

THE INFLUENCE OF THE DEPTH OF CUT ON THE TWO-WAY APPLICATION OF CUTTING FLUIDS

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 results from great heat being generated due 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 30° to 180°. 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 150°. 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 were achieved for all the angles except for angle 30° when the depth of was 2mm. However, the tool wear values were lowest when the depth of cut was 1.0mm 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.

22 **KEY WORDS:** Surface Roughness, Tool Wear, Temperature, Feeding Angle, Depth of Cut.

23 1.0 INTRODUCTION

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

30 The depth of cut is thickness of the layer of metal removed in one cut or pass measured in a
31 direction perpendicular to the machined surface [1].

32 Cutting speed, feed and depth of cut are considered to be the main independent variables in
33 cutting processes. Their increase will lead to increase in the cutting force, power and
34 temperature and consequently leads to high rate of tool wear and poor surface finish. [2, 3]

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

37 There are various cutting fluids (CF) available such as the emulsion mineral oil, synthetic [4-
38 5], but the choice of particular CF depends on a number of factors like the material of
39 workpiece, the operation type, etc. [6]. The effectiveness the CF depends to a large extent on
40 the method of its feeding. The method of CF feeding employed for this research work was a
41 two-way application of cutting fluids method [7].

42 Nevertheless, variation in the depth of cut will affect the surface finish, the tool wear (tool
43 life) and surface integrity, the temperature at cutting zone irrespective of the type of CF used
44 and the method of application. According SO Yakubu and CO Izelu [7], 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.

2.0 MATERIALS AND METHOD

2.1 Materials and equipment

The material used for the investigation was medium carbon steel. The cutting fluid was the normal soluble oil mixed with water to form slurry. 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. The equipment used are presented in figures 2.1 – 2.3.



Fig. 2.1 - Germany Non Contact Temperature Measuring Device



Fig. 2.2 - Insize Digital Vernier Caliper



Fig. 2.3 - Insize Surface Roughness Tester ISR 16

2.2 Experimental Procedures

The experiment was conducted on lathe machine model XL400. The experimental test was carried out under the following process variables (conditions): feed rate = 0.75, Speed of cutting = 125 rpm. Each experiment was conducted for 1 hour 40 minutes at an interval of 20 minutes. The parameters determined were the surface roughness, tool 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, while the tool wear was measured with the aid of an Insize Digital Vernier Caliper Model SR44. 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. 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.

3.0 RESULTS AND DISCUSSION

3.1 Results

Condition of Machining: Feed (f) = 0.75mm, Spindle Speed (V) = 125rpm

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

	Feeding Angle = 30°
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Depth of Cut, mm	Surface Roughness (Ra), μm	Tool Wear, mm	Temperature, $^{\circ}\text{C}$
1.0	9.63	0.03	25.36
1.5	11.55	0.43	31.83
2.0	9.79	0.07	27.50

86

87 Table 3.2. Results of the Surface Roughness, Tool Wear and Temperature at Feeding angle 60°C

Depth of Cut, mm	Feeding Angle = 60°		
	Surface Roughness (Ra), μm	Tool Wear, mm	Temperature, $^{\circ}\text{C}$
1.0	9.91	0.035	27.36
1.5	11.08	0.38	31.63
2.0	8.63	0.06	26.11

88

89 Table 3.3. Results of the Surface Roughness, Tool Wear and Temperature at Feeding angle 90°C

Depth of Cut, mm	Feeding Angle = 90°		
	Surface Roughness (Ra), μm	Tool Wear, mm	Temperature, $^{\circ}\text{C}$
1.0	9.57	0.04	27.03
1.5	11.29	0.34	31.48
2.0	8.76	0.07	25.81

90

91 Table 3.4. Results of the Surface Roughness, Tool Wear and Temperature
92 at Feeding angle 120°C

Depth of Cut, mm	Feeding Angle = 120°		
	Surface Roughness (Ra), μm	Tool Wear, mm	Temperature, °c
1.0	9.36	0.04	27.20
1.5	10.96	0.39	31.30
2.0	8.92	0.05	26.25

93

94 Table 3.5. The results of the Surface Roughness, Tool Wear and Temperature at Feeding angle
95 150°C

Depth of Cut, mm	Feeding Angle = 150°		
	Surface Roughness (Ra), μm	Tool Wear, mm	Temperature, °c
1.0	9.24	0.04	27.02
1.5	10.68	0.33	29.73
2.0	8.41	0.05	26.11

96

97 Table 3.6. The results of the Surface Roughness, Tool Wear and Temperature at Feeding angle
98 180°C

Depth of Cut, mm	Feeding Angle = 180°		
	Surface Roughness (Ra), μm	Tool Wear, mm	Temperature, °c
1.0	9.29	0.04	26.08

1.5	10.25	0.44	31.83
2.0	8.53	0.06	26.20

99

100 3.2 Discussion

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

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

110 However, when the depth of cut was increased from 1.5 mm to 2.0 mm, interesting results were
 111 obtained. The obtained values for the surface roughness, the tool wear and the temperature were
 112 lower than those got when the depth of cut was 1.0 mm and 1.5 mm respectively for all the
 113 angles of CF feeding. This was particularly obvious for the surface roughness values. In fact the
 114 lowest surface roughness values were achieved when the depth of cut was 2.0 mm and it was
 115 8.41 µm. But the situation was not exactly the same in terms of the tool wear rate and the
 116 temperature for the same depth of cut. The obtained values for tool wear at this depth of cut (i.e.
 117 2.0 mm) for all the angles of CF feeding were only lower than those obtained when the depth of

118 cut was 1.5 mm. However, the tool wear values were higher than those got when the depth of cut
119 was 1.0 mm under any given angle of CF feeding.

120 On the contrary, temperature decrease was observed under 2.0 mm depth of cut as compared to
121 1.0 mm when the angle of CF feeding was 60° , 90° , 120° and 150° respectively. The temperature
122 was only higher when the feeding angle was 30° and 180° (tables 3.1 and 3.6) respectively. But
123 comparing the temperature values to those obtained when the depth of cut was 1.5 mm, the
124 values were all lower irrespective of the CF feeding angle.

125 It is worthy to note that the lowest surface roughness values (the highest surface quality) were
126 obtained when the CF feeding angle was 150° for all the three values of the depth of cut (1.0, 1.5,
127 & 2.0 mm). The only exception was when the depth of cut was 1.5 mm and the feeding angle
128 was 180° . The same thing applied to the tool wear values except when feeding angles were 30°
129 and 60° respectively and the depth of cut was 1.0 mm.

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

136 4. CONCLUSION

137 The depth of cut influenced the performances of the two-way application of cutting fluid in
138 different ways. Based on the values of the depth of cut used, the following conclusions were
139 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 feeding 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 25.36° respectively when the feeding angle was 30° and depth of cut was 1.0mm as against 11.55 μm , 0.43 mm and 31.83° 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 150°. 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 150° . However, the lowest tool wear and temperature values were got when the depth of cut was 1.0 mm and the feeding angle was 30° .

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