British Journal of Applied Science & Technology
12(3): 1-6, 2016, Article no.BJAST.18856
ISSN: 2231-0843, NLM ID: 101664541

SCIENCEDOMAIN ***international***
www.sciencedomain.org

The Influence of the Depth of Cut on the Two-way Application of Cutting Fluids

S. O. Yakubu[1*] and D. K. Garba[1]

[1]*Department of Mechanical Engineering, Nigerian Defence Academy, P.M.B. 2109, Kaduna, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author SOY formulate the research topic, carried out literature review, designed and carried out the experimental procedure, analysed and discussed the results, wrote the first draft of the manuscript and subsequent revised ones. Author DKG participated in the experimental design, literature searches and proof read the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2016/18856
Editor(s):
(1) Elena Lanchares Sancho, Department of Mechanical Engineering, University of Zaragoza, Zaragoza, Spain.
Reviewers:
(1) Siva Prasad Kondapalli, Anil Neerukonda Institute of Technology and Sciences, India.
(2) Djordje Cica, University of Banja Luka, Bosnia and Herzegovina.
(3) Anonymous, Koszalin University of Technology, Poland.
(4) Salah H. R. Ali, National Institute for Standards (NIS), Giza, Egypt.
Complete Peer review History: http://sciencedomain.org/review-history/11621

Original Research Article

Received 13th May 2015
Accepted 8th September 2015
Published 29th September 2015

ABSTRACT

The depth of cut is one of the important parameters of machining. It influences a great number of factors of machining like the surface finish, the tool wear, the temperature/heat, energy/power consumption etc. It is of course obvious that the depth of cut affects the rate of heat generated and consequently the temperature in various degrees depending on the conditions of machining, the material etc. So, in order to reduce the negative effect of high temperature which is as a result of the large heat generated due to high rate of friction at the workpiece – tool interface, cutting fluids and lubricants are used. This research focused on the effect of the depth of cut on the two-way application of cutting fluids. The angle of feeding was varied from 30º to 180º. The feed rate was 0.75 mm/rev and the speed was 125 rpm. It was established that the two-way application of the cutting fluids was most effective in terms of the surface finish when the depth of cut was 2 mm and at angle of 150º. In other words, the lowest surface roughness (8.41 µm) was obtained at this angle and depth of cut. In fact the lowest surface roughness (highest surface quality) and temperature

**Corresponding author: E-mail: drsoyakubu4real@gmail.com;*

were achieved under all the feeding angles except angle 30º and when the depth of was 2 mm. However, the tool wear values were lowest when the depth of cut was 1.0 mm as compared to other values of depth of cut used. Therefore, the recommended values for the depth of cut are 1 mm and 2 mm in terms of the surface quality and tool wear obtained respectively.

Keywords: Surface roughness; tool wear; temperature; feeding angle; depth of cut.

1. INTRODUCTION

Out of tolerance in cutting processes can produce a number of problems like surface finish and geometrical deformation [1-2].

Depth of cut is one the cutting parameters that influence the quality of the surface finish of the work piece, the rate of the tool wear and the heat generated (temperature) at the cutting zone. The temperature at the cutting zone is factor of the friction at the workpiece – tool interface. The higher the friction, the higher the heat generated and consequently the higher the temperature. Increase in the depth of cut usually lead to increase in the friction the tool-workpiece interface.

The depth of cut is thickness of the layer of metal removed in one cut or pass measured in a direction perpendicular to the machined surface [3].

Cutting speed, feed and depth of cut are considered to be the main independent variables in cutting processes. Their increase will lead to increase in the cutting force, power and temperature and consequently leads to high rate of tool wear and poor surface finish [4,5].

Therefore, in other to reduce the negative effect of the temperature, cutting fluids/lubricants are applied.

There are various cutting fluids (CF) available such as the emulsion mineral oil, synthetic [6-7], but the choice of particular CF depends on a number of factors like the material of workpiece, the operation type, etc. [8]. The effectiveness the CF depends to a large extent on the method of its feeding. The method of CF feeding employed for this research work was a two-way application of cutting fluids method [9].

Nevertheless, variation in the depth of cut will affect the surface finish, the tool wear (tool life) and surface integrity, the temperature at cutting zone irrespective of the type of CF used and the method of application. According SO Yakubu and CO Izelu [9], the two-way application of cutting fluid was found to be effective in turning processes. Therefore, it was considered important to investigate how the depth of cut would influence the effectiveness of the two-way application of cutting fluids in terms of the surface finish the tool wear and temperature.

2. MATERIALS AND METHODS

2.1 Materials and Equipment

The material used for the investigation was a medium carbon steel. Its chemical composition is presented in the Table 2.1. The cutting fluid was soluble oil mixed with water to form a milky colour. The cutting tool used was cemented carbide tool insert type T107 and grade YG8. The equipment used were the non contact temperature measuring apparatus, the centre lathe machine model XL 400, digital vernier caliper, surface roughness tester type SR16.

2.2 Experimental Procedures

The experiment was conducted on lathe machine model XL400. The experimental set up is shown in Fig. 2.1. The experimental test was carried out under the following process variables (conditions): feed rate = 0.75, Speed of cutting = 125 rpm, Depth of cut was within the range of 1 – 2 mm and the CF feeding angles were from 30º – 180º. Each experiment was conducted for 1 hour 40 minutes (100 minutes) at an interval of 20 minutes.

The parameters determined were the surface roughness, tool flank wear and the temperature at the cutting zone. After every 20 minutes the average values of readings taken from three different points on the workpiece and the tool were recorded. The surface roughness values were measured with an Insize surface roughness tester model ISR-16 at three different points on the machined surface and the average value was recorded. The Tester was placed parallel on the worpiece surface and then the power button was put on and the stylus travelled a certain distance giving the readings of the surface texture. The tool flank wear was measured with the aid of an Insize Digital Vernier Caliper Model SR44. The reading was conducted thus: the initial and the final heights were taken and the differences were recorded. This was repeated thrice and the average value was recorded as the tool flank wear after every 20 minutes. The overall averages after machining for 1 hour 40 minutes i.e. 100 minutes were recorded in the Tables 3.1 – 3.6. The temperature was measured with the help of a German non contact temperature measuring instrument (Therma Twin) model TN408LC. The temperature was measured during the operation at three different points on the workpiece and at three different positions of the cutting zones. Thereafter the average values were recorded after every 20 minutes of machining. The grand averages after every 100 minutes of machining were recorded in the 3.1 to 3.6 respectively. The temperature was measured in Degree Celsius.

However, presented in 3.1 – 3.6 are the average values of the measured parameters at the end of one (1) hour forty (40) minutes machining.

Table 2.1. Chemical composition of the workpiece

Material	Element, %											
Medium	C	Si	Mn	P	Fe	Ni	Cr	Mo	Cu	V	Pb	Al
carbon steel	0.38	0.22	0.49	0.01	98.73	0.03	0.04	0.03	0.02	0.02	0.02	0.01

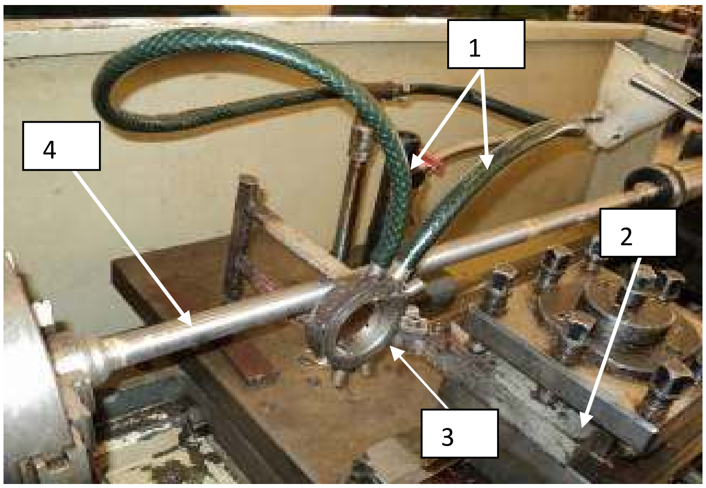

Fig. 2.1. Experimental set up
1 – CF hoses, 2 – Cutting Tool, 3 – Two-way CF feeding device, 4 – Workpiece

Table 3.1. Results of the surface finish, tool wear and temperature at a feeding angle 30º

Depth of cut, mm	Feeding angle = 30°		
	Surface roughness (Ra), µm	Tool wear, mm	Temperature, ºC
1.0	9.63	0.03	25.36
1.5	11.55	0.43	31.83
2.0	9.79	0.07	27.50

Table 3.2. Results of the surface roughness, tool wear and temperature at feeding angle 60ºC

Depth of cut, mm	Feeding angle = 60°		
	Surface roughness (Ra), µm	Tool wear, mm	Temperature, ºC
1.0	9.91	0.035	27.36
1.5	11.08	0.38	31.63
2.0	8.63	0.06	26.11

Table 3.3. Results of the surface roughness, tool wear and temperature at feeding angle 90ºC

Depth of cut, mm	Feeding angle = 90º		
	Surface roughness (Ra), µm	Tool wear, mm	Temperature, ºC
1.0	9.57	0.04	27.03
1.5	11.29	0.34	31.48
2.0	8,76	0.07	25.81

Table 3.4. Results of the surface roughness, tool wear and temperature at feeding angle 120ºC

Depth of cut, mm	Feeding angle = 120º		
	Surface roughness (Ra), µm	Tool wear, mm	Temperature, ºC
1.0	9.36	0.04	27.20
1.5	10.96	0.39	31.30
2.0	8.92	0.05	26.25

Table 3.5. The results of the surface roughness, tool wear and temperature at feeding angle 150ºC

Depth of cut, mm	Feeding angle = 150º		
	Surface roughness (Ra), µm	Tool wear, mm	Temperature, ºC
1.0	9.24	0.04	27.02
1.5	10.68	0.33	29.73
2.0	8.41	0.05	26.11

Table 3.6. The results of the surface roughness, tool wear and temperature at feeding angle 180ºC

Depth of cut, mm	Feeding angle = 180º		
	Surface roughness (Ra), µm	Tool wear, mm	Temperature, ºC
1.0	9.29	0.04	26.08
1.5	10.25	0.44	31.83
2.0	8.53	0.06	26.20

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Conditions of machining

Feed (f) = 0.75 mm, Spindle Speed (V) = 125 rpm, Depth of Cut = 1 – 2.0 mm, CF feeding angles = 30º – 180º

3.2 Discussion

The effect of the depth of cut on the two-way application of cutting fluids was quantified with quality of the surface finish in terms of the surface roughness, the tool wear rate (tool life) and the temperature. The depth of cut was varied from 1.0 mm to 2.0 mm while the CF feeding angle was also varied from 30º to 180º.

Irrespective of the cutting fluids (CF) feeding angle, it was established that as the depth of cut was increased from 1.0 mm to 1.5 mm, the surface roughness, tool wear and the temperature increased. Definitely as the temperature at the cutting zone rose, it was expected that it would lead to a rise in the tool wear rate and consequently the surface roughness. In other words the tool life and the surface quality of the machined workpiece decreased.

However, when the depth of cut was increased from 1.5 mm to 2.0 mm, interesting results were obtained. The obtained values for the surface roughness, the tool wear and the temperature were lower than those got when the depth of cut was 1.0 mm and 1.5 mm respectively for all the angles of CF feeding. This was particularly obvious for the surface roughness values. In fact the lowest surface roughness values were achieved when the depth of cut was 2.0 mm and it was 8.41 µm. But the situation was not exactly the same in terms of the tool wear rate and the temperature for the same depth of cut. The obtained values for tool wear at this depth of cut (i.e. 2.0 mm) for all the angles of CF feeding were only lower than those obtained when the depth of cut was 1.5 mm. However, the tool wear values were higher than those got when the depth of cut was 1.0 mm under any given angle of CF feeding.

On the contrary, temperature decrease was observed under 2.0 mm depth of cut as compared to 1.0 mm when the angle of CF feeding was 60º, 90º, 120º and 150º respectively. The temperature was only higher when the feeding angle was 30º and 180º (Tables 3.1 and 3.6) respectively. But comparing the temperature values to those obtained when the depth of cut was 1.5 mm, the values were all lower irrespective of the CF feeding angle.

It is worthy to note that the lowest surface roughness values (the highest surface quality) were obtained when the CF feeding angle was 150º for all the three values of the depth of cut (1.0, 1.5, & 2.0 mm). The only exception was when the depth of cut was 1.5 mm and the feeding angle was 180º. The same thing applied to the tool wear values except when feeding angles were 30º and 60º respectively and the depth of cut was 1.0 mm.

The cutting zone temperature did not change significantly except when the depth of cut was equal to 1.5 mm. However, relatively low temperature was achieved under the depth of cut equal to 2.0 mm. This may be due to the absence of self excited vibration and/or any other vibrations which has facilitated a very smooth turning process. It may also have been attributed to a better penetration of cutting fluids at the cutting zone which led to better cooling and consequently a reduction in the temperature.

4. CONCLUSIONS

The depth of cut influenced the performances of the two-way application of cutting fluid in different ways. Based on the values of the depth of cut used, the following conclusions were deduced from the analysis of the results:

i. The surface roughness and the tool wear and the temperature values were relatively the same when the depth of cut was 1.0 mm and 2.0 mm respectively. Whereas the highest tool wear, surface roughness and temperature values were recorded when the depth was 1.5 mm irrespective of feeing angle. In other words, the performance of the two-way application of the CF was at its lowest when the depth of cut was 1.5 mm.
ii. Tool wear rate was very high at the depth of cut equal to 1.5 mm compared to the other values of the depth of cut irrespective of the feeding angle. The differences in the values of the surface roughness, tool wear and the temperature when the depth of cut was 1.0 and 2.0 mm in comparison with those obtained at the depth of cut equal to 1.5 mm for any feeding angle were high. For instance, the surface roughness, the tool wear and the temperature were 9.63 µm, 0.03 mm and 25.36º respectively when the feeding angle was 30º and depth of cut was 1.0mm as against 11.55 µm, 0.43 mm and 31.83º respectively when the depth of cut was 1.5 mm for the same feeding angle.
iii. The minimum negative effect of the depth of cut on the effectiveness of the two-way application of the cutting fluids was achieved when the feeding angle was 150º. All the three determined factors (surface roughness, tool wear & temperature) were at their lowest at this angle.
iv. The cutting zone temperature did not change significantly except when the depth of cut was equal to 1.5 mm. However, relatively low temperature was achieved under the depth of cut equal to 2.0 mm. This may be due to the absence of self excited vibration and/or any other vibrations which has facilitated a very smooth turning process. It may also be attributed to a better penetration of cutting fluids at the cutting zone which led to better cooling and consequently a reduction in the temperature.
v. The lowest surface roughness value was achieved when the depth of cut was 2.0 mm and the feeding angle was 150º. However, the lowest tool wear and temperature values were got when the depth of cut was 1.0 mm and the feeding angle was 30º.

ACKNOWLEDGEMENT

The Authors wish to express their profound gratitude to Mr Jafaru A. Muhammed and Suleiman Iliyasu for assisting in carrying out the experiments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ali SHR, Dadoura HH, Bedewy MK, Identifying cylinder liner wear using precise coordinate measurements. Int. Journal of Precision Eng. and Manuf. 2009;10(5): 19-25.
2. Ali SHR. The influence of fitting algorithm and scanning speed on roundness error for 50 mm standard ring measurement using CMM. Metrology and Measurement Systems. 2008;15:1.
3. Sharma PC. A textbook on production engineering. Chand S. Publisher. New Delhi. India. 2006;181–183.
4. Serope Kalpakjian, Steven Schmid. Manufacturing engineering technology. Fifth Edition; 2006.
5. Jain RK. Production technology. 6th Edition, khanna Publishers. India; 2005.
6. Abu JO. Applicable heat treatment processes for improved machine-ability of high carbon steel. Journal of NIMechE, Nigeria. 2009;1(1):46-56.
7. Yakubu SO, Aku SY, Apochi MJ. The effect of feeding angle on the performance of a two-way application of cutting fluids. Journal of Scientific Research & Reports. Sciencedomain.org. UK. 2014;3(24): 3117–3125
8. Machine Shop 1. Cutting Fluids Types and Uses. Accessed; 2014.

   Available: http://its.fvtc.edu/machine_shop1/coolant/cutting fluids
9. Yakubu SO, Izelu CO. Design and Construction of a cutting fluid two-way/multi-feeding device for turning operation. British Journal of Applied Science & Technology. 2013;3(3): 598–608.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/11621