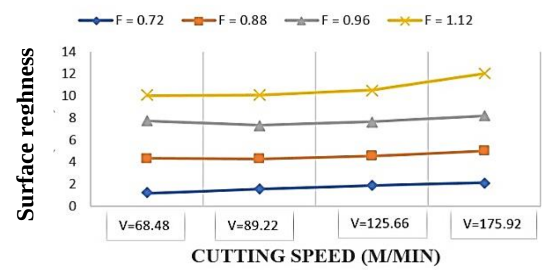

Figure 7. Compares Ra and cutting speed for steel 03 at different feed rates

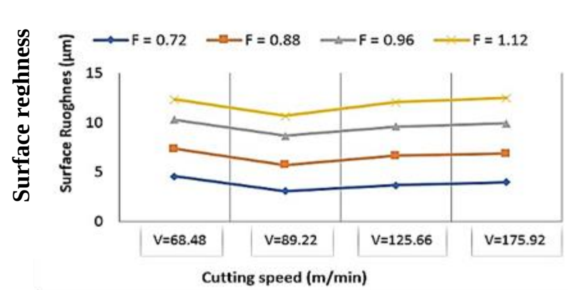

Figure 8. Compares the Ra and speed of cut for Steel 45 at various feed rates

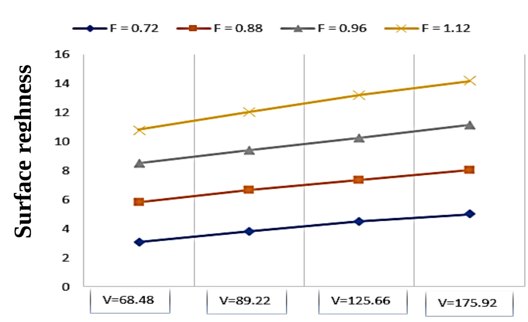

Figure 9. Depicts a comparison of surface roughness and cutting speed for (Steel Y8) at various feed rates

Figure. 10 shows the relationship between cutting speed and roughness values for different metals. In general, increasing the cutting speed leads to a decrease in surface roughness up to a certain point, after which further increases in cutting speed can lead to an increase in surface roughness.

According to the result, the lower surface roughness value is obtained (1.119 µm) when machining (steel 03) at cutting speed (175.92m/min). The results showed the highest degree of surface roughness (4.999 µm) at cutting speed (68.48 m/min) when machining (steel Y8) metal and that's approved by a study [20].

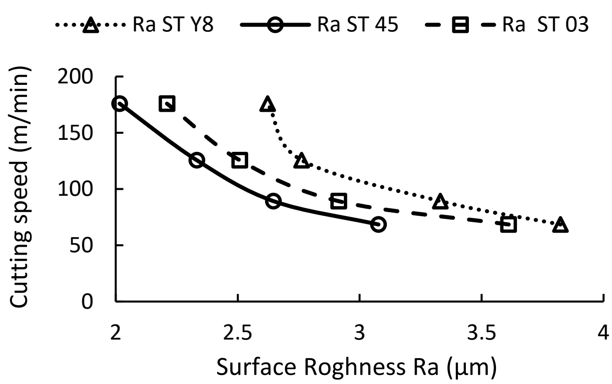

Figure 10. Compares the cutting speed and SR for three metals (Steel 03, 45 and Y8)

5. Conclusion

This study has arrived at the following conclusions:

- The sample (steel y8) had the roughest surface with a feed rate of 1.12 and a speed of cut was 68.48 (m/min)
- The sample (steel 03) has a lower surface roughness when the feed rate is 0.72, and the Vc is 175.92 m/min.
- The variations in roughness seen across the three minerals are attributable to their unique chemical and physical properties.
- When two samples are machined with comparable feed rates and cutting depth but differing speeds, the Ra is equal.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Funding source

This study didn't receive any specific funds.

REFERENCES

[1] D. Karayel, "Prediction and control of surface roughness in CNC lathe using artificial neural network," J. Mater. Process. Technol., vol. 209, no. 7, pp. 3125–3137, 2009. https://doi.org/10.1016/j.jmatprotec.2008.07.023.

[2] Z. Chen, R. Lin Peng, J. Zhou, R. M'Saoubi, D. Gustafsson, and J. Moverare, "Effect of machining parameters on cutting force and surface integrity when high-speed turning AD 730TM with PCBN tools," Int. J. Adv. Manuf. Technol., vol. 100, no. 9–12, pp. 2601–2615, 2019. https://doi.org/10.1007/s00170-018-2792-1

[3] S. Y. Kassab and Y. K. Khoshnaw, "The Effect of Cutting Tool Vibration on Surface Roughness of Workpiece in Dry Turning Operation," Eng. Technol., vol. 25, no. 7, pp. 879–889, 2007.

[4] R. Thamma, N. Pydisetti, M. Rajai, and H. Wang, "Comparison of regression models to study the effect of turning parameters on the surface roughness," Int. J. Agil. Manuf., vol. 11, no. 1, pp. 1–9, 2009.

[5] M. Mia et al., "Effect of time-controlled MQL pulsing on surface roughness in hard turning by statistical analysis and artificial neural network," Int. J. Adv. Manuf. Technol., vol. 91, no. 9, pp. 3211–3223, 2017. https://doi.org/10.1007/s00170-016-9978-1

[6] V. R. N. Vikas B. Magdum, "Experimental Study of the Effects of Machining Parameters on the Surface Roughness in the Turning Process," vol. 4, no. 2, pp. 1–8, 2018. https://doi.org/10.22362/ijcert/2018/v5/i5/v5i502.

[7] P. Kumar et al., "Influence of different grades of CBN inserts on cutting force and surface roughness of AISI H13 die tool steel during hard turning operation," Materials (Basel)., vol. 12, no. 1, 2019. https://doi.org/10.3390/ma12010177.

[8] V. Sivalingam, Y. Zhao, R. Thulasiram, J. Sun, G. kai, and T. Nagamalai, "Machining Behaviour, surface integrity and tool wear analysis in environment-friendly turning of Inconel 718 alloy," Measurement, vol. 174, p. 109028, 2021. https://doi.org/10.1016/j.measurement.2021.109028.

[9] S. Padhan, A. Das, A. Santoshwar, T. R. Dharmendrabhai, and S. R. Das, "Sustainability Assessment and Machinability Investigation of Austenitic Stainless Steel in Finish Turning with Advanced Ultra-Hard SiAlON Ceramic Tool under Different Cutting Environments," Silicon, vol. 13, no. 1, pp. 119–147, 2021. https://doi.org/10.1007/s12633-020-00409-1.

[10] A. Ibrahim, "prediction of surface roughness in turning machine using taguchi method," vol. 8, Jan. 2015.

[11] K. Ahmed Al-Dolaimy, "Effect of Cutting Parameters on Surface Roughness in Turning Operations," J. Eng. Sci., vol. 9, no. 4, pp. 442–449, 2016.

[12] R. H. I. Haider M. Mohammad, "Effect Of Cutting Parameters On Surface Roughness And Cutting Tool Temperature In Turning AISI 1045 Steel," vol. 8, no. 2, pp. 127–137, 2017.

[13] A. F. Huayier, "Experimental Investigation of cutting conditions parameters on surface roughness in aluminum alloys (AL-2024)," Al-Qadisiyah J. Eng. Sci., vol. 15, no. 3, pp. 142–147, 2022. https://doi.org/10.30772/qjes.v15i3.826.

[14] P. A. Sutar and A. J. Gujar, "Study the effect of machining parameters on surface roughness in CNC Milling of AISI 316L," Int. J. Eng. Technol., vol. 10, no. 1, pp. 801–804, 2017.

[15] H. Abdulridha, A. Helael, and A. Al-duroobi, "Prediction the Influence of Machining Parameters for CNC Turning of Aluminum Alloy Using RSM and ANN," Eng. Technol. J., vol. 38, no. 6, pp. 887–895, 2020 https://doi.org/10.30684/etj.v38i6A.705

[16] Y. Qin, "Micro-manufacturing engineering and technology," Micro-Manufacturing Eng. Technol., 2015. https://doi.org/10.1016/C2013-0-19351-8.

[17] M. H. M. Ghazali, A. Z. A. Mazlan, L. M. Wei, C. T. Tying, T. S. Sze, and N. I. M. Jamil, "Effect of Machining Parameters on the Surface Roughness for Different Type of Materials," IOP Conf. Ser. Mater. Sci. Eng., vol. 530, no. 1, 2019. doi: 10.1088/1757-899X/530/1/012008.

[18] B. M. Gurumurthy, J. Hindi, A. Hegde, S. Sharma, and A. Kini, "Effect of Machining Parameters on Tool Life and Surface Roughness of AISI 1040 Dual Phase Steel," Mater. Res., vol. 25, 2022. doi: 10.1590/1980-5373-MR-2021-0351.

[19] O. Zurita, V. Di-Graci, and M. Capace, "Effect of cutting parameters on surface roughness in turning of annealed AISI-1020 steel," Rev. Fac. Ing., vol. 27, no. 47, pp. 111–118, 2018. doi: 10.19053/01211129.v27.n47.2018.7928.

[20] Aghdeab, S., Abdulwahhab, A., & Mohsein, Z. , "Investigation study of electrical discharge machining parameters on material removal rate for AISI M2 material". Al-Qadisiyah Journal for Engineering Sciences,2023, 16(1), 042-046. https://doi.org/10.30772/qjes.v16i1.832