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Research Article

Examination of Surface Hardness and Roughness of AISI 1050 Steel Material in Milling Based on Surface Processing Conditions

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Abstract: It is known that material hardness and surface conditions have a significant impact on the operating life of machine elements working with each other. In this study, Surface roughness values obtained depending on processing conditions and hardness changes on the machined surfaces during milling of AISI 1050 steel were examined. In experimental studies, ideal machining conditions were determined by taking into account surface roughness values and hardness changes using the Taguchi L18 experimental design method. In all experiments, it was observed that the lowest surface hardness was achieved under dry conditions when 6500 1/min speed, 4000 mm/min feed rate, and 0.4 mm cutting depth values were applied. When the speed increased from 5500 1/min to 6000 1/min and the feed rate increased from 4500 mm/min to 5000 mm/min, improvements in surface quality were observed in both machining conditions. In conclusion; In experiments where coolant was applied at high cutting speeds, it was determined that surface hardness and surface roughness values were higher than in dry machining conditions.

Keywords: *Surface Hardness, Surface Roughness, Taguchi method.*

AISI 1050 Çelik Malzemenin Frezelemesinde Yüzey İşleme Koşullarına Bağlı Olarak Yüzey Sertliği ve Yüzey Pürüzlülüğünün İncelenmesi

Özet: Birbiri ile çalışan makine elemanlarının çalışma ömürlerinde malzeme sertliği ve yüzey durumlarının önemli etkisi olduğu bilinmektedir. Bu çalışmada; AISI 1050 çeliğinin frezelenmesi esnasında işleme koşullarına bağlı olarak elde edilen yüzey pürüzlülük değerleri ve işlenmiş yüzeylerdeki sertlik değişimleri incelenmiştir. Deneysel çalışmalarda Taguchi L18 deney tasarımı yöntemiyle yüzey pürüzlülük değerleri ve oluşan sertlik değişimleri göz önüne alınarak ideal işleme şartları tespit edilmiştir. Tüm deneylerde en düşük yüzey sertliği kuru şartlarda 6500 1/dak devir, 4000 mm/dak ilerleme hızı 0,4 mm kesme derinliği değerleri uygulandığında ulaşıldığı gözlemlenmiştir. Devir sayısı 5500 1/dak'dan 6000 1/dak'a çıktığında ve ilerleme hızı 4500 mm/dak'dan 5000 mm/dak'a çıkartıldığında iki işleme şartında da yüzey kalitesinde iyileşmeler görülmüştür. Sonuç olarak; yüksek kesme hızlarında, soğutma sıvısının uygulandığı deneylerde yüzey sertliği ve yüzey pürüzlülüğü değerlerinin kuru işleme şartlarına göre daha yüksek olduğu tespit edilmiştir.

Anahtar kelimeler: *Yüzey Sertliği, Yüzey Pürüzlülüğü, Taguchi yöntemi.*

1. Introduction

The discourse centers on the pivotal role of steel in the manufacturing industry, emphasizing its widespread utilization owing to its malleability, production efficiency, and

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mechanical attributes [1]. It delineates the intricate manufacturing stages, beginning with material design, progressing through production methods, and culminating in quality control. Central to these phases are machining applications, pivotal within the manufacturing domain [2].

The industry's primary objectives encompass rapid, quality-driven, and cost-effective part production, prompting the development of innovative manufacturing methodologies [3-4]. Milling, among the prominently evolved processes, significantly influences surfaces in machining and is intrinsically linked to cutting parameters. Misjudged cutting parameters yield tool wear and suboptimal surface quality, leading to financial setbacks and compromised output integrity [5-6].

Surface quality emerges as a determinant of functional properties and product caliber, impacting tribological traits, wear resistance, and aesthetic appeal. While favorable surface quality enhances material attributes, it also escalates production expenses [7]. The milling process, affected by multifarious factors -such as cutting speed, depth, feed amount, and tool geometry- highlights the significance of measuring and characterizing surface properties for process optimization [8]. Various research endeavors have delved into these optimizations.

Studies by Gürbüz et L. (2021), Baday et al. (2020), Yılmaz & Güllü (2020), Yıldız (2018) and Yağmur et al. (2017) investigate distinct facets of machining processes, emphasizing surface roughness correlations with cutting parameters, heat treatments, tool coatings, and material types. These investigations employ diverse methodologies, ranging from regression analysis to experimental design methods, to discern optimal machining conditions and surface quality enhancements [9-13].

Furthermore, Yağmur et al. (2017), Sarikaya et al. (2015), Sarikaya & Güllü (2015), Kara & Budak (2015) and Yılmaz et al. (2014) engaged in multifaceted analyses encompassing drillability, milling, turning, and milling-turning hybrid processes. Their endeavors employed methodologies like Taguchi analysis, grey relational analysis, and multi-objective optimization to optimize parameters influencing tool wear, surface finish, material removal rates, and cutting forces [14-17].

These collective studies contribute significantly to the comprehension of machining operations, surface quality enhancements, and optimization methodologies within the manufacturing sector. Nonetheless, a focused synthesis or comparative analysis of these diverse investigations could yield a more comprehensive understanding and potentially pave the way for further advancements in machining processes and surface quality improvements. As a result of the literature research, it has been seen that various optimization studies have been carried out in many types of machining related to AISI 1050 Steel and different steel materials. However, in these studies, it was observed that material surface hardness, depending on the processing conditions in the milling process, was not discussed in many literature. Unlike other studies, in this study, different speeds, feed rates, and depths of cut were used in two different milling conditions: wet and dry. As a result of the experiments, the microhardness of the machining surfaces was measured and their effects on the surface condition were examined.

2. Materials and Methods

This study focuses on determining the effect of machining parameters on surface roughness and surface hardness in the milled surfaces of AISI 1050 steel using Taguchi’s orthogonal array DoE (L18) technique optimizing the cutting parameters. Four factors and two, three levels with 18 experimental runs were conducted and the details are shown in Tables 4 and 5.

2.1. Test Pieces

AISI 1050 material with dimensions of 40x40x40 mm was used as the workpiece material in the experiments (Figure 1). The chemical and mechanical properties of this material are given in Table 1. and Table 2. respectively.

Figure 1. *Test pieces*

Table 1 Chemical composition of AISI 1050 Steel [18]

Fe	C	Si	Mn	P_{max}	S_{max}
Balance	0,42-0,50	0,15-0,35	0,50-0,80	0,045	0,045

Table 2 Mechanical properties of AISI 1050 steel [19]

Yield S(MPa)	Tensile S(MPa)	Elasticity M(GPa)	Elongation (min. %)	Hardness (HRC)
580	690	205	10	13(190HV)

2.2. Milling machine, tool, and coolant

In the experiments, a SPINNER brand VC 1150 3-axis CNC machining center with 35/25 kW engine power and a maximum spindle speed of 18,000 rpm was used.

WNT 5405912200 end mill with 12 mm diameter and 4 flutes was used as the cutting tool. The material of the end mills used was Tungsten Carbide coating Ti1200. The end mill had two edges of 35° and two edges of 38°. The cutting tool was used with AD40 ER32 A=100 tool holder. The cutting tool and the cutting tool holder are shown in Figure 2. In experimental studies, a 10 mm radial depth of cut was used.

Two different processes were carried out in the experiments, some of the experiments using coolant and the other as dry processing (without coolant). CNC machining coolant comprises special chemical additives formulated for compound concentration. The coolant mixture ratios used in the machine for processes using coolant are given in Table 3.

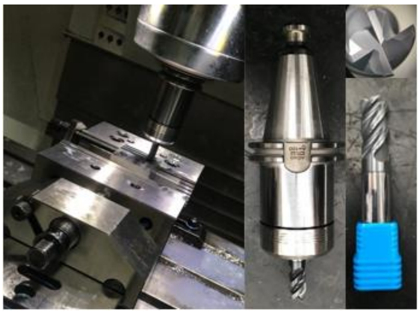

Figure 2. *Cutting tools and tool holders used in experiments*

Table 3 The concentration of coolant

Additives	Concentration (L)
Mobil cut 100-new	%5 (10)
Eurocide te-sd	%1,5 (3)
Eurolub tess-san antifoam s	%1,5 (3)
Eurocide te-b	%1,5 (3)
Water	%90,5 (181)
Capacity of cooling system	%100 (200)

2.3. Experimental Parameters

The experiments were carried out in two different ways. These are using coolant and are dry-cut. Machining parameters are given in Table 4. The cutting parameters used in the experiments were determined as a result of preliminary tests, taking into account the cutting tool catalog values [20].

Table 4 Machining parameters and their levels

Parameters	Symbol	Level		
		1	2	3
Coolant	**A**	1 (Dry)	2 (Wet)	-
Speed (1/min)	**B**	5500	6000	6500
Feed rate, (mm/min)	**C**	4000	4500	5000
Depth of cut (mm)	**D**	0,2	0,4	0,6

Taguchi L18 (2^1 3^3) orthogonal array (OA) was used in this study. In the experimental design, two different cooling methods, three different speeds (5500; 6000, and 6500 m/min), three different feed rates (4000; 4500, and 5000 mm/min), and three different cutting depths (0.2, 0.4, and 0.6) were used for 18 cuttings. According to the surface roughness and machined surface hardness values obtained after the experiments, S/N ratios were calculated using the "smallest is best equation".

$$S/N = -10 \log \frac{1}{n} \sum_{i=1}^{n} y_i^2 \qquad (1)$$

2.4. Measuring Devices and Methods

The surface roughness values (Ra) obtained in the experiments were measured with the Mitutoyo SJ-210 surface roughness measuring device according to DIN EN ISO 16610-21. Surface roughness measurements were used in statistical analysis by taking the average of 5 different measurements taken on the samples (Figure 3). The surface hardness of the processed and untreated test samples was measured as $HV_{0.1}$ with the MICROBUL 1000-DN microhardness device (Figure 3). Surface hardness was also used in statistical analysis by taking the average of 5 different measurements taken from the sample surfaces.

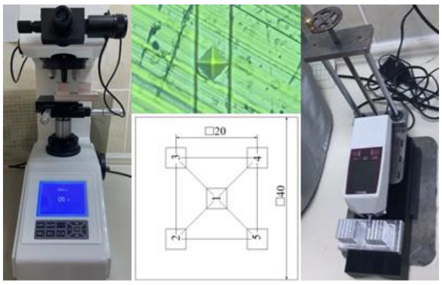

Figure 3. *Measurement locations, microhardness testing machine and surface roughness tester*

3. Results and Discussion

According to the experimental plan, the first 9 experiments were carried out using a coolant and at different cutting speeds, feed rates, and depth of cut values. The next experiments 9 to 18 were carried out under dry conditions. In the experiments carried out under coolant and dry conditions, a new cutting tool was used for each cutting speed.

3.1. Surface Roughness and Surface Hardness Results

The surface roughness and machined surface hardness results were obtained as a result of the experiments presented in Table 5.

3.2. Determination of the optimum cutting condition

Utilizing the S/N (Signal-to-Noise) ratio analysis, the optimal cutting performance in milling operations was ascertained. This analysis facilitated the determination of delta statistics and subsequent ranking based on the obtained results. Table 6 presents the mean outcomes, revealing that the depth of cut holds the foremost rank (rank 1) and exerts the most pronounced influence on surface roughness. This is followed by the speed parameter, the feed rate, and finally, the cooling factor, in terms of their impact on surface roughness.

Similarly, Table 7 delineates the mean results, showcasing that the speed parameter attains the highest rank (rank 1) and exhibits the most substantial effect on surface hardness. Subsequently, the cooling factor follows in influence, succeeded by the feed rate, and lastly, the depth of cut, regarding their impact on surface hardness.

This S/N ratio analysis, encapsulated in Tables 6 and 7, underscores the varying degrees of influence exerted by different cutting parameters on both surface roughness and surface hardness in milling operations. The rankings highlight the relative significance of these parameters in shaping the desired cutting performance outcomes.

The effects of cutting factors on Ra and Hv as a result of the experiments are shown in Figure .4. The factors used in the graphs are the first two factors that are most effective on Ra and HV. These factors were determined as a result of variance analysis.

Figure 5 and Figure 6 shows the main effect plot for the means of the S/N ratios of the surface roughness Ra and surface hardness $HV_{0.1}$. According to Figure 5, the first level of the cooling (A1), the third level of the speed (B3), the second level of the feed rate (C2), and the first level of the cutting depth (D1) results in the minimum values of the Ra.

According to Figure 6, the first level of the cooling (A1), the third level of the speed (B3), the first level of the feed rate (C1), and the second level of the cutting depth (D2) results in the minimum values of the $HV_{0.1}$.

The mean analysis (Table 6 and Table 7) suggests that the levels of the variables (A1, B3, C2, D1) (A1, B3, C1, D2) are the optimum levels for the minimum Ra and $HV_{0.1}$ respectively. This situation also be seen from the main effects plot for the S/N ratio in Figure 5 and Figure 6.

Table 5 Experimental surface roughness and hardness results with calculated S/N ratio

Test No:	A	B	C	D	Surface roughness (µm)	Predicted Ra (µm)	S/N ratio (dB)	Surface hardness ($HV_{0.1}$)	Predicted ($HV_{0.1}$)	S/N ratio (dB)
1	1	5500	4000	0,2	**0,86140**	0,93592	1,29590	**181,700**	204,550	-45,1871
2	1	5500	4500	0,4	**1,08000**	0,96039	-0,66848	**188,300**	190,657	-45,4970
3	1	5500	5000	0,6	**1,04680**	1,08874	-0,39727	**250,300**	219,139	-47,9692
4	1	6000	4000	0,2	**0,81580**	0,80829	1,76833	**158,067**	173,958	-43,9768
5	1	6000	4500	0,4	**0,84800**	0,83276	1,43208	**165,200**	160,065	-44,3602
6	1	6000	5000	0,6	**0,92175**	0,96111	0,70774	**166,150**	188,547	-44,4100
7	1	6500	4000	0,4	**0,94175**	0,94204	0,52129	**158,933**	148,250	-44,0243
8	1	6500	4500	0,6	**0,82025**	0,85865	1,72108	**169,200**	164,786	-44,5680
9	1	6500	5000	0,2	**0,70325**	0,65111	3,05781	**191,125**	179,022	-45,6263
10	2	5500	4000	0,6	**1,32525**	1,30135	-2,44596	**235,200**	236,218	-47,4287
11	2	5500	4500	0,2	**0,81980**	0,88207	1,72584	**237,833**	238,508	-47,5255
12	2	5500	5000	0,4	**1,15350**	1,11828	-1,24035	**232,300**	236,561	-47,3210
13	2	6000	4000	0,4	**1,03120**	1,09771	-0,26686	**218,000**	190,735	-46,7691
14	2	6000	4500	0,6	**1,00020**	1,01431	-0,00174	**193,300**	207,271	-45,7246
15	2	6000	5000	0,2	**0,90400**	0,80678	0,87663	**241,367**	221,507	-47,6535
16	2	6500	4000	0,6	**1,23350**	1,12360	-1,82278	**197,267**	195,456	-45,9011
17	2	6500	4500	0,2	**0,68425**	0,70432	3,29570	**205,200**	197,746	-46,2435
18	2	6500	5000	0,4	**0,83725**	0,94053	1,54290	**159,333**	195,799	-44,0461

***T_{Ra}** (Ra arithmetic mean)= 0,946 µm, **T_{HV}** (HV microhardness arithmetic mean)= 197,154 $HV_{0.1}$*

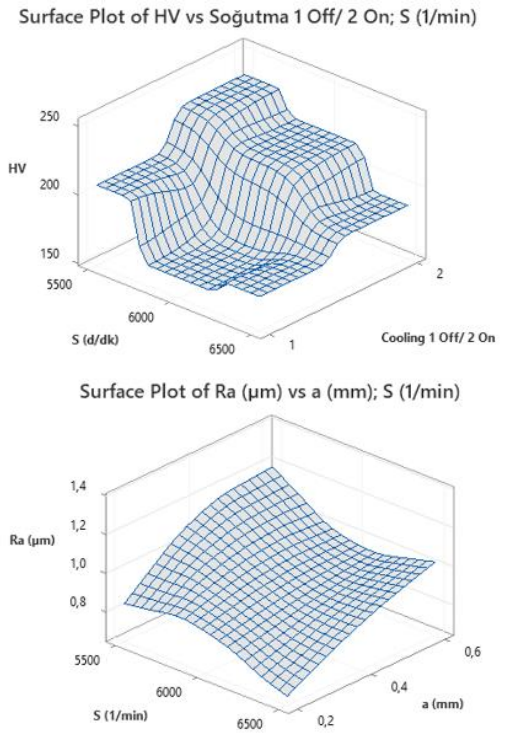

***Figure 4.** Effect of cutting factors on Ra and HV*

Table 6 Response table for means and significance for surface roughness- Smaller is better

Level	A	B	C	D
1	**0,8932**	1,0478	1,0348	**0,7981**
2	0,9988	0,9202	**0,8754**	0,9819
3		**0,87**	0,9278	1,058
Delta	0,1056	0,1777	0,1594	0,2599
Rank	**4**	**2**	**3**	**1**

Control factor optimal levels are shown in bold.

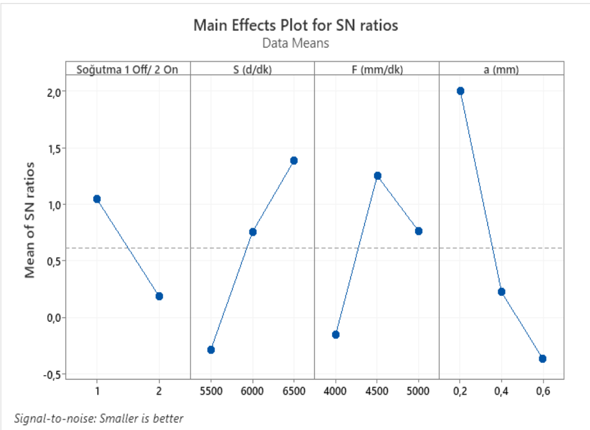

***Figure 5.** S/N ratios response graph for Ra*

Table 7 Response table for means and significance for surface hardness- Smaller is better.

Level	A	B	C	D
1	**181**	220,9	**191,5**	202,5
2	213,3	190,3	193,2	**187**
3		**180,2**	206,8	201,9
Delta	32,3	40,8	15,2	15,5
Rank	**2**	**1**	**4**	**3**

Control factor optimal levels are shown in bold.

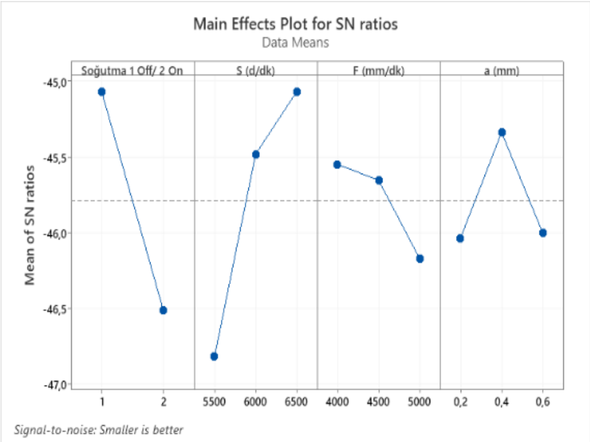

Figure 6. *S/N ratios response graph for each control factor*

3.3. Analysis of Variance (ANOVA)

The primary objective of employing Analysis of Variance (ANOVA) in this investigation was to discern the significant impact of milling parameters on the performance attributes exhibited by machined surfaces. This study employed ANOVA to scrutinize how cooling, spindle speed, feed rate, and depth of cut influence both surface roughness and surface hardness. The analysis was conducted at a 5% significance level and a 95% confidence interval. In ANOVA, the significance of control factors is determined by assessing the F-values associated with each control factor. The obtained ANOVA outcomes for surface roughness and surface hardness are outlined in Tables 8 and 9, respectively. Consequently, through the evaluation of percent additive rates, the depth of cut (a) was identified as the most impactful factor contributing to surface roughness (41.60%), while spindle speed emerged as the predominant factor influencing surface hardness (31.47%).

In summary, this study employed ANOVA as a statistical tool to discern the significant influences of various milling parameters on both surface roughness and surface hardness. The outcomes, delineated in Tables 8 and 9, underscored the substantial impact of the depth of cut and spindle speed on these respective performance characteristics, highlighting their predominant roles in shaping the machined surfaces' attributes.

Table 8 Analysis of Variance (Ra)

Source	DF	Contribution	Adj SS	Adj MS	P-Value
Cooling 1 Off/ 2 On	1	9,74%	0,05013	0,050134	0,024
S (1/min)	2	19,57%	0,10079	0,050397	0,012
F (mm/min)	2	15,38%	0,07922	0,039609	0,023
a (mm)	2	41,60%	0,21424	0,107119	0,001
Error	10	13,70%	0,07056	0,007056	
Total	17	100,00%			

Table 9 Analysis of Variance (Hv_{100})

Source	DF	Contribution	Adj SS	Adj MS	P-Value
Cooling 1 Off/ 2 On	1	27,37%	4698,8	4698,8	0,014
S (1/min)	2	31,47%	5401,8	2700,9	0,030
F (mm/min)	2	4,89%	839,0	419,5	0,480
a (mm)	2	5,40%	927,2	463,6	0,447
Error	10	30,88%	5300,5	530,1	
Total	17	100,00%			

3.4. Regression analysis

Regression analysis serves as a pivotal tool in modeling and analyzing diverse variables, particularly in exploring the relationships between a dependent variable and one or more independent variables. In the context of this study, regression analysis was employed to derive equations for estimating surface roughness. These estimations were formulated within a linear model framework. The calculated linear equations pertaining to surface roughness and surface hardness are presented in Tables 10 and 11, respectively.

This study harnessed regression analysis to establish predictive equations, specifically focusing on surface roughness estimation. These equations, formulated within a linear model structure, are encapsulated in Tables 10 and 11, providing a quantitative basis for estimating both surface roughness and surface hardness.

Table 10 Regression Equation for Ra

Cooling 1 Off/ 2 On		
1	Ra (μm)=2,182 - 0,000178 S (1/min) - 0,000107 F (mm/min) + 0,650 a (mm)	(2)
2	Ra (μm)= 2,287 - 0,000178 S (1/min) - 0,000107 F (mm/min) + 0,650 a (mm)	(3)

Table 11 Regression Equation for Hv_{100}

Cooling 1 Off/ 2 On		
1	HV= 358 - 0,0408 S (1/min) + 0,0152 F (mm/min) - 1,6 a (mm)	(4)
2	HV= 390 - 0,0408 S (1/min) + 0,0152 F (mm/min) - 1,6 a (mm)	(5)

3.5. Fitted plots assessment

Figure 7 illustrates the fitted plots comparing the predicted values against the actual values for the responses Ra and HV0.1. These plots depict the deviation between the actual and predicted values. Notably, the proximity of the residuals to the diagonal line indicates the significance of the model. This proximity suggests that the model adequately represents the data, affirming its statistical significance.

Furthermore, the Pearson correlation coefficients computed between the predicted and actual values for the responses Ra and HV0.1 were determined to be 0.87 and 0.70, respectively, with a p-value of 0.00. These coefficients signify a strong linear relationship between the predicted and actual values for both response variables. The high correlation coefficients, especially the value of 0.87 for Ra, denote a substantial association between the predicted and observed values, underscoring the reliability of the model in capturing and explaining the variability within the data. [21].

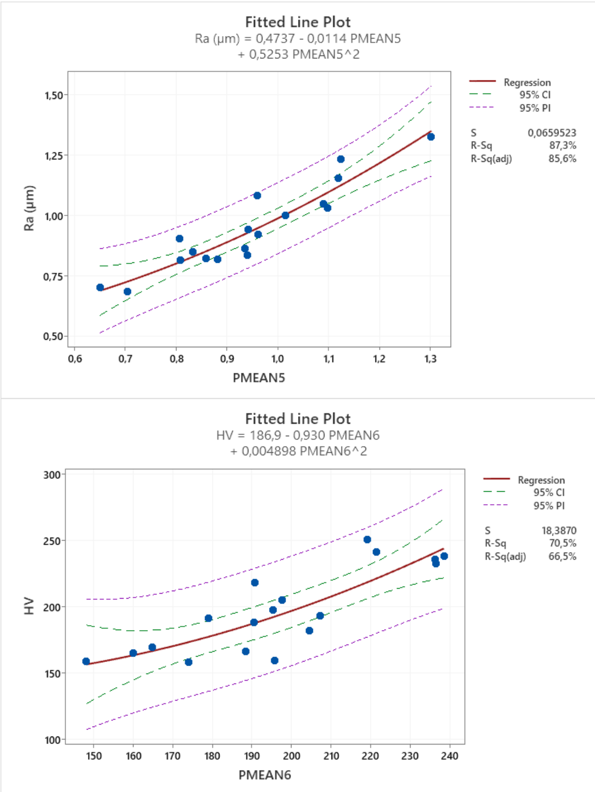

Figure 7. *Comparison of predicted values and experimental results for output parameters of Ra and* $Hv_{0.1}$

3.6. Estimation of surface roughness and surface hardness

In the Taguchi optimization technique, at least one verification experiment is required to verify the optimized condition [22]. Optimal results were obtained using the Taguchi approach. The estimated optimum surface roughness values (Rap) and surface hardness (RHv) were calculated using Equation (6) and Equation (7) respectively. The comparison of predicted values and experimental results for output parameters are given in Figure 7.

$$Rap = T_{Ra} + (A1 - T_{Ra}) + (B3 - T_{Ra}) + (C2 - T_{Ra}) + (D2 - T_{Ra}) \quad (6)$$

$$R_{Hv} = T_{Hv} + (A1 - T_{Hv}) + (B3 - T_{Hv}) + (C1 - T_{Hv}) + (D2 - T_{Hv}) \quad (7)$$

The average response values of surface roughness and hardness control factor of machined surfaces are presented in Table 6 and Table 7, respectively. In these equations; The arithmetic mean values of the optimum experimental conditions A1B3C2D1 for Ra and A1B3C1D2 for $HV_{0.1}$ are taken from these tables, respectively. T_{Ra} and T_{HV} were calculated using the data in Table 5. The estimated optimum values of R_{ap}= 0,599 and R_{Hv} = 148,238 were calculated using the relevant equations.

3.7. Confirmation run

Once the optimal levels for all control factors were determined, the subsequent crucial phase involved prediction and execution of a confirmation run. The amalgamation of these identified optimal levels across all factors is expected to yield the most favorable outcome in terms of SR magnitude, aiming for minimized Ra (surface roughness) and HV (surface hardness). However, to solidify this deduction, it's imperative to bolster these findings through the conduction of confirmation runs. The confirmation runs serve as a vital step to validate the anticipated outcomes based on the optimal factor levels. These runs aim to substantiate that the combination of optimal levels across all factors indeed produces the most desirable magnitude of SR, characterized by the attainment of the smallest Ra (reflective of superior surface roughness) and HV (indicative of the desired surface hardness). This validation through confirmation runs adds a crucial layer of assurance to the determined optimal levels and their anticipated impact on SR attributes.

The mean predictions were made in Minitab software, and the results are shown in Table 6 and Table 7. The optimal levels for the controllable factors for Ra were cutting condition at dry (A1), the speed at 6500 1/min (B3), feed rate at 4500 mm/min (C2), and depth-of-cut 0,2 mm (D1). The optimal levels for the controllable factors for HV were cutting condition at dry (A1), speed at 6500 1/min (B3), feed rate at 4000 mm/min (C1), and depth-of-cut 0,4 mm (D2).

Three samples were cut under the optimal parameter set up in the study for confirmation run. Table 12 shows the results of the confirmation run. All confirmation samples produced a closely similar result with the estimated optimum surface roughness (Rap= 0.599 µm) and surface hardness (RHv= 148,238) values. Therefore, the confirmation run indicated that the selection of the optimal levels for all the parameters produced the minimum surface roughness and minimum surface hardness [23].

Table 12 The prediction and results of the confirmation test

	Average surface roughness (µm) (A1B3C2D1)	Average Surface hardness (Hv_{100}) (A1B3C1D2)
Prediction	0,6235	152,96
Confirmation 1	0,742	168,5
Confirmation 2	0,78	157,75
Confirmation 3	0,648	155,25

4. Conclusion

This study addresses the investigation of how surface hardness and surface roughness of AISI 1050 steel material are affected by varying surface processing conditions during milling operations. The study explores how different milling parameters or techniques influence the surface properties of the steel material, specifically its hardness and roughness.

The following results were obtained:

- When the spindle speed increased from 6000 1/min to 6500 1/min and the feed rate increased from 4500 mm/min to 5000 mm/min, improvements in surface quality were observed in dry and wet machining conditions.
- It was determined that the effect of depth of cut on surface roughness was higher than other factors, and in the second place, the spindle speed was more effective than the other two factors.
- It has been observed that using coolant increases the surface roughness.
- In all experiments, the lowest surface roughness (Ra=0,68425) was obtained under dry machining conditions when 6500 1/min cutting speed, 4500 mm/min feed rate, and 0.2 mm cutting depth were applied.
- When all experiments were examined, the highest surface roughness (Ra= 1,32525) was observed under wet machining conditions when 5500 1/min cutting speed, 4000 mm/min feed rate, and 0.6 mm cutting depth were applied.
- When all experiments were examined, it was observed that the hardness of the samples processed under wet processing conditions was higher than that of the samples processed under dry conditions (Table 5).
- When the feed rate increased, the surface hardness increased in wet machining, while the surface hardness decreased in dry machining.
- In all experiments, the highest surface hardness ($HV_{0.1}$= 250,300) was observed under dry conditions when 5500 1/min cutting speed, 5000 mm/min feed rate, and 0.6 mm cutting depth values were applied.
- In all experiments, the lowest surface hardness ($HV_{0.1}$= 158,067) was observed under dry conditions when 6000 1/min cutting speed, 4000 mm/min feed rate, and 0.2 mm cutting depth values were applied.

Author Contribution

Data curation – İbrahim Savaş Dalmış (ISD); Formal analysis –ISD; Investigation - Serdar Osman Yılmaz (SOY); Experimental performance – Özdemir Berk Varal (OBV); Data collection - Beyza Avcı (BA); Processing – ISD and BA; Literature review - BA; Writing – ISD and BA; Review and editing – SOY and ISD.

Declaration of Competing Interest

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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