# OPTIMIZATION OF TECHNIQUES IN PARAMETERS OF TOOL LIFE AND SURFACE ROUGHNESS BY THE TAGUCHI METHOD

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**Abstract:** During this study, the impact and improvement of machining parameters on surface roughness and gear life during a turning operation was investigated by mistreatment the Taguchi technique. The experimental studies were conducted below varied cutting speeds, feed rates, and depths of cut. Associate in Nursing orthogonal array, the signal-to-noise {ratio/signal/noise ratio/signal/noise/S/N ratio} (S/N) ratio, and also the analysis of variance (ANOVA) were utilized to the study the performance characteristics within the turning of business Ti-6Al-4V alloy mistreatment CNMG 120408-883 insert cutting tools. The conclusions discovered that the feed rate and cutting speed were the foremost influential factors on the surface roughness and gear life, severally. The surface roughness was mainly associated with the cut- ting speed, whereas the axial depth of cut had the best impact on tool life.

Keywords Surface roughness, Tool life. Taguchi technique, Analysis of variance, Ti-6Al-4V.

## INTRODUCTION

Recent trends within the region trade are to extend the employment of metal alloys thanks to the outstanding mechanical properties that may be provided at crucial load-carrying locations in several military and industrial craft [1]. These alloys square measure typically used for a part which needs the best responsibility and, therefore, the surface roughness should be maintained. To boot, it’s essential to satisfy surface integrity needs mistreatment the cutlery material in Associate in nursing economic time-frame [2]. Turning is one among the elemental machining processes, particularly for the finishing of machined components. Usually, the choice of accept- able machining parameters is troublesome and depends heavily on the operators’ expertise and also the machining parameters tables provided by the machine-tool builder for the target material. Hence, the improvement of in operation parameters is of nice importance wherever the economy and quality of a machined half play a key role [3]. In recognizing the requirement to cut back the price and improve quality and productivity, corporation shave initiated total quality management (TQM). TQM could be a revolutionary management commitment, worker involvement, and also the use of applied mathematics tools. the standard engineering technique of Dr. Taguchi, using style of experiments (DOE), is one among the foremost vital applied mathematics tools of TQM for coming up with high-quality systems at reduced value. Taguchi strategies offer Associate in Nursing economical and systematic thanks to optimize styles for performance, quality, and cost. This technique has been used with success in coming up with reliable, high-quality product at low value in such areas as automotive, aerospace, and shopper physical science [4]. The purpose of this paper is to demonstrate Associate in Nursing application of Taguchi parameter style so as to spot the optimum surface roughness and gear life performance with a selected combination of cutting parameters in turning metal alloy.

**TABLE 1** chemical composition of Ti-6Al-4V alloy

| Ti | Al | V | Fe | O | C | N | H |
|---|---|---|---|---|---|---|---|
| 89.464 | 6.08 | 4.02 | 0.22 | 0.18 | 0.02 | 0.01 | 0.0053 |

**TABLE 2** Machining setting used in experiment

| | |
|---|---|
| Work piece material | Ti-6Al-4V |
| Hardness (HV) | 600 |
| Melting point (°C) | 1660 |
| Ultimate textile strength (Mpa) | 832 |
| Yield strength | 745 |
| Impact-toughness (J) | 34 |
| Modulus of elasticity (×106 Mpa) | 11.3 |

**TABLE 3** Experimental design using the $L_9$ orthogonal array and experimental results

| Symbol | Cutting parameter | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| A | Cutting speed (m/min) | 30 | 60 | 90 |
| B | Feed rate (mm/rev) | 0.15 | 0.25 | 0.35 |
| C | Depth of cut (mm) | 0.5 | 1 | 2 |

## ANALYSIS AND THE DISCUSSION OF EXPERIMENTAL RESULTS

### Analysis of the signal-to-noise ratio

**TABLE 4**

| Exp. no. | A | B | C | Surface roughness ($\mu$m) | Tool life (s) | S/N ratio for surface roughness | S/N ratio for tool life |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1.198 | 2458 | −5.6570 | 67.8116 |
| 2 | 1 | 2 | 2 | 3.365 | 2176 | −10.5397 | 66.7532 |
| 3 | 1 | 3 | 3 | 11.428 | 1531 | −21.1594 | 63.6995 |
| 4 | 2 | 1 | 2 | 2.785 | 742 | −8.8965 | 57.4081 |
| 5 | 2 | 2 | 3 | 5.136 | 670 | −14.2125 | 56.5215 |
| 6 | 2 | 3 | 1 | 8.634 | 360 | −18.7242 | 51.1261 |
| 7 | 3 | 1 | 3 | 4.900 | 893 | −13.8039 | 59.0170 |
| 8 | 3 | 2 | 1 | 2.131 | 200 | −6.5717 | 46.0206 |
| 9 | 3 | 3 | 2 | 4.416 | 344 | −12.9006 | 50.7312 |

Table 4 shows the experimental results for the surface roughness and tool life and corresponding S/N ratios using Eqs. 2 and 3. The mean S/N ratio for each level of the other machining parameters was calculated in a similar manner and the results are shown in Tables 5 and 6, respectively. Additionally, the total mean S/N ratio is computed by averaging the total S/N ratios. Based on the data presented in Table 5, the optimal machining performance for the surface roughness was obtained at 90 m/min cutting speed (Level 3), 0.15 mm/rev feed rate (Level 1), and 0.5 mm depth of cut (Level 1) settings. Figure 2 presents plots of the S/N ratio for the three control parameters A, B, and C, studied at three levels for the surface roughness.

The S/N S=$N_{SB}$ 1 —10 log

Response table mean signal-to-noise (S/N) ratio for surface roughness
factor and significant interaction Symbol Cutting parameter Mean S/N
ratio Level 1 Level 2 Level 3 max−min

A Cutting speed −12.452 −13.944 −11.092a 1.36

B Feed rate −9.452a −10.441 −17.595 8.143

C Depth of cut −10.318a −10.779 −16.392 6.074

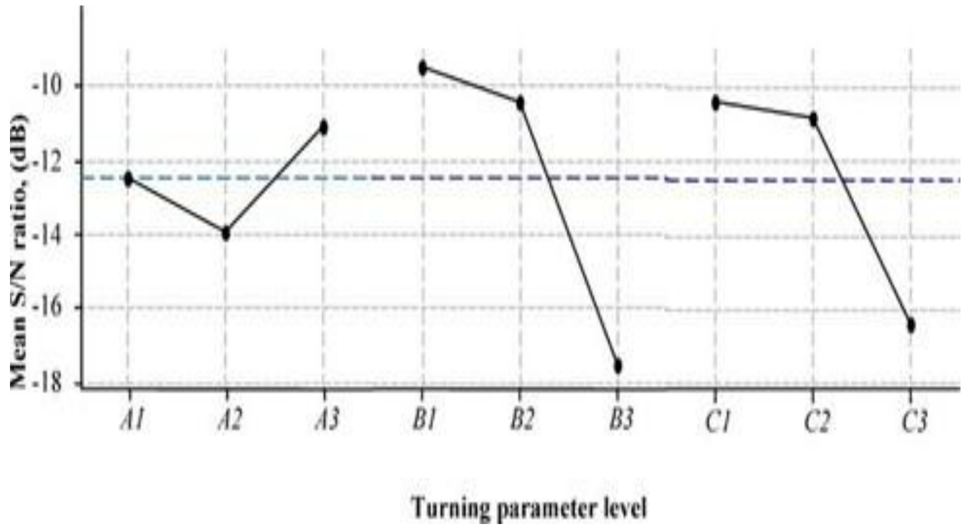



**FIGURE 1** Mean signal-to-noise (S/N) ratio graph for surface roughness

Comparison of actual and predicted and residual and predicted S/N ratios of surface rough- ness using regression analysis

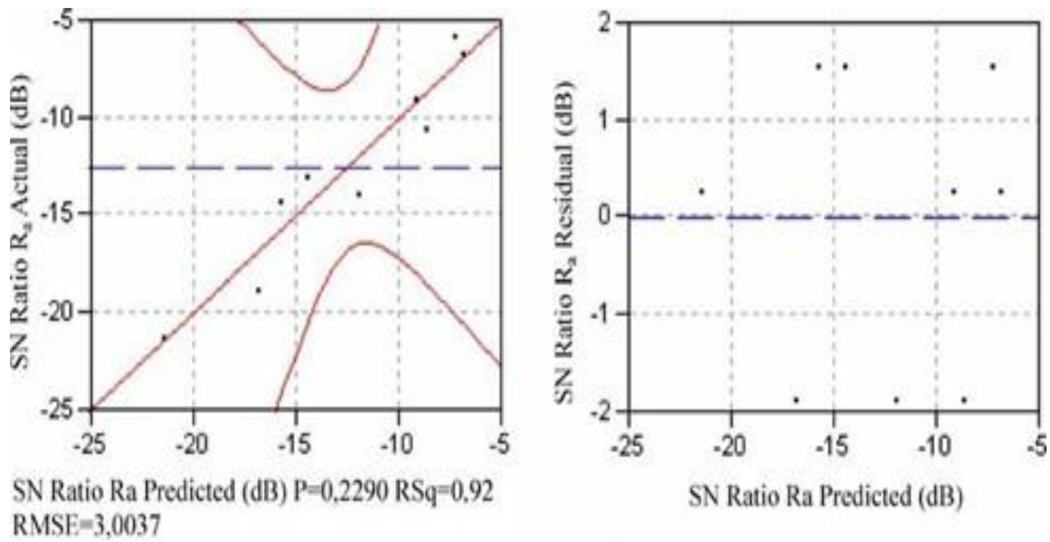



**FIGURE 2** Comparison of actual and predicted and residual and predicted S/N ratios of surface roughness using regression analysis

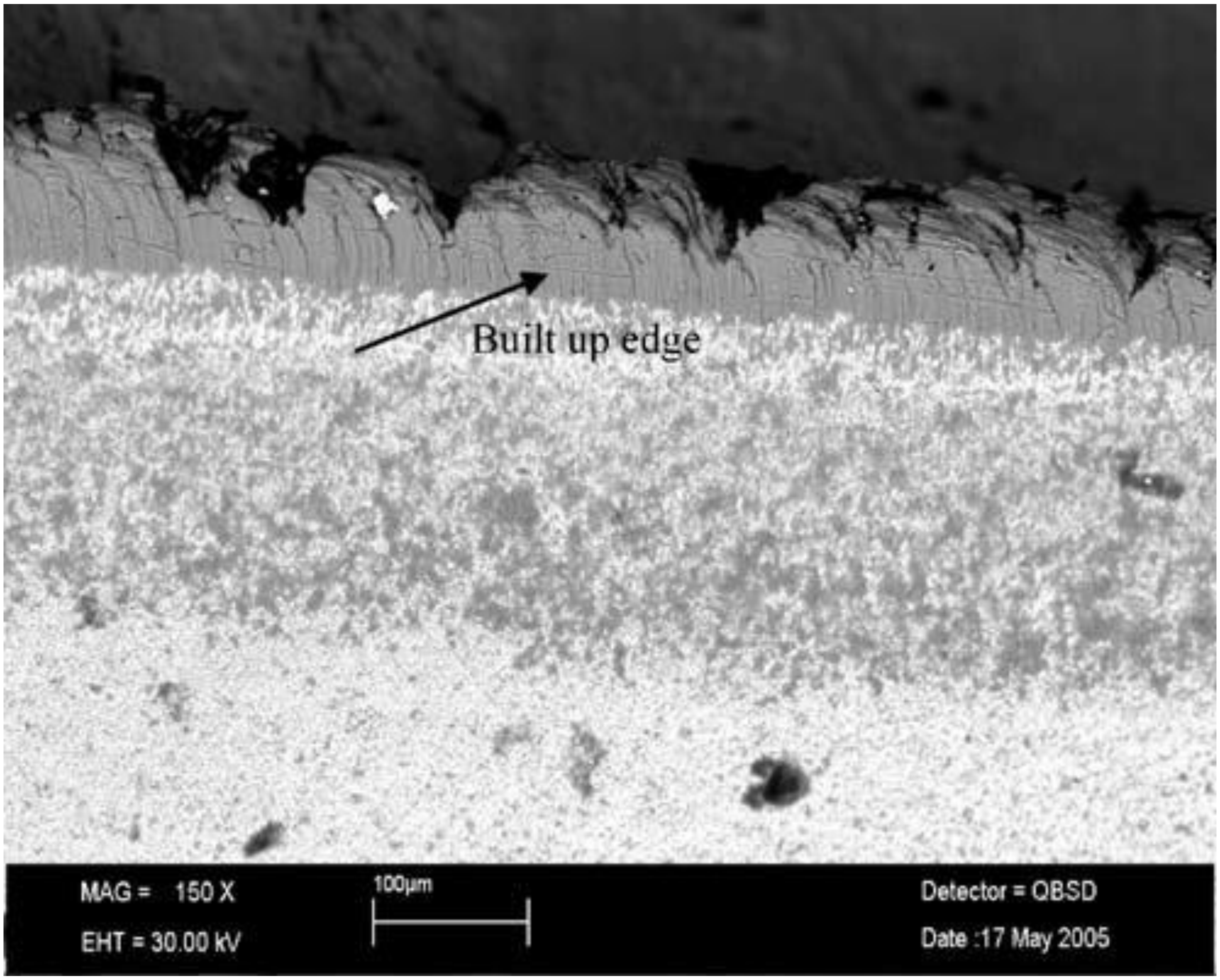
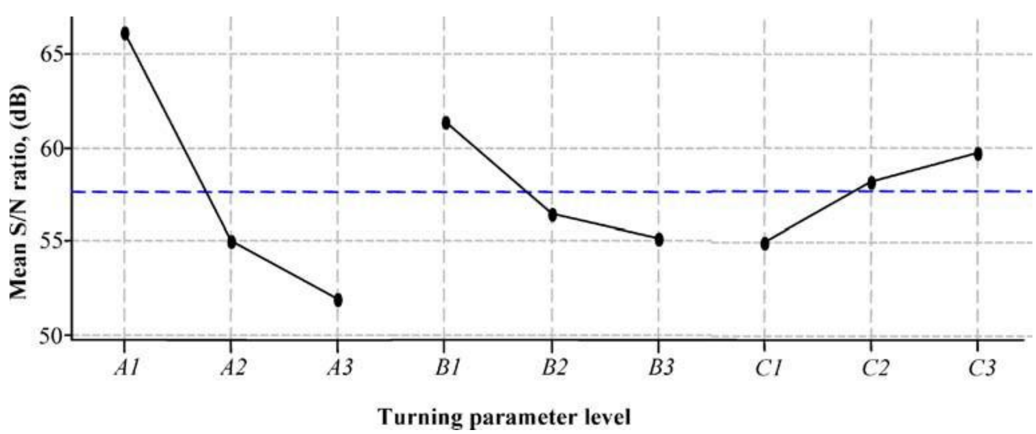



**FIGURE 3** Scanning electron microscopy (SEM) image of the cutting tool showing the built up edge (BUE) after machining Ti-6Al-4 V alloy (V=60 m/min, a=1 mm, f=0.25 mm/rev)



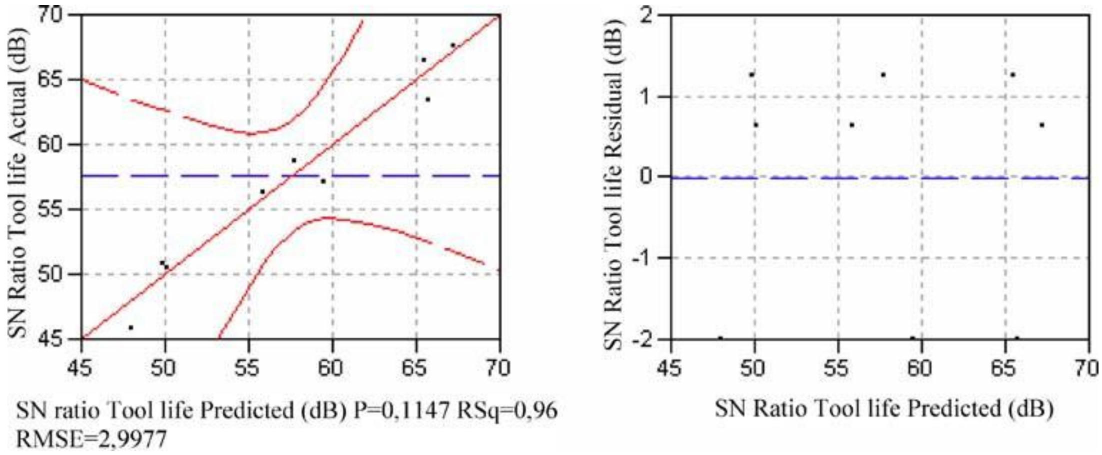



**FIGURE-5** Comparison of actual and predicted and residual and predicted S/N ratios of tool life using regression analysis

**TABLE 5** Results of analysis of variance (ANOVA) for surface roughness

| Machining parameter | Degrees of freedom | Sum of squares | Mean square | F ratio | Contribution (%) |
|---|---|---|---|---|---|
| Cutting speed | 2 | 12.2 | 6.1 | 2.606 | 5.62 |
| Feed rate | 2 | 118.4 | 54.2 | 23.162 | 54.50 |
| Depth of cut | 2 | 68.6 | 34.3 | 14.658 | 31.57 |
| Error | 2 | 4.680 | 2.340 | | 8.31 |
| Total | 8 | 203.88 | | | 100 |

**TABLE 6** Results of ANOVA for tool life

| Machining parameter | Degrees of freedom | Sum of squares | Mean square | F ratio | Contribution (%) |
|---|---|---|---|---|---|
| Cutting speed | 2 | 332.770 | 166.385 | 71.104 | 73.69 |
| Feed rate | 2 | 65.129 | 32.564 | 13.916 | 14.42 |
| Depth of cut | 2 | 35.720 | 17.860 | 7.632 | 7.91 |
| Error | 2 | 4.680 | 2.340 | | 3.99 |
| Total | 8 | 438.299 | | | 100 |

**TABLE 7** Results of the confirmation experiment for tool life

| | | Prediction | Experiment |
|---|---|---|---|
| Level | A2B2C2 520 | A1B1C3 | A1B1C3 1,746 |
| Surface roughness ($\mu$m) | | | |
| S/N ratio (dB) | 54.3201 | 68.8079 | 64.8409 |
| Improvement of S/N ratio | | 10.520 | |

**TABLE 8** Initial cutting parameters Optimal cutting parameters

| | | Prediction | Experiment |
|---|---|---|---|
| Level | A2B2C2 | A3B1C1 | A3B1C1 |
| Surface roughness ($\mu$m) | 4.215 | −5.2200 | 1.726 |
| S/N ratio (dB)<br>Improvement of S/N ratio | −12.4960 | 7.7552 | −4.7408 |

## CONCLUSION

In this study, an investigation on the surface roughness and tool life based on the parameter design of the Taguchi method in the optimization of turning operations has been investigated and presented. Summarizing the mean experimental results of this study, the following generalized conclusions can be drawn:

1. Based on the analysis of variance (ANOVA) results, the highly effective parameters on both the surface roughness and tool life were determined. Namely, the feed rate parameter is the main factor that has the highest importance on the surface roughness and this factor is about 1.72 times more important than the second ranking factor (depth of cut). The cutting speed does not seem to have much of an influence on the surface roughness.
2. The tool life is affected strongly by the cutting speed (73.69%), whereas the feed rate and depth of cut have a significant statistical influence.
3. Based on the signal-to noise ratio results in Tables 5 and 6, we can conclude that the A3B1C1 (V=90 m/min, f=0.15 mm/rev, a=0.5 mm) and A1B1C3 (V=30 m/min, f=0.15 mm/rev, a=2 mm) settings are the optimal machining parameters for surface roughness and tool life, respectively.
4. The improvement of the surface roughness from the initial machining parameters to the optimal machining parameters is about 244%, whereas the tool life is improved by 335%.
5. The regression results showed that the deviations between the actual and predicted S/N ratios of both surface roughness and tool life are small for each parameter.

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