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# Optimization of turning process parameters for enhanced surface quality in aluminum alloy AA2024

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## HIGHLIGHTS

- Surface roughness improved both cost and quality.
- Feed rate showed the largest percentage contribution at 54.51%.
- Feed rate was the only factor with a significant P-value of 0.006.
- The optimal levels were a DOC of 0.9 mm, a feed of 0.066 mm/min, a speed of 1100 rpm, and a tool nose radius of 0.8.

## ARTICLE INFO

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## ABSTRACT

Surface roughness is a critical parameter that profoundly influences the functionality and performance of materials and components across various industries. Additionally, estimating the ideal machining parameter circumstances is the best way to minimize costs and get the item's surface quality. This research investigated four factors- depth of cut, spindle speed, feed, and nose radius- for the turning of aluminum alloy AA2024 to estimate the surface roughness. The study's experimental efforts were done by utilizing a manual turning machine, and the experiment setup used the Taguchi method of L18 array orthogonal (OA). The Taguchi approach is employed to optimize the selection of tools. The average surface roughness (Ra) measurements were converted to signal-to-noise (S/N) ratios and analyzed statistically using the analysis of variance (ANOVA) method. The results illustrated that nose radius, feed, speed, and depth of cut that produced the best results were 0.8, 0.066 mm/min, 1100 rpm, and 0.9 mm, respectively. The feed rate contributed the most with 54.51%, while the nose radius had the smallest impact with 0.84% of the percentage contribution. A2/B3/C1/D2 is the most efficient arrangement for lathe parameters. Among the selected components, only the feed rate showed a significant P-value of 0.006. Surface roughness offers numerous benefits for AA2024, an aluminum alloy widely utilized in aerospace applications. Enhanced surface roughness fosters better adhesion of coatings and adhesives and is crucial for strong bonds in aircraft components.

## 1. Introduction

Metal cutting is the cornerstone of the production sectors, and the majority extensively use technology to produce a wide range of items, from cars to extremely accurate parts in the electronics and apparatus industries globally [1]. Most metal-cutting research found that the product's output quality and processing efficiency are significantly influenced by the work materials, machine settings, and tool attributes [2,3]. Consequently, the machining process is optimized by increasing the appropriate processing parameter. The process of machining (milling, boring, broaching, turning, drilling, grinding, honing, and lapping) is the most significant method of adding value to metal cutting [4,5]. Milling machines are widely employed in the industrial sector as a standard method of classical machining for material removal. The die, manufacturing, and equipment design industries frequently employ the best-machined surfaces for connecting to other parts [6,7]. Surface roughness is one of the most important factors in determining a product's technological excellence and a major source of cost savings. A complicated, process-dependent system that is always evolving creates surface roughness. Consequently, doing a theoretical investigation will be difficult [8,9]. Furthermore, because surface roughness influences the performance of mechanical components in terms of things like wear, corrosion resistance, heat generation, fatigue strength, creep life, etc., it is an essential component of mechanical design [10,11]. It also has a major impact on how much two connected components adapt. Additionally, it enhances the product's surface finish's tribological qualities, including fatigue strength, resistance to corrosion, and visual attractiveness.



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The metal-cutting process relies on surface issues like size and geometric constraints to create machined components. It also aims to mold the component [12,13]. Several techniques and tools are used to determine optimization parameters, such as the Taguchi method, Failure Modes and Effects Analysis (FMEA), Simulated Annealing Algorithm (SAA), Grey Relational Analysis (GRA), Analysis of Variance (ANOVA), Response Surface Methodology (RSM), and many more. Consequently, to maximize surface quality in the quickest possible time, parametric optimization is required for both optimization and augmentation of machining operations [14,15]. Nonetheless, Genichi Taguchi created the statistical techniques referred to as "Taguchi methods" to assess the caliber of components that were manufactured. Recently, the disciplines of biology, engineering, marketing, and advertising have all used these techniques [16-18]. Manganese (Mn) and copper (Cu) are the main alloying elements of the well-known alloy aluminum 2024. The main features of aluminum alloy 2024 are its lightweight, good strength-to-weight ratio, and poor ductility or flexibility, which makes it a costly material to machine. Consequently, it finds use in the biotechnology, automotive, and structural aerospace sectors [19,20]. Numerous studies have been conducted to create and enhance turning machine cutting conditions, as the preceding study shows. However, several twisting operations were performed in order to improve the surface roughness of AA2024 using Taguchi's orthogonal array (OA) technique. According to Rogov and Siamak [21], at utilizing the Taguchi Technique, aluminum alloy AA2024 Vibration and Surface Roughness Optimization say in turning aluminum alloy AA2024, this study concentrated on improving surface quality and lowering costs through parameter optimization during machining. AISI 5140 standard tool and carbide tool with TiC coating were employed in the experiments on a lathe. the L9 orthogonal array of the Taguchi method was utilized. It was determined that the tool with holes in the tool holder had the smallest surface roughness (Ra), measuring 0.64 µm, whereas the standard tool had the smallest Ra of 0.814 µm. The lowest results were 2038.6 Hz and 2124 Hz for natural frequency, respectively. According to the study's findings, tool overhang was the primary element influencing natural frequency for both tools. In contrast, feed rate and tool overhang had a greater impact on the tool with holes.

For the conventional tool, spindle speed was found to have a substantial effect on (Ra) [21], as mentioned by Abas et al., [22]. The optimization of machining parameters for aluminum alloy during the turning process was carried out under dry Minimum Quantity Lubricant (MQL) conditions, utilizing olive oil as the coolant. Using a Taguchi orthogonal array (L16) for 16 experimental runs, the study targeted the improvement of multiple responses, including surface roughness, tool life, and material removal rate. The optimization process employed a composite desirability function integrated with the CRITIC method. An Analysis of Variance (ANOVA) shows that feed rate has a substantial impact on surface roughness, that cutting speed and feed rate have an impact on tool life, and that cutting speed has the biggest impact on material removal rate. The ideal settings for dry conditions are 500 m/min cutting speed, 0.3 mm/rev, feed rate 2 mm cut depth, and a 15° positive rake angle. Similar settings work best under MQL circumstances but with a 0.4 mm/rev, feed rate that is a little bit higher. Surface quality and tool life are also improved in MQL circumstances; tool life increases to 3215 seconds from 2398 seconds in dry conditions, and material removal rates are similar in both approaches [22]. Based on Javidikia et al. [23], (analysis of surface roughness optimization in AA6061-T6 turning under variable conditions and settings) in turning aluminum alloy AA 6061-T6, this study uses Response Surface Method (RSM) and Central Composite Design (CCD) to examine the effects of machining environments and cutting settings on surface roughness.

The process of developing predictive models for surface roughness measures under DRY, Minimum Quantity Lubrication (MQL), and WET conditions involved the application of Analysis of Variance (ANOVA). With an ideal feed rate of 0.07 mm/rev for minimizing roughness, the results showed that feed rate is the most important factor influencing surface roughness. The DRY mode provided the least surface roughness out of all the environments examined. According to the study, surface quality can be greatly increased by utilizing a DRY atmosphere and maximizing feed rate. The present study examined the impact of several cutting parameters, including tool nose, feed, spindle speed, and cut depth, on AA2024. Then, the most effective method is used to reduce costs and achieve the product's surface quality by using the ANOVA technique and Taguchi method, which are not often mentioned in the literature because the primary objectives in machining applications are production rate, machining quality, and operational cost. Therefore, to assess the lowest is best (LB) characteristics of average surface roughness, the cutting parameters are converted into the signal-to-noise (S/N) ratio. After selecting the optimal combination, the Analysis of Variance (ANOVA) was used to forecast the effectiveness ratio of the specified cutting parameters. The following section consists of the methodology, including materials used in the present study, controllable factors and their levels, surface roughness tester, and Minitab software.

## 2. Methodology

### 2.1 Materials

The aluminum alloy type 2024 was utilized for this project; its chemical substances arrangement is described in Table 1 and its properties are shown in Table 2. Figure 1 describes the Sandvik tool that we used, which combines aluminum and silicon.

**Table 1:** Chemical composition of AA2024

| Material | Mg | Mn | Cu | Fe | Si | Cr | Zn | Al |
|---|---|---|---|---|---|---|---|---|
| AA2024 | 1.45 | 0.5 | 4.40 | 0.21 | 0.3 | 0.1 | 0.25 | REM |

**Table 2:** Mechanical properties of aluminum AA2024

| Elongation % | Tensile Strength MPa (Ultimate) | Hardness (HB) | Yield point MPa |
|---|---|---|---|
| 13.6 | 471 | 115=125 | 325 |


**Figure 1:** Sandvik coromant

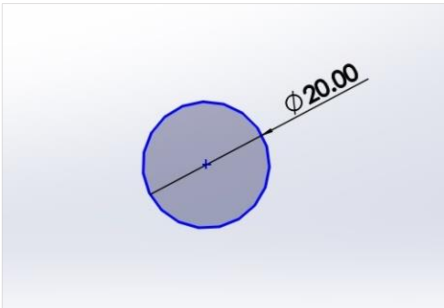
## 2.2 Controllable factors and their levels

The control factors of the machined exterior's surface roughness are the feed, spindle speed, tool nose, and cutting depth. This study examines four adjustable parameters; all parameters have three degrees of adjustment, with the exception of the tool nose, which has two. Table 3 displays the specifications and their corresponding levels.

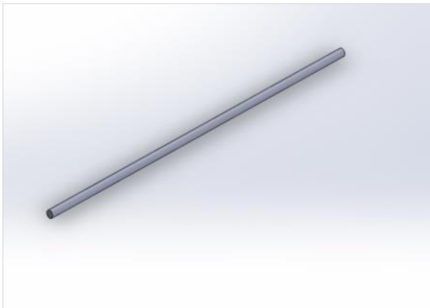
Figure 2 shows the aluminum alloy 2024 specimen with the designated dimensions: (a) a diameter of 20 mm and (b) a length of 1 m. Figure 3 The corner of the tool where two cutting edges merge to form the nose radius is known as the tool nose.

**Table 3:** Control factors and their levels

| Parameter | Level | | | Unit |
|---|---|---|---|---|
| | Low | Medium | High | |
| Tool nose (A) | 0.4 | 0.8 | ... | mm |
| Speed (B) | 525 | 700 | 1100 | RPM |
| Feed (C) | 0.066 | 0.103 | 0.132 | mm/rev |
| DOC (D) | 0.6 | 0.9 | 1.2 | mm |




**(a)**



**(b)**

**Figure 2:** The dimensions of the AA2024 specimen (a) Diameter, (b) Length

**Figure 3:** Tool nose

The Taguchi design approach emphasizes the necessity of correct experimental design in achieving successful results in experimental investigations. As a result, the experiments were designed and evaluated utilizing Genichi Taguchi's technique. This technique involves assessing outcomes using the signal-to-noise (S/N) ratio to improve the consistency and reliability of the findings. The Minitab application is then used to show that we were able to obtain results in (L18), where (L) stands for "number of runs," which appears in Table 4. Also, Figure 4 illustrates the experiments during work.

**Table 4:** The orthogonal array L18

| Run | Tool nose | Speed | Feed | Depth of cut |
|---|---|---|---|---|
| **1** | 0.4 | 525 | 0.066 | 0.6 |
| **2** | 0.4 | 525 | 0.103 | 0.9 |
| **3** | 0.4 | 525 | 0.132 | 1.2 |
| **4** | 0.4 | 700 | 0.066 | 0.6 |
| **5** | 0.4 | 700 | 0.103 | 0.9 |
| **6** | 0.4 | 700 | 0.132 | 1.2 |
| **7** | 0.4 | 1100 | 0.066 | 0.9 |
| **8** | 0.4 | 1100 | 0.103 | 1.2 |
| **9** | 0.4 | 1100 | 0.132 | 0.6 |
| **10** | 0.8 | 525 | 0.066 | 1.2 |
| **11** | 0.8 | 525 | 0.103 | 0.6 |
| **12** | 0.8 | 525 | 0.132 | 0.9 |
| **13** | 0.8 | 700 | 0.066 | 0.9 |
| **14** | 0.8 | 700 | 0.103 | 1.2 |
| **15** | 0.8 | 700 | 0.132 | 0.6 |
| **16** | 0.8 | 1100 | 0.066 | 1.2 |
| **17** | 0.8 | 1100 | 0.103 | 0.6 |
| **18** | 0.8 | 1100 | 0.132 | 0.9 |


**Figure 4:** Surface roughness tester during experiments

To evaluate the roughness of the surface, a surface roughness tester was employed. Every testing process was performed six times with the new cutting to increase reliability and acquire accurate surface roughness readings under these conditions. There are several methods to represent the most common surface roughness measurements of a workpiece, such as average peak-to-valley height (Rz), peak roughness (RP), and arithmetic average (Ra). An arithmetic average (Ra) was employed in the current study by ISO 1302. We measured the surface roughness (Ra) using a roughness tester model V2.0 and the serial number K01122033001 to determine the average cutting surface roughness. The surface roughness tester is shown in Figure 5(a) front and (b) back of the tester.


**(a)** **(b)**

**Figure 5:** Surface roughness tester (a) front and (b) back of the tester

## 3. Results and discussion

It was investigated how the tool nose, feed, depth, and spindle speed were among the cutting parameters that impacted surface roughness on the aluminum alloy AA2024. The Sandvik cutting tool was used for the tests, which were conducted on a turning machine, and the information was subsequently converted into the S/N ratio. In addition, Figure 6 shows the completed samples that are machined using the turning machine technique, according to the data displayed in Table 5. Hence, it is necessary to identify the ideal machining parameter settings to save production costs and achieve the required surface quality. This study investigates surface roughness in aluminum alloy AA2024 as a function of cutting settings. Regarding the surface smoothness of the machine components, run number 9 had the highest surface roughness number. On the other hand, run number four has the least amount of surface roughness. Table 5 also includes the surface roughness value, standard deviation, and S/N ratio of the experimental work. It was previously determined that lower costs, lower power consumption, and higher-quality products required minimal surface roughness. The findings were adjusted to account for the S/N ratio, which shows that, with regard to surface roughness, "smaller is better" since the lowest possible level is required to yield the best possible surface quality. The quality feature that deviates from the target value via the Taguchi technique is measured using the (S/N) ratio approach. The experimental findings are also converted into a value for the evaluation characteristic in the optimal parameter analysis using this method rather than the average value. The findings were adjusted to reflect the S/N ratio. Since surface roughness must be minimal to provide the highest surface quality, as shown in Equation 1, the maxim " smaller is better " is used,

$$\frac{S}{N} = -10\ log\ \left[\frac{1}{n}\sum_{i=1}^{n} Y_i^{\,2}\right] \qquad (1)$$

**Figure 6:** Finished sample after the turning machine process

**Table 5:** The S/N ratio and standard deviation of the test findings

| Run | Roughness (μm) | | | | | | Average roughness (μm) | Standard deviation | S/N ratio |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.72 | 0.76 | 0.78 | 0.65 | 0.74 | 0.66 | 0.718 | 0.048 | 2.873 |
| 2 | 0.88 | 0.75 | 0.82 | 0.78 | 0.8 | 0.64 | 0.778 | 0.073 | 2.176 |
| 3 | 2.52 | 2.49 | 2.48 | 2.6 | 2.04 | 2.48 | 2.426 | 0.180 | -7.700 |
| 4 | 0.56 | 0.54 | 0.53 | 0.54 | 0.52 | 0.54 | 0.538 | 0.012 | 2.689 |
| 5 | 1.04 | 1.1 | 1.07 | 1.2 | 1.04 | 0.98 | 1.064 | 0.065 | -0.541 |
| 6 | 3.4 | 2.98 | 3.5 | 3.3 | 3.6 | 3.7 | 3.413 | 0.232 | -10.663 |
| 7 | 0.54 | 0.64 | 0.59 | 0.6 | 0.61 | 0.7 | 0.613 | 0.048 | 4.246 |
| 8 | 1.52 | 1.68 | 1.57 | 1.55 | 1.7 | 1.63 | 1.608 | 0.066 | -4.127 |
| 9 | 3.1 | 3.04 | 2.02 | 2.48 | 2.87 | 2.45 | 2.660 | 0.380 | -8.497 |
| 10 | 0.79 | 0.78 | 0.74 | 0.69 | 0.72 | 0.84 | 0.760 | 0.049 | 2.383 |
| 11 | 1.15 | 1.13 | 1.12 | 1.11 | 1.14 | 1.17 | 1.136 | 0.019 | -1.112 |
| 12 | 1.36 | 1.35 | 1.43 | 1.41 | 1.42 | 1.37 | 1.390 | 0.031 | -2.860 |
| 13 | 1.7 | 1.72 | 1.73 | 1.74 | 1.76 | 1.77 | 1.736 | 0.023 | -4.794 |
| 14 | 1.21 | 1.22 | 1.17 | 1.18 | 1.24 | 1.16 | 1.196 | 0.028 | -1.559 |
| 15 | 2.55 | 2.56 | 2.57 | 2.59 | 2.6 | 2.61 | 2.580 | 0.021 | -8.232 |
| 16 | 0.59 | 0.6 | 0.6 | 0.61 | 0.65 | 0.67 | 0.620 | 0.029 | 4.152 |
| 17 | 0.77 | 0.81 | 0.77 | 0.82 | 0.77 | 0.72 | 0.776 | 0.032 | 2.195 |
| 18 | 0.91 | 1.11 | 0.79 | 0.91 | 0.81 | 0.88 | 0.901 | 0.103 | 0.899 |

The optimal amounts of each component separately are displayed in Table 6 and Figure 7, A2/B3/C1/D2 is the ideal combination of turning parameters. Conversely, the optimal settings for nose radius, spindle speed, feed, and DOC are 0.8, 1100 rpm, 0.066 mm/min, and 0.9 mm, respectively. The nose radius has minimal influence on the surface roughness of AA 2024. In contrast, the feed is the most significant factor influencing the surface roughness (Ra) of AA2024, the result confirmed by Mahshad et al., [24], and Sahoo et al., [25]. The feed significantly affects surface roughness, with surface roughness substantially reduced as the feed changes. In comparison with the remaining three factors, as indicated in Table 6.

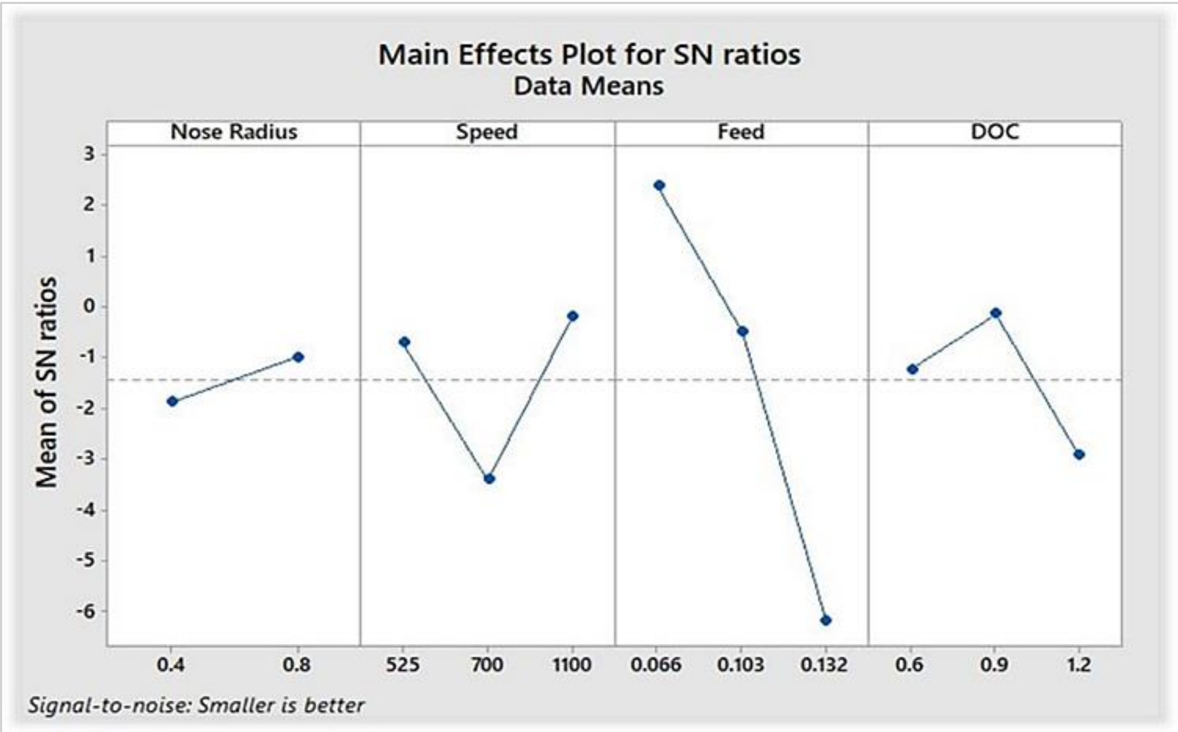



**Figure 7:** Average performance plot

**Table 6:** Average performance of S/N ratio

| Level | Nose radius (A) | Speed (B) | Feed (C) | DOC (D) |
|---|---|---|---|---|
| 1 | -1.8728 | -0.7065 | 2.3733 | -1.2325 |
| 2 | -0.9921 | -3.4020 | -0.4948 | -0.1457 |
| 3 | | -0.1888 | -6.1758 | -2.9191 |
| Delta | 0.8807 | 3.2132 | 8.5492 | 2.7735 |
| Rank | 4 | 2 | 1 | 3 |

The optimal choices are based on the minimum, according to the interaction plot in Figure 8. The relationships between noses for different rates of depth of cut are: the best nose for a cutting depth of 0.6 is nose (0.4), and for a cutting depth of 0.9 is nose (0.4), for a depth of cut of 1.2 is nose (0.8). The relationship between noses for different feed rates: the best nose for a feed rate of 0.066 is nose (0.4), and for a feed rate of 0.103, it is nose (0.8), and for a feed rate of 0.132, it is the nose (0.8). The relationships between noses for different speed ratios are: the best nose for a speed of 525 is nose (0.8), and for a speed of 700 is nose (0.4), and for a speed of 1100 is nose (0.8). The relationships between speeds for different feed rates are: the best speed for a feed rate of 0.066 is 1100, and for a feed rate of 0.103, it is 525, and for a feed rate of 0.132, it is 1100.

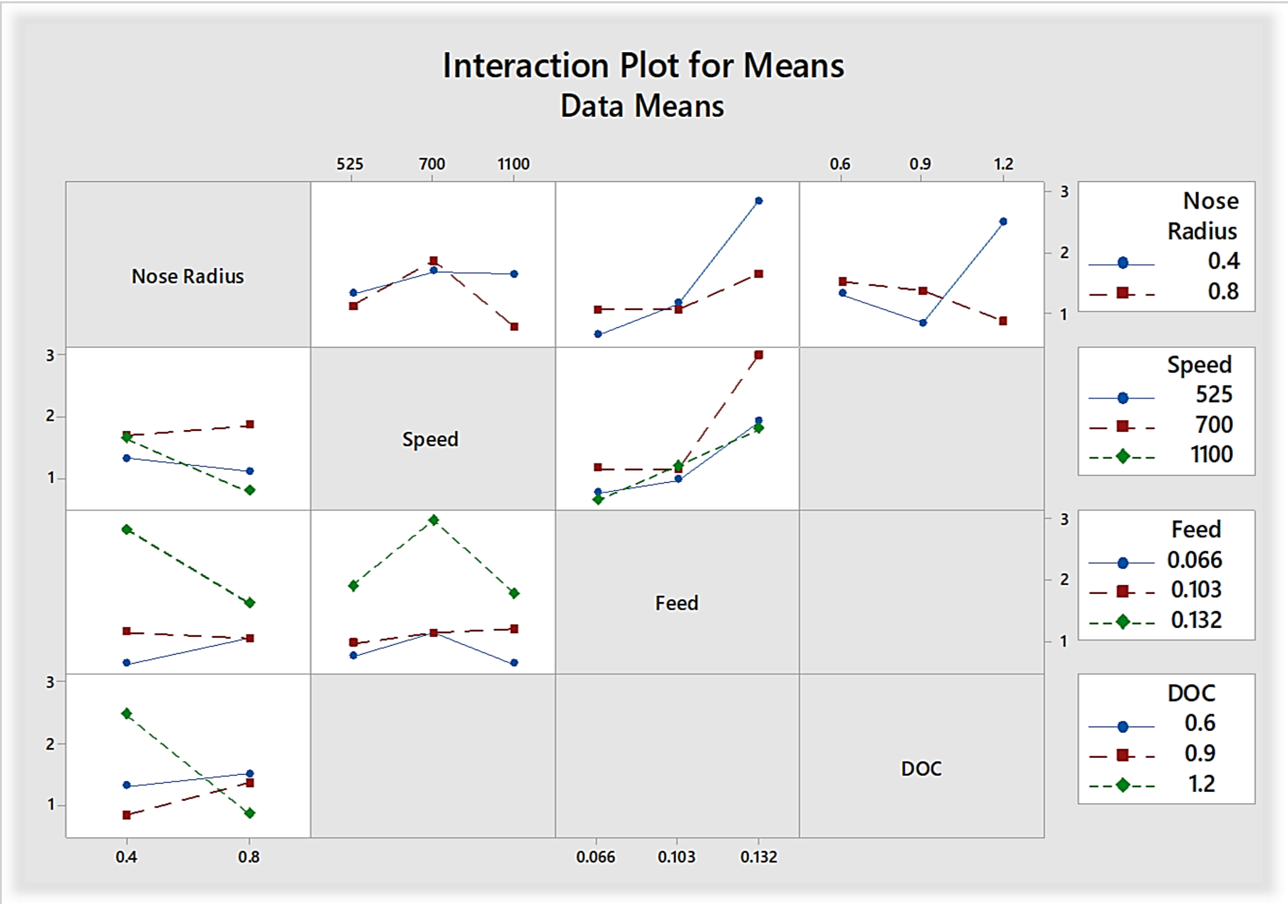



**Figure 8:** Interaction plot for means

ANOVA is conducted to demonstrate the percentage contribution of every factor influencing surface roughness, and Minitab 18 software is utilized to analyze the output properties and surface finish. Stat-ANOVA-General linear model-Fit general linear model was used to create the ANOVA test. P-value is a measure of a parameter's significance in an ANOVA test. Since a confidence level of 95.0% was selected for the current study, the P-value was below 0.05 for the feed, indicating statistical significance and a notable impact on the response variable. Equations (2 to 14) contain the data from the analysis of the variance table, each factor's degree of freedom and error are computed as follows:

$$DOF_T = \text{N} - 1 \quad (2)$$

$$DOF_f = \text{number of levels} - 1 \quad (3)$$

$$DOF_e = DOF_T \text{ - total of } DOF_f \quad (4)$$

By measuring the deviation of each factor from the general average mean, we can assess its significance:

$$\text{T} = \sum_{i=1}^{n} Y_i \quad (5)$$

$$\text{C.F} = \frac{T^2}{N} \quad (6)$$

The squared deviation's entire sum is:

$$SS_T = (\sum_{i=1}^{n} Y_i^{\,2}) - \text{C.F} \quad (7)$$

Each factor sum of squared deviation is:

$$SS_f = \left(\frac{{A_1}^2}{n_1} + \frac{{A_2}^2}{n_2} + \ldots\right) - \text{C.F} \quad (8)$$

Then, the error term of the sum of squared deviations is found by:

$$SS_e = SS_T - \text{total of } SS_f \quad (9)$$

The variance or the mean square of each factor is:

$$V_f = \frac{SS_f}{DOF_f} \quad (10)$$

The error of variance is defined by:

$$V_e = \frac{SS_e}{DOF_e} \quad (11)$$

The variance ratio of each factor is determined by:

$$F_f = \frac{V_f}{V_e} \quad (12)$$

The percentage contribution of each parameter in the sum of squared total deviations is:

$$P_f = \frac{SS_f}{SS_T} \text{ x } 100 \quad (13)$$

The process's mistake(error) in terms of its percentage contribution is:

$$P_e = \frac{SS_e}{SS_T} \text{ x } 100 \quad (14)$$

Additionally, Table 7 summarizes the results of the ANOVA test. As can be observed, according to Figure 9, the feed value percentage with the greatest percentage is 54.51%. Furthermore, Figure 9 shows that increasing the feed rate would improve surface quality; the feed is only a significant influence (P-value of 0.006). Generally speaking, for the same cutting depth, speed, and nose radius, surface roughness is affected by a number of variables, like the machining settings (for example, depth of cut, feed, and cutting speed), tool geometry, material qualities (such as ductility and hardness), lubrication, cooling techniques, and ambient influences. To optimize manufacturing processes and achieve the appropriate surface smoothness, it is crucial to comprehend how these elements relate to surface roughness.

**Table 7:** Analysis of Variance (ANOVA) test

| Source | DF | SS | V | F-Value | P% | P-Value |
|---|---|---|---|---|---|---|
| Nose Radius | 1 | 3.49 | 3.49 | 0.28 | 0.84 | 0.611 |
| Speed | 2 | 35.717 | 17.858 | 1.41 | 8.57 | 0.289 |
| Feed | 2 | 227.178 | 113.589 | 8.95 | 54.51 | 0.006 |
| DOC | 2 | 23.436 | 11.718 | 0.92 | 5.62 | 0.429 |
| Error | 10 | 126.906 | 12.691 | | 30.45 | |
| Total | 17 | 416.727 | | | | |

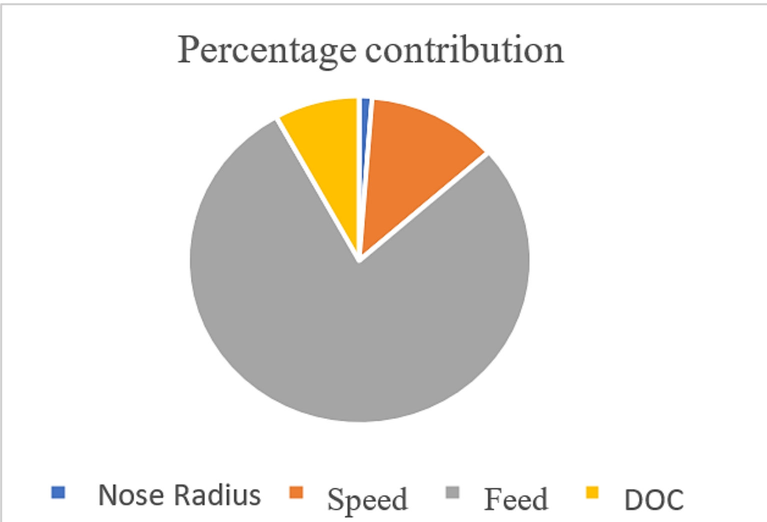



**Figure 9:** The percentage contribution of the cutting parameters

## 4. Conclusion

The effects of key machining parameters—feed rate, depth of cut, cutting speed, and tool nose radius—were experimentally investigated to evaluate their impact on the average surface roughness of AA2024 aluminum alloy workpieces. Using Taguchi's Orthogonal Array (OA), eighteen trials were conducted, and the experimental data was analyzed through the statistical method of ANOVA. The final results indicate that:

1) Each cutting parameter has an impact on the surface roughness of the machine part.
2) Feed had the largest percentage contribution (54.51%), while the nose radius had the least (0.84%).
3) Only feed had a significant P-value of 0.006 among the components that were chosen
4) The parameters with the highest levels of performance were the cutting depth (0.9 mm), feed (0.066 mm/min), spindle speed (1100 rpm), and nose (0.8).
5) By using the Taguchi method in the design of experiments, it's possible to optimize the surface roughness of machined products while also minimizing production time and costs.

## Abbreviation

| | | | |
|---|---|---|---|
| **ANOVA** | **Analysis of variance** | **P-value** | **Calculated probability** |
| **C.F** | Correction Factor | **P%** | Percentage contribution |
| **C.I** | Confidence interval | **Ra** | Surface roughness |
| **DOC** | Depth of cut | **S/N** | Signal-to-noise ratio (dB) |
| **$DOF_e$** | Degrees of freedom of error term | **SS** | Sum of square |
| **DOF** | Degree of freedom | **T** | Total every result |
| **$DOF_i$** | Degrees of freedom of the significant factors | **$V_e$** | The error variance |
| **$DOF_m$** | Degree of freedom mean | **$V_f$** | The mean square or variance for every component |
| **F-test** | Variance ratio | **V** | Variance |
| **N** | The total number of experiments | **$y_i$** | The measured surface roughness value for the trial (in micrometers) |
| **n** | Number of observations of the result | | |
| **OA** | Orthogonal Array | | |

### Author contributions

Conceptualization, N. Mahmood, E. Mahmood, S. Mahmood, M. Aziz, and D. Ahmad; data curation, S. Mahmood; formal analysis, D. Ahmad.; investigation, M. Aziz.; methodology, E. Mahmood; project administration, N. Mahmood, resources, D. Ahmad.; software, N. Mahmood.; supervision, N. Mahmood.; validation, S. Mahmood, D. Ahmad., and M. Aziz.; visualization, E. Mahmood.; writing—original draft preparation, E. Mahmood.; writing—review and editing, N. Mahmood. All authors have read and agreed to the published version of the manuscript.

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### Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

### Conflicts of interest

The authors declare that there is no conflict of interest.

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