



The Effect of Machining Parameters on Surface Roughness for Material ASSAB DF-3 Tool Steel

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KEYWORDS	ABSTRACT
ASSAB DF-3 Carbide insert Dry Cutting Lathe Surface Roughness Turning Tool Wear	<p>Performance of conventional lathe machine almost depends on how fast the machine cut the workpiece, it means more faster the turning process the material, more finish product are produce in a period of time. The productivity of the machine also high. High productivity needed high rate of metal removal, so it will reduce the cost of manufacturing and operation time. Although the faster process is needed, it did not guarantee the quality of produce the product in term of surface roughness. This project investigates the relation of the machining parameters on ASSAB DF-3 tool steel material that can affect the surface roughness of material and tool wear of cutting tool. Three parameter were selected for speed of spindle, constant depth of cut and feed rate. This project is to investigate the effect of machining parameters such as depth of cut, cutting speed and feed rate on the surface roughness. Then to identify the effect of tool wear in turning operation and optimization model based on statistical method on the machining parameters using the ASSAB DF-3 steel material. The results were discussed in terms of wear behavior of cutting tools and surface quality of the workpiece, which is indicated by surface roughness. A full factorial experimental design was employed in the present work and the results were evaluated using main effects plots. Furthermore, the analysis of variance (ANOVA) method was applied to specify both reactive and non-reactive effects of experimental parameter reactions. The results showed that surface roughness is reduced using low feed rates and high spindle speed in the operations. Furthermore, it was also found that surface roughness increases as the wear rate of inserts increases.</p>

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1.0 INTRODUCTION

In metal cutting industries, machining types, especially turning operation is very basic type of machining. Traditionally, the selection of cutting conditions for machining was left to the manufacturing engineer, machine operator or machine setup technician is often expected to utilize experience and published shop guidelines for determining the proper machining parameters to achieve a specified level of requirement condition like surface roughness and tool wear. Machining parameters and process of composite materials are important to produce the necessary part for resulting assembly and achieved required geometrical shapes and dimensional tolerances. Cutting speed is the largest of the relative velocities of cutting tool or work piece. Depth of cut (d) is the distance the cutting tool penetrates into the work piece and feed rate is movement of the tool per revolution.

Surface roughness is a measurement of finished surface area where it indicates the state of machined surface. A better surface finishing is one of the desired requirements in industry as it improves fatigue strength and minimizes friction. The parameters that affect the surface roughness can be classified into primary and natural surface roughness effects. Primary surface roughness effect is contributed by cutting tool geometry, feed rate and cutting speed while natural surface roughness effect is contributed by the machine tool and uncontrolled variation in machining process such as tool wear, dynamic unbalance of machining system and chip formation.

D6 tool steel is a high-carbon, 12% chromium alloy cold work tool steel with tungsten. D6 steel is an air hardening alloy tool steel with excellent resistance to wear and abrasion. As a high carbon high chromium tool steel D6 has better through hardening properties than ASSAB DF-3 steel and dimensional stability combined with high resistance to tempering.

The purpose is to study more comprehensively about the behaviors of Carbide insert tool in different parameter process on ASSAB DF-3 Steel materials using Conventional Lathe Machine. Specifically, the tool wear and surface roughness are measured in order to assess the effects of turning process on ASSAB DF-3 steel work piece.

2.0 METHODOLOGY

The experiment used the Response Surface Method (RSM) to arrange the selected parameters before conducting the process of getting the sample part. For both of cutting operation, the machining parameters were set into three variables which were cutting speed, feed rate and depth of cut were constant. The details of the machining parameters are provided in Table 1 below:

Table 1: The Parameters Considered for Conducting The Experiment

Machining parameters	Units	Level 1	Level 2	Level 3
Cutting speed	(m/min)	800	1200	1600
Feed rate	(mm/min)	0.1	0.15	0.2
Depth of cut	(mm)	1	1	1

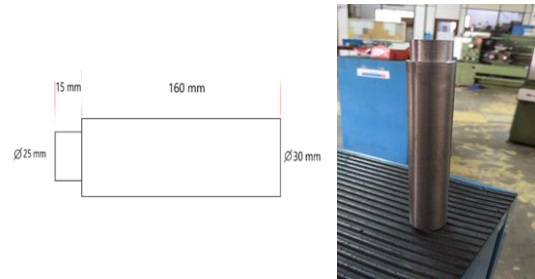


Figure 1: Size of Workpiece ASSAB DF-3



Figure 2: Carbide Insert Tool



Figure 3 : Experiment Setup

This experiment was conducted using conventional turning . Experiment were setup as shown in the Figure 3 above. The experiment use ASSAB DF-3 as the work piece which is length about 350mm and the work piece was were divided into two pieces to easiar the process of taking data and there were 3 pieces Carbide insert had been used by each experiment run .

3.0 RESULTS AND DISCUSSION

Table 2: Result Table

STD	RUN	BLOCK 1	SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	RESPONSE: SURFACE Roughness (Ra)	RESPONSE: TOOL WEAR (mm)
11	1	BLOCK 1	1200	0.15	2.911	0.297
1	2	BLOCK 1	800	0.10	1.899	0.38
10	3	BLOCK 1	1200	0.15	2.9525	0.307
12	4	BLOCK 1	1200	0.15	2.836	0.205
13	5	BLOCK 1	1200	0.15	2.8673	0.228
6	6	BLOCK 1	1600	0.15	2.143	0.174
9	7	BLOCK 1	1200	0.15	2.217	0.168
7	8	BLOCK 1	1200	0.10	1.7307	0.117
2	9	BLOCK 1	1600	0.10	1.1333	0.238
3	10	BLOCK 1	800	0.20	3.199	0.44
4	11	BLOCK 1	1600	0.20	2.677	0.184
5	12	BLOCK 1	800	0.15	2.353	0.368
8	13	BLOCK 1	1200	0.20	2.598	0.274

The experiment was conducted 13 run by using three different spindle speeds 800, 1200 and 1600 rpm and three different feed rates 0.1, 0.15 and 0.2 mm / min⁻¹ also with constant depth of cut 1 mm which react to surface roughness, and tool wear as shown above.

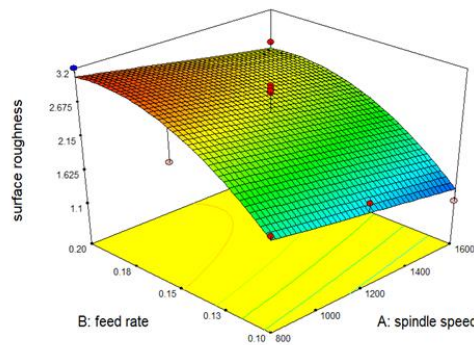


Figure 4: 3D Graph of Surface Roughness

Surface roughness was measured by using Mitutoyo SJ-210 Surface Roughness Tester. From the graph shown the result of surface roughness between three different feed rate and spindle speed. The lower value is the best surface roughness produce by the higher spindle speed 1600 rpm which is produce for Ra is 1.1333 μm when feed rate at 0.10 (mm/min). While at 800 rpm with feed rate 0.20 (mm/min) the Ra was measured 3.199 μm . It prove that lower feed rate better the result of surface roughness. The experiment prove that higher the spindle speed the lower the value of feed rate better the result of surface roughness.

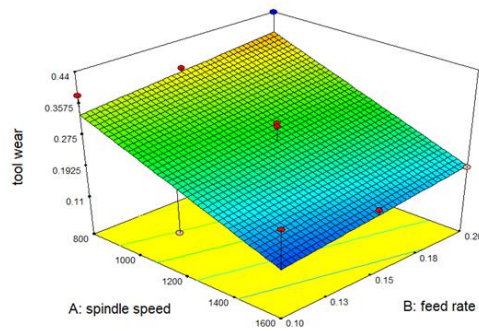


Figure 5: 3D Graph of Tool Wear

The tool wear of the carbide insert cutting tool was observed using a Zeiss Stemi 2000-C Microscope Profile Optical Video Measuring System. The result shown that the wear of the carbide insert were related by the time of machining used and the hardness of the workpiece material. The harder the material, the more the tool to wear.

4.0 CONCLUSION

In the present work, the turning operation of ASSAB DF-3 was investigated in terms of the surface quality of the workpiece and the wear behaviour of cutting tools. The study reveals the relationship between these parameters, such as feed rate, and spindle speed. From the roughness results, repeated measurements on each specimen exhibited close values, which means that the repeatability of the measurements are quite good since the Standard Deviation are within a percentage of 5% from the mean of surface roughness. Based on the ANOVA results, surface roughness more affected by the value of feed rate and also by speed of spindle respectively.

Thus, the insert nose radius has the most powerful impact on the surface roughness of the workpiece. Feed rate has also considerable influence, whereas high value is relatively low on the surface quality of the workpiece. The results show that surface roughness is reduced using low feed rates. Furthermore, it was also found that surface quality is related to wear rate of cutting tools, which means that surface roughness increases as the wear rate of inserts increases. Therefore, the study provided brief results for appropriate tool selection in the turning operation of ASSAB DF-3.

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REFERENCES

- A. J. Makadia and J. Nanavati, "Optimisation of machining parameters for turning operations based on response surface methodology," *Measurement*, vol. 46, pp. 1521-1529, 2013.
- Aatakhov, V.P. Surface integrity-definition and importance in functional performance. London: Springer, 2010.
- Bayly, P. V, Insperger, T., Mann, B. P., Ste, G., 2003. Stability of up-milling and down-milling, part 1: alternative analytical methods ´. *International Journal of Machine Tools & Manufacture* 43,p. 25-34.
- Bouzakis, K.-D., Gerardis, S., Katirtzoglou, G., Makrimalakis, S., Michailidis, N., Lili, E., 2008. Increasing tool life by adjusting the milling cutting conditions according to PVD films' properties. *CIRP Annals - Manufacturing Technology* 57(1), p. 105-108.

- G. Cukor, Z. Jurkovic, M. Sekulic, Rotatable Central Composite Design Of Experiments Versus Taguchi Method In The Optimization Of Turning, *Metalurgija* 50 (2011) 1, 17-20
- H Ku and W C Chia, Design Of Multi-Purpose Carbide End Mill, *Journal - The Institution of Engineers, Malaysia* (Vol. 67, No. 2, June 2006), pp. 34-40.
- H. Gokkaya and M. Nalbant, The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel, *Materials and Design* 28, (2007), 717-721.
- H. Bouchelaghem, M. A. Yallese, A. Amirat and S. Belhadi: *Mechanika* Vol.3 (2007), p57.
- Haikuo, M.; Xinda, H.; Yichu, Y.; Xiaoming, Z.; Han, D.; Investigation of surface integrity of aluminum lithium alloy in high speed machining. *Scientia Sinica Technologica*, 2014, 44:89-98.
- Julia Hricova, Martin Kovac, Peter Sugar. Experimental investigation of high speed milling of aluminium alloy. p 773-777
- Kasim, M. S., Che Haron, C. H., Ghani, J. a., Sulaiman, M. A., Yazid, M. Z. A., 2013. Wear mechanism and notch wear location prediction model in ball nose end milling of Inconel 718, *Wear*, In press.
- Kasim, M. S., Che Haron, C. H., Ghani, J. a., Sulaiman, M. A., Yazid, M. Z. A., 2013. Wear mechanism and notch wear location prediction model in ball nose end milling of Inconel 718, *Wear*, In press.
- Li, H. Z., Zeng, H., Chen, X. Q., 2006. An experimental study of tool wear and cutting force variation in the end milling of Inconel 718 with coated carbide inserts. *Journal of Materials Processing Technology* 180(1-3), p. 296-304.
- M. A. Hadia, J.A. Ghania, C.H. Che Harona, M. S. Kasimb, Comparison between up-milling and down-milling operations on tool wear in milling Inconel 718, *Procedia Engineering* 68 (2013) 647 - 653
- M. Aruna and V. Dhanalakshmi, Optimisation of turning parameters of Inconel 718 alloy using RSM, *Int. J. Manufacturing Technology and Management*, Vol. 25, Nos. 1/2/3, (2012), pp.113-134.
- M.A. Korkut, Donertas, U. Seker, Three-dimensional dynamometer design and production, *Zku, Karabuk, Technical Education Faculty, J. Technol.*2, (1-2), (1999), 115-129.
- Marko Reibenschuh, Franc Cus, Uros Zuperl, Turning of high quality aluminium alloys with minimum costs, *Tehnički vjesnik* 18, 3(2011), 363-368
- P. Sahoo, Optimization of turning parameters for surface roughness using RSM and GA, *Advances in Production Engineering & Management* 6(3), (2011), 197-208.
- R. Nur, M. Noordin, S. Izman, and D. Kurniawan, "Machining parameters effect in dry turning of AISI 316L stainless steel using coated carbide tools," *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering*, p.0954408915624861, 2015.
- Rakowski, L R (1980), Tips on choosing/using end mills, *Machine and tool blue book*, Vol. 75, No. 1, pp. 60-72.
- Sahin and Motorcu, Inconel 718 with use of whisker reinforced ceramic tools, *Journal of Materials Processing Technology* 212, (2012), pp.372-384.
- Suha K. Shihab*, Zahid A. Khan, Aas Mohammad, Arshad Noor Siddiqueed, RSM Based Study of Cutting Temperature during Hard Turning with Multilayer Coated Carbide Insert, *Procedia Materials Science* 6 (2014) 1233 - 1242
- V. Kryzhanivskyy, V. Bushlya, O. Gutnichenko, I. Petrusha, and J.-E. Ståhl, "Modelling and Experimental Investigation of Cutting Temperature when Rough Turning Hardened Tool Steel with PCBN Tools," *Procedia CIRP*, vol. 31, pp. 489-495, 2015.
- Y. Sahin, A.R. Motorcu, Surface roughness model in machining hardened steel with cubic boron nitride cutting tool, *International Journal of Refractory Metals & Hard Materials* vol.26, (2008), pp.84-90.