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Impact of Cutting Speed on CNC Turning Machines: A Signal to Noise Analysis

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Abstract: ***This study investigates the impact of cutting speed on the performance characteristics of a mild steel type SC45 workpiece using the signal - to - noise SN ratio method. The results indicate that cutting temperature and flank wear increase with cutting speed, while surface roughness decreases. These findings provide valuable insights for optimizing CNC turning processes.***

Keywords: cutting speed, (S/N) ratio**,** temperature, surface roughness, flank wear, CNC turning machines

1. Introduction

The signal - to - noise ratio measurement is defined as the ratio of signal power to the noise power corrupting the signal. It represents the defining factor when used for quality of measurement. It is also used to measure the performance characteristic deviation from the desired value **[1].** A high (S/N) ratio ensures clear and good results with low distortions caused by noise, in addition, the better the (S/N) ratio, the better the signal stands out, also, the better its quality, the better the ability to obtain the results desired. A ratio higher than 1: 1 indicates more signal than noise**. Narayan and Puneethb [2]** studied signal to noise ratios for surface roughness, material removal rate and machining time for Al 7050 alloy to find the optimum parameter setting. The S/N ratio values of the surface roughness are calculated using the smaller the better characteristics. Taguchi recommends analyzing data using the S/N ratio that will offer two advantages; it provides guidance for selection the optimum level based on least variation around on the average value, which closest to target, and also it offers objective comparison of two sets of experimental **Basil M. Eldhoseet. al [3]** studied the desired characteristic for surface roughness using lower the better ratios (smaller is better). Low surface roughness is obtained at speed 160, feed 0.1, and depth of cut 0.6. In the analysis, speed is shown as the most influencing parameter followed by depth of cut and feed. **A. P. D. Salmanet. al. [4]** studied optimizing of cutting parameters of EN - 46 by using Taguchi technique in CNC Turning. The experiments are conducted by using Taguchi L9 orthogonal array method. Signal - to - Noise ratio and Analysis of Variance (ANOVA) is used to analyses the effect of cutting parameters on surface roughness and material removal rate. By high performance, good machinability better surface finish, lesser rate of tool wear, higher material removal rate, faster rate of production etc. the S/N ratio is used (the lower is the better methodology) because the desired values of output performance parameters must be as low as possible. The minimum value can be achieved when the value of the S/N ratio is high; and this gives better results of output.

In paper [5] the experiment was conducted to optimize the cutting parameters for turning of Aluminium alloy Al 7050 on a CNC machine. The Taguchi analysis using Signal to Noise Ratios for each parameter (i. e. Surface roughness, Material removal rate and machining time) was done to find the optimum parameter setting. The data collected show that the surface roughness was minimum for a speed of 500 rpm and a feed of 0.09 mm/rev, material removal rate was maximum for a speed of 2000rpm and a feed rate of 0.09 mm/rev and machining time was minimum for a speed of 500 rpm and a feed of 0.09 mm/rev.

2. How to Calculate S/N Ratio

The loss function for the lower unit gives better performance characteristics, and is used for performance characteristics in the analysis of the S/N ratio. This can be expressed as in Equation (1) [**1**] and [**6]**

$$\text{Lij} = \frac{1}{n}\sum_{k=1}^{n} \text{y2 ijk} \quad (1)$$

where Lij is the loss function of the i^{th} performance characteristic in the j^{th} experiment, yijk is the experimental value of the i^{th} performance characteristic in the j^{th} experiment at the k^{th} trial, and n is the number of trials.

The loss function Lij for the ith performance characteristic in the j^{th} experiment can be transformed into an S/N ratio, and expressed as Equation (2).

$$\text{S/N Ratio} = -10 \log (\text{Lij}) \quad (2)$$

The evaluation of temperature, surface roughness and flank wear performed using S/N rario analysis is used to determine which settings of the controllable factors results in the mean as close as possible to the desired target, and a maximum value of the signal - to - noise (S/N) ratio.

3. Experimental Results Analysis using S/N Ratio

Based on the CNC turning experimental results, it can be calculate the S/N ratio for temperature, surface roughness and flank wear under different cutting conditions effect such as cutting speed, feed rate and depth of cut. The experimental results can be arrange and prepare to S/N ratio analysis as in Table 1: -

Table 1: Experimental results of s/n ration analysis

Trail	Vc (m/min)	T (C°)	Ra (µm)	W (mm)
1	140	540	3.21	0.35
2	140	490	3.97	0.29
3	140	320	2.4	0.25
4	120	506.29	4.1	0.29
5	120	431	3.6	0.28
6	120	442.72	3	0.26
7	100	160.5	2.75	0.22
8	100	219	2.20	024
9	100	200	1.02	0.26
10	60	157	2.62	0.18
11	60	152.5	0/26	0.10
12	60	153.3	0.78	0/16
13	40	171	0.87	0.06
14	40	150	2.57	0.08
15	40	143	0.27	0.07

The effects of cutting parameters on performance characteristics and S/N ratios can be obtaining as shown in details below: -

4. Influence of Cutting Speed on Performance Parameters

4.1 Influence of Cutting Speed on Temperature

Depending on the experimental results of Table 1, the variance of S/N ratio and temperature with cutting speed is shown as in Table 2:

Table 2: Variance of S/N ratio and temperature with cutting speed

Vc (m/min)	Mean T (°C)	S/N ratio (dB)
140	(540 + 490 + 320) / 3 = 450	- 53
120	(506.29+432+442.72) /3 = 460	- 53.25
100	(160.5+219+200) / 3 = 193.16	- 45.71
60	(157+152.5+153.3) / 3 = 154.26	- 48.14
40	(171+150+148) / 3 = 156.3	- 43.87

Variance of S/N ratio and temperature with cutting speed can be shown as in Figure 1:

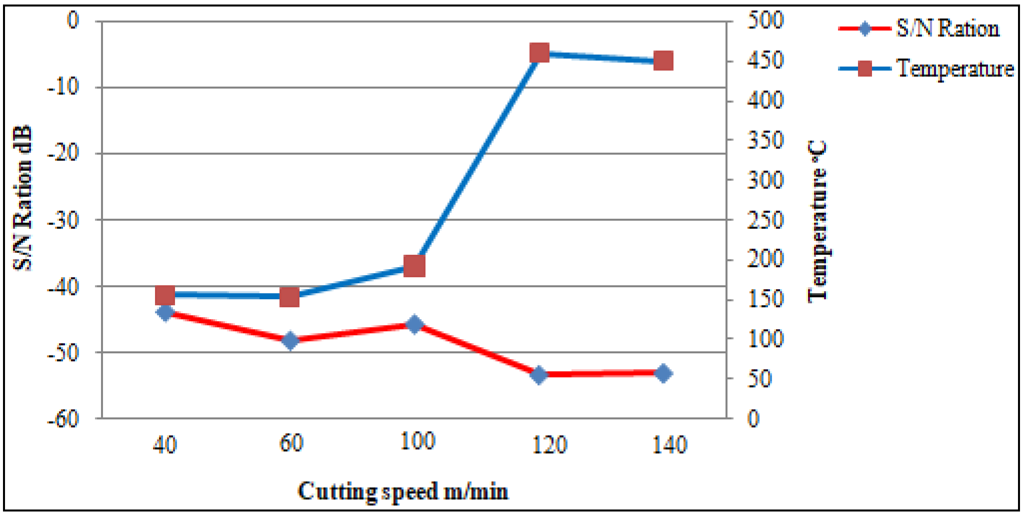

Figure 1: Variance of S/N Ratio and Temperature with Cutting Speed

Figure 1 indicates that the cutting temperature increase with cutting velocity and the maximum value of S/N ratio occurs at cutting speed (40 m/min), which means that the best temperature can be obtained at this velocity and equal to 156.3°C.4.**2**

Influence of Cutting Speed on Surface Roughness

Depending on the results of Table 1, variance of S/N ratio and roughness with cutting speed is shown in Table 3: -

Table 3: Variance of S/N Ratio and Roughness with Cutting Speed

Vc (m/min)	Mean Ra (µm)	S/N ratio (dB)
140	1.22	- 1.72
120	1.23	- 1.79
100	1.99	- 5.97
60	3.19	- 10.07
40	3.56	- 11.02

Variance of S/N ratio and roughness with cutting speed is shown as in Figure 2: -

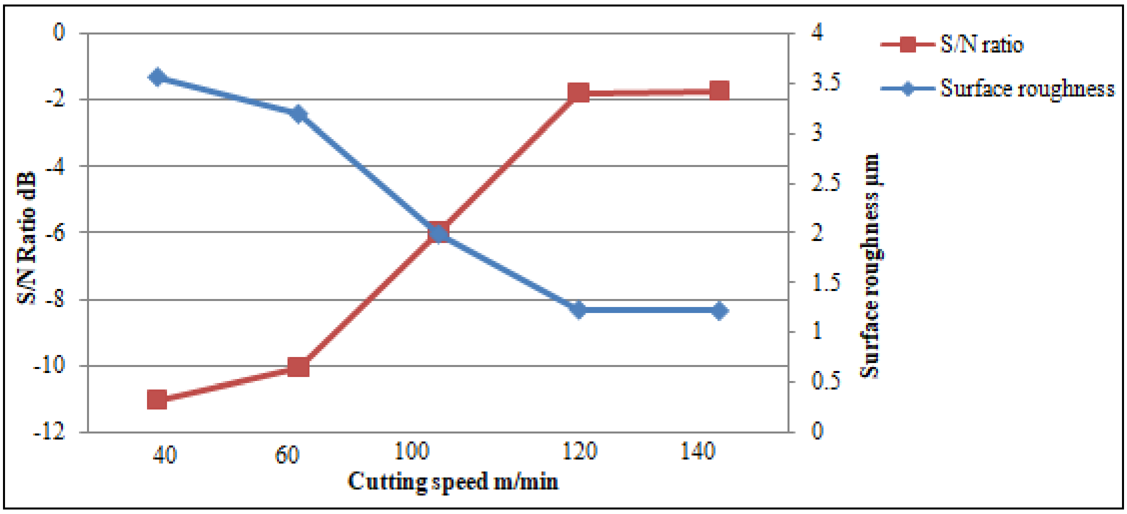

Figure 2: Variance of S/N Ratio and Roughness with Cutting Speed

Figure 2 indicates that the surface roughness decrease with the cutting velocity increase and the maximum value of S/N occurs at cutting speed (140 m/min), which means that the best surface roughness can be obtained at this speed and equal to 1.22 µm.

4.3Influence of Ctting Speed on Flank Wear

Depending on the results of Table 1, the variance of S/N ratio and flank wear with cutting speed is shown in Table 4: -

Table 4: Variance of S/N Ratio and Flank Wear with Cutting Speed

Vc (m/min)	Mean W (mm)	S/N ratio (dB)
140	0.29	10.75
120	0.27	11.37
100	0.24	12.39
60	0.14	17
40	0.07	23.09

Variance of S/N ratio and flank wear with cutting speed is shown as in Figure 3:

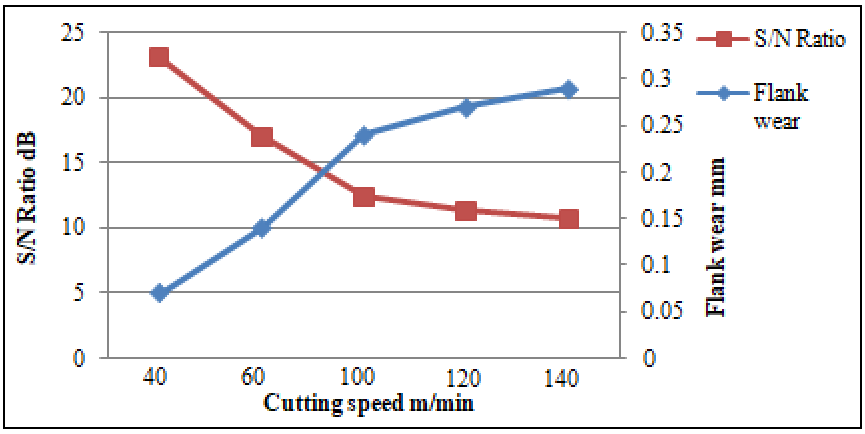

Figure 3: Variance of S/N Ratio and Flank Wear with Cutting Speed

Figure 3 indicates that the flank wear increases with the cutting velocity increasing, and maximum value of S/N is at cutting speed (40 m/min), which means that the best flank wear value can be obtained at this speed and equal to 0.07 mmto (0.16 mm).

5. Conclusions

The study reveals that cutting speed significantly impacts the performance characteristics of a mild steel work piece. Specifically, cutting temperature and flank wear increase with cutting speed, while surface roughness decreases. These insights are crucial for optimizing CNC turning processes.

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