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ANALYSIS OF THE EFFECT OF MACHINING VARIABLES ON SURFACE ROUGHNESS AND VIBRATION AMPLITUDE IN TURNING AISI 1045 STEEL USING THE TAGUCHI METHOD

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Abstract: *The development of the manufacturing industry is growing very rapidly so that the products of the manufacturing industry must have high quality, especially machining products such as turning products. This research investigates the effect of turning parameters, namely feed and spindle rotation on surface roughness and vibration amplitude of turning AISI 1045 steel using carbide tools. Surface roughness measurements were taken using an OLS4100 Microscope and vibration amplitude was measured using a Vibxpert II. From the results of the analysis conducted, the feed factor is the most significant factor on the results of surface roughness and vibration amplitude. The most optimal machining parameters for surface roughness are feed 0.1 mm/put (lvl 1), spindle speed 400 rpm (lvl4) with a surface roughness value of 4.757 µm. The most optimal machining parameters for vibration amplitude are feed 0.1 mm/put (lvl 1) and spindle speed 100 rpm (lvl 1) with a vibration amplitude value of 0.11 m/s.*

Abstrak: Perkembangan Industri manufaktur berkembang sangat pesat sehingga hasil Produk dari industri manufaktur harus memiliki kualitas yang tinggi, terutama produk hasil permesinan seperti produk pembubutan. Penilitian ini menyelediki pengaruh dari parameter pembubutan yaitu feed dan putaran spindel terhadap kekasaran pemukaan dan amplitudo getaran pembubutan baja AISI 1045 dengan menggunkan pahat karbida. Pengukuran kekasaran permukaan dilakukan menggunakan Microscope OLS4100 dan amplitudo getaran diukur menggunakan vibxpert II. Analisis yang dilakukan dari hasil pengukuran menggunakan perangkat lunak Minitab Statistical Software 22. Dari hasil analisis yang dilakukan, faktor feed merupakan faktor yang paling signifikan terhadap hasil kekasaran permukaan maupun amplitudo getaran. Parameter permesinan yang paling optimal terhadap kekasaran permukaan yaitu adalah feed 0.1 mm/put (lvl 1), kecepatan spindle 400 rpm (lvl4) dengan nilai kekasaran permukaan 4.757 µm. Parameter permesinan yang paling optimal terhadap Amplitudo getaran yaitu feed 0.1 mm/put (lvl 1) dan kecepatan spindle 100 rpm (lvl 1) dengan nilai amplitudo getaran adalah 0.11 m/s.

INTRODUCTION

Machining is one of the most common manufacturing processes found in the industrial world. Today's industry requires quality machining, high production safety, low production costs and short machining times. Machine operators are often expected to utilize experience and workshop guidance to determine the right machining parameters to get the most optimal production results. The rapid development of the manufacturing industry has also resulted in economic, environmental and social changes ranging from global warming to hazardous waste generation.

Conventional machines are usually controlled by hand wheels or levers. These machines take more time to make a component and require humans as controllers. This makes the products produced very expensive and the quality of the products varies according to the skill of the human operating the machine. Significant efforts have been put forward by several researchers in understanding and modeling surface quality, material removal rate which is a factor affecting machining time and cost, tool wear development and tool model development in metal cutting. Surface roughness is one of the important aspects in mechanical design such as wear resistance, corrosion, fatigue strength and heat conducting ability. The vibration generated in the turning process produces a large cutting force that can damage the machine, cutting tool and workpiece.

The use of carbon steel in the industrial world is very widely used because it has a continuous cycle and is 100% recyclable, carbon steel is also one of the most researched materials in the manufacturing science family for more than half a century. Aisi 1045 steel is the most commonly used steel because it is relatively cheap and has a low tensile strength so it is easy to process and apply in many things such as shafts, gears and piston connecting rods. Most studies on machining show that the machining performance most considered by researchers are surface roughness, tool life, cutting temperature and material removal rate which affect production costs [6]. The focus of this research is to develop a statistical model for using the main cutting parameters of cutting speed and feed rate on AISI 1045 Steel workpiece.

METHOD

The material used in this research is AISI 1045 steel. This steel is recyclable and has almost an unlimited life cycle. AISI 1045 steel is widely used in various industries such as construction, transportation, structural design, automotive electrical etc. The material removal rate is a function of the expected productivity during the machining process. A total of 12 experiments will be conducted according to the experimental design. The cutting length for each process is 60 mm, 10 mm clearance and a length of 30 mm is provided to clamp the workpiece into the lathe chuck. Each workpiece was 100 mm long and 25.4 mm in diameter. The workpieces were cut to a depth of 0.5 mm to remove any rust or hardened layer from the surface and to minimize the effect of inhomogeneity on the experimental results. This research was conducted using an HMT lathe with a carbide tool. The chemical composition and mechanical properties of the workpieces used were tested in the Physical Metallurgy laboratory as shown in the following tables.

Table 3.1. Chemical composition of AISI 1045 steel

No	Unsur	Persentase(%)
1	Carbon	0.45
2	Mangan	0.75
3	Fosfor	0.04
4	Belerang	0.05
5	Silikon	0.16

Table 3.2. Mechanical properties of AISI 1045 steel

No	Sifat mekanik	Nilai
1	Density	7.8 kg/m3
2	Elastic Modulus	205 Gpa
3	Yield Strength	505 Mpa
4	Tensile Strength	585 Mpa
5	Hardness	170 HB

1. Machine Tool

   Turning is done using HMT Center Lathe. The workpiece was held with a chuck and tailstock as shown in figure 3.1 below:

Figure 3.1. HMT Lathe

2. Carbide Chisel

   Carbide chisels are the cutting tools used in this research. Inserts used in accordance with ISO TNMG which have a nose radius of 0.4mm are mounted on a holder. The carbide insert mounted on the holder is shown below in figure 3.2

Figure 3.2: Carbide Chisel

3. AISI 1045 steel

   AISI 1045 steel is the material used in this research. The steel used measures 100 mm in length and 25.4 mm in diameter as shown below in Figure 3.3.

Figure 3.3. AISI 1045 steel

4. Experimental Design

   Experiments were conducted using an HMT lathe. The material used in the study is AISI 1045 steel so that the appropriate tool used to cut steel is a carbide tool. Cutting speed (Vc) and mechanical motion (f) are the input parameters selected for this study. Surface roughness (Ra) and vibration amplitude are characteristics that are assessed to determine the effect of the resulting machining parameters. The machining parameters in the study can be seen in table 3 below.

Table 3.3. Machining Parameters

Level	Spindle Speed (rpm)	Feed Rate (mm/rev)
1	100	0.1
2	200	0.22
3	300	0.35
4	400	0.44

Turning variables in this study are based on predetermined machining parameters. The turning variables can be seen in table 3.4 below.

Table 3.4. Turning variables

No	Feed (mm/put)	a (mm)	n(rpm)
1	0.1	1	100
2	0.1	1	200
3	0.1	1	300
4	0.1	1	400
5	0.22	1	100
6	0.22	1	200
7	0.22	1	300
8	0.22	1	400
9	0.35	1	100
10	0.35	1	200
11	0.35	1	300
12	0.35	1	400
13	0.44	1	100
14	0.44	1	200
15	0.44	1	300
16	0.44	1	400

5. Surface Roughness Determination

   Surface roughness in turning results is one of the factors that determine quality and is also a factor in the occurrence of cracks and corrosion in a product. Surface roughness (Ra) is the dependent variable and is measured using an OLS4100 Microscope. Surface roughness is measured at three different points on each workpiece.

6. Determination of Vibration Amplitude

   Vibrations that occur in the turning process can create large cutting forces that can cause damage to the machine, tool, product quality and can cause noise that disturbs the environment. Vibration is also the dependent variable in this study and is measured using Vibxpert II.

RESULT AND DISCUSSION

Results

1. Surface Roughness

   The surface roughness of the turning results was measured on each of the 3 sample surfaces using the Laser 3D Measuring Laser Microscope OLS4100, then each of the 3 measurement results per sample was averaged. Roughness measurement results can be seen in table 4.5 below.

Table 4.5. Surface Roughness Value

NO	Surface Roughness (µm)			
	T1	T2	T3	Average
1	6.612	6.672	6.741	6.675
2	6.101	6.025	6.014	6.047
3	5.418	5.481	5.461	5.453
4	4.761	4.729	4.781	4.757
5	7.781	7.735	7.791	7.769
6	7.082	7.145	7.125	7.117
7	6.471	6.41	6.491	6.457
8	5.871	5.916	5.891	5.893
9	8.917	8.951	8.928	8.932
10	8.341	8.329	8.361	8.344
11	7.743	7.685	7.782	7.737
12	6.929	6.946	6.918	6.931
13	9.892	9.916	9.871	9.893
14	9.273	9.291	9.259	9.274
15	8.581	8.571	8.613	8.588
16	7.927	7.951	7.893	7.924

2. Vibration Amplitude

   Vibration Amplitude is measured using Vibxpert II, the sensor is attached to the tool then the data is processed using the OMNITREND application. The results of vibration amplitude data processing can be seen in table 4.6 below.

Table 4.6: Vibration Amplitude Value

NO	rms	FFT(mm/s)
1	0.68	0.11
2	1.62	1.14
3	1.82	0.54
4	2.24	1.52
5	0.99	0.41
6	2.04	1.14
7	2.88	1.93
8	3.97	9.8

9	0.85	0.36
10	1.71	0.34
11	2.44	1.05
12	1.14	0.57
13	0.85	0.19
14	1.41	0.57
15	2.49	1.4
16	0.59	0.065

3. Taguchi Analysis

Taguchi analysis was conducted using Minitab Statistical Software 22. In Table 4.7 below, it can be seen that the turning parameter that has the most influence on the roughness value of the turning surface is the feed.

Table 4.7. Response Table for Signal to Noise Ratios (Surface Roughness)

Level	Rpm	Feed
1	-18.31	-15.1
2	-17.61	-16.62
3	-16.85	-18.01
4	-15.94	-18.98
Delta	2.37	3.88
Rank	2	1

In Table 4.8 below, it can be seen that the turning parameter that has the most influence on the turning vibration amplitude value is the feed.

Table 4.8. Response Table for Signal to Noise Ratios (Vibration Amplitude)

Level	rpm	Feed
1	12.5538	4.9373
2	2.9942	-4.7324
3	-0.9263	5.6758
4	1.2907	10.0317
Delta	13.4802	14.764
Rank	2	1

The signal to noise ratio (S/N Ratio) effect plots shown in Figures 4 and 5 below were used to determine the optimal values for each parameter during the turning process for surface hardness and vibration amplitude.

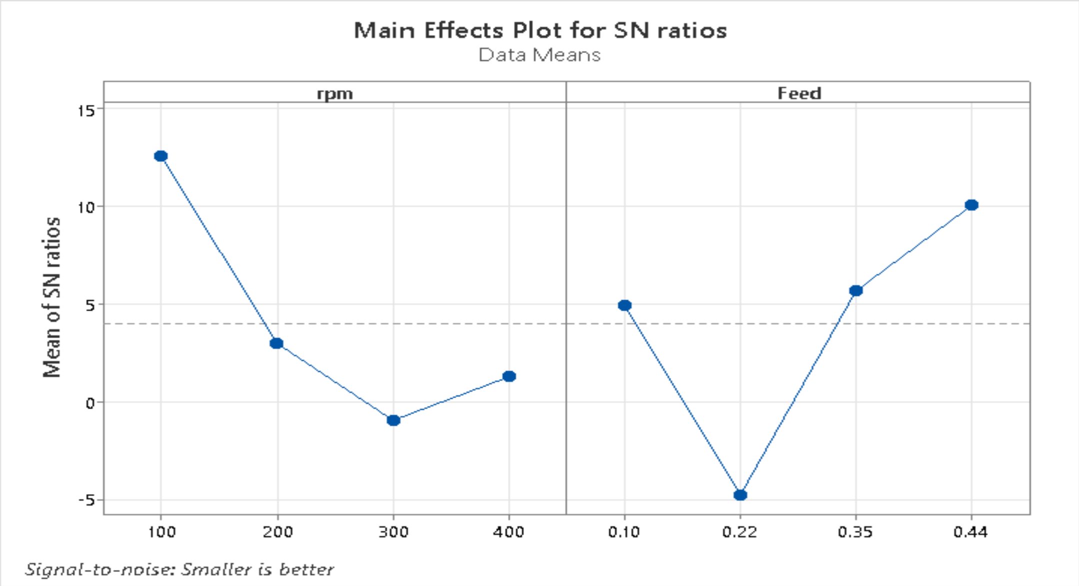

Figure 4.4 . Main effects plot for SN ratios (Surface Roughness)

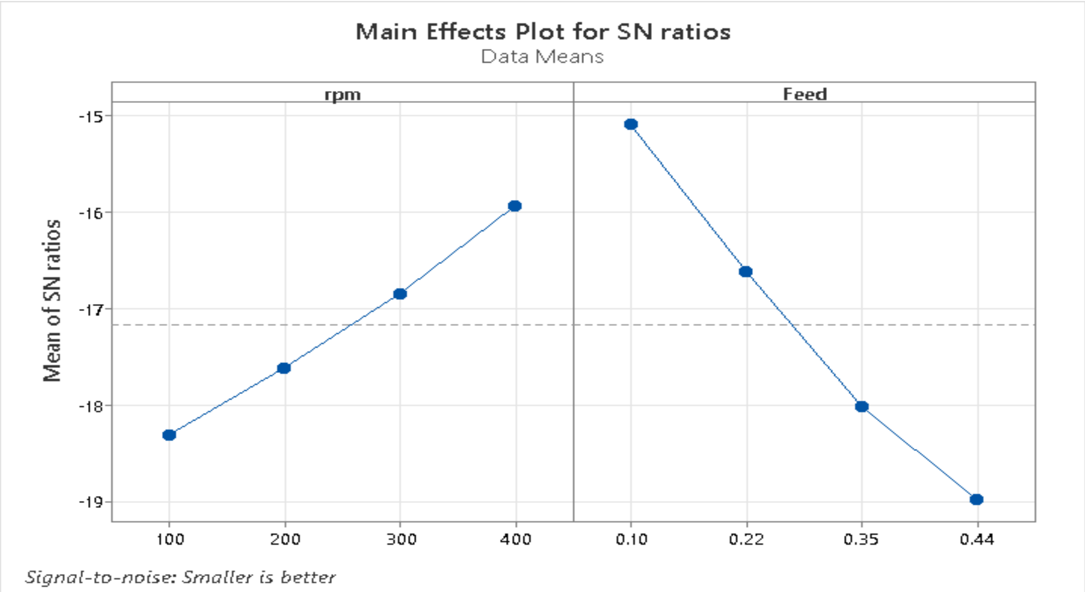

Figure 4.5. Main effects plot for SN ratios (Vibration Amplitude)

Smaller is better characteristics were chosen for both surface roughness and vibration amplitude. The optimal turning parameters for surface roughness value in Figure 4.4 are feed 0.1 mm/put (lvl 1), spindle speed 400 rpm (lvl4), while for vibration amplitude in Figure 4.5 are feed 0.1 mm/put (lvl 1) and spindle speed 100 rpm (lvl 1).

From table 4.7 and it can be concluded that the feed factor has the greatest influence on the surface roughness value of the turning results with a rank of 1. From the average of each factor, the smallest rank value is recommended as the proposed design because the quality characteristics in this case are (Smaller is better).

4. ANOVA Analysis

ANOVA analysis was also conducted using Minitab Statistical Software 22. ANOVA statistics shown in tables 4.9 and 4.10 were used to determine the effect of input parameters on surface roughness and vibration amplitude.

Table 4.9. Analysis of Varience (Surface Roughness)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Feed	3	23.1015	7.70049	3632.4	0
rpm	3	8.3505	2.78349	1313	0
Error	9	0.0191	0.00212		
Total	15	31.471			

As shown in table 4.9 above, feed has the most significant contribution of 73.4% and spindle rotation only has a contribution of 26.52%.

Table 4.10. Analysis of Varience (Vibration Amplitude)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Feed	3	21.49	7.165	1.5	0.28
rpm	3	16.69	5.565	1.16	0.376
Error	9	43.04	4.782		
Total	15	81.23			

As shown in table 4.10 above, feed has the most significant contribution of 10.69% and spindle rotation only has a contribution of 3.51%.

CONCLUSION

Surface roughness and vibration amplitude in the turning process are basically influenced by feed, spindle speed and depth of cut. Feed is the most significant contributing parameter. The most optimal machining parameters for surface roughness are feed 0.1 mm/put (lvl 1), spindle speed 400 rpm (lvl4) with a surface roughness value of 4.757 µm. The most optimal machining parameters for vibration amplitude are feed 0.1 mm/put (lvl 1) and spindle speed 100 rpm (lvl 1) with a vibration amplitude value of 0.11 m/s.

REFERENCES

Aleksandrovich, R. V., & Siamak, G. (2014). THE EFFECT OF TOOL CONSTRUCTION AND CUTTING PARAMETERS ON SURFACE

ROUGHNESS AND VIBRATION IN TURNING OF AISI 1045 STEEL USING TAGUCHI METHOD. Modern Mechanical Engineering, 4(1), 8–18. https://doi.org/10.4236/mme.2014.41002

Fischer, A., & Eberhard, P. (2011). SIMULATION-BASED STABILITY ANALYSIS OF A THIN-WALLED CYLINDER DURING TURNING WITH IMPROVEMENTS USING AN ADAPTRONIC TURNING CHISEL. Archive of Mechanical Engineering, 58(4). https://doi.org/10.2478/v10180-011-0023-5

Industrial Engineering Letters (2021) OPTIMIZATION OF PROCESS PARAMETERS OF SURFACE ROUGHNESS AND MATERIAL REMOVAL RATE IN ORTHOGONAL TURNING OF AISI 1045 CARBON STEEL USING TAGUCHI TECHNIQUE. https://doi.org/10.7176/iel/11-1-03

Kumar, M. S., & Kumar, K. K. (2017). OPTIMIZATION TECHNIQUES IN TURNING OPERATION BY USING TAGUCHI METHOD. International Journal of Engineering and Advanced Technology (IJEAT), 6(6), 45–50. https://doi.org/ISSN:2249-8958

Muley, R. A., Kulkarni, A. R., & Deshmukh, R. R. (2016, May 8). OPTIMIZATION OF SURFACE ROUGHNESS AND MATERIAL REMOVAL RATE IN TURNING OF AISI D2. In Proceedings of the 54th IRF International Conference, Pune, India. ISBN: 978-93-86083-10-4.

Rama, K. K., & Srinivas, J. (2011). STUDY OF TOOL DYNAMICS WITH A DISCRETE MODEL OF WORKPIECE IN ORTHOGONAL TURNING. International Journal of Machining and Machinability of Materials, 10(1–2), 71–85.

Sangwan, K. S. (2011). DEVELOPMENT OF A MULTI-CRITERIA DECISION MODEL FOR JUSTIFICATION OF GREEN MANUFACTURING SYSTEMS. Green Economics, 5, 285–305.

Yusup, N., Mohd, A., Zaiton, S., & Hashirn, M. (2012). EVOLUTIONARY TECHNIQUES IN OPTIMIZING MACHINING PARAMETERS: REVIEW AND RECENT APPLICATIONS (2007–2011). Expert Systems with Applications, 39, 9909–9927.