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Performance Evaluation of Feed Rate on Turning Mild Steel Using the Two-Way Application of Cutting Fluids

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ABSTRACT

The research was conducted to establish the influence of the feed rate on lathe machining (turning) using the two-way application of cutting fluids. The objective was to find out how the variation of the feed rate affect the surface quality of the machined surface, the tool wear (tool life) as well as the cutting zone temperature. The experimental research was conducted on a universal XL lathe machine under the following conditions: the material for the workpiece was low carbon steel (Mild Steel); the tool material was carbide insert; depth of cut was 1.5 mm; speed (spindle speed) was 125 rpm; the two-way application of cutting fluid was done at angle 30^o to each other; the feed rate range was from 0.75 to 1.75 mm/rev with the application of cutting fluid. The machining duration was 120 minutes. The factors evaluated were the tool wear, surface roughness and the temperature at the cutting zone. It was established that the higher the value of the feed rate the higher the rate of tool wear and the surface roughness, viz-a-viz the shorter the tool life and lower the machined surface quality. The increase in the temperature at cutting zone was not significant. When the feed rate was varied from 0.75 mm/rev to 1.75 mm/rev, the corresponding increase in values for surface roughness, tool wear and temperature at the cutting zone were 9.63 µm – 15.0 µm, 0.03 mm – 0.33 mm and 25.36^{o}C – 31.30^{o}C respectively. However, the greatest influence of the feed rate was on the tool wear (tool life). The increase in the rate of tool wear was 100%, whereas the other two parameters were less.

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INTRODUCTION

Orthogonal machining precisely the lathe machining, is a high-speed process which leads to the generation of lot of heats. The increase in heat leads to proportional increase in the temperature at the cutting (machining) zone. [1]

The heat generated at the cutting zone is usually absorbed by the chips, the cutting tool and the workpiece. However, larger percentage of this heat is taken away by the chips, then the cutting tool and the least is by the workpiece.

However, at the tool-workpiece interface, particularly at the tip of cutting tool, about ninety five percent of the generated heat is being absorbed by cutting tool. This in turn leads to a very high temperature on the cutting edge and consequently leads to its (tool) fast wearing. [2, 3]. Consequently, it will lead to frequent re-sharpening and replacement of the tool and as result leads to high tooling costs.

When the tool wears, the cutting edge becomes blunt and will not be able to cut satisfactorily. In order words it will lead to poor surface finish, dimensional accuracy and more power consumption, due to more force is required to do the cutting. All these (tool cost, energy cost etc) will lead to high production/operational cost. Therefore, cutting fluids are usually applied during orthogonal machining.

A two-way application of cutting fluids (CF) is a method developed by S.O. Yakubu and C.O Izelu[1] to feed the cutting fluids to the cutting zone in turning operations. They developed a two-way/multiple feeding device that can feed the CF to the cutting zone at different angles [4]

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It has been established that the three most vital parameters in the orthogonal machining are the cutting speed (spindle speed), the depth of cut and the cutting fluids feed rate. In fact, cutting process cannot take place, if any of these three parameters is missing.

Feed rate is one of the cutting parameters, which is provided for moving the tool against the workpiece for covering the entire surface to be machined. Usually, it is imparted in a direction perpendicular to cutting velocity; however, the angle between cutting velocity vector and feed vector may also deviate from 90º. [5]

A lot of Researchers have done a lot of works on these parameters to determine how they influence orthogonal machining processes. AA Latif et al carried out a research study on the effect of feed rate and cutting speed on the surface roughness and material removal rate of mild steel [6]

S. O Yakubu[2] and D. K. Garba [7] worked on the influence of the depth of cut and S.O Yakubu[3] et al [8] have worked on the influence of the Cutting Speed on the two-way application of cutting fluids and so on.
However, nobody has study the effect of feed rate on the surface finish, tool wear and temperature at cutting zone in lathe machining under the two-way application of cutting fluids.

Therefore, this research seeks to fill the gap by carrying out performance evaluation of the feed rate on lathe machining under the two-way application of cutting fluids (CF) [4] which is the third very important parameter for cutting processes.

MATERIALS AND METHOD

Materials and Equipment

The materials used were low carbon steel (mild steel) of 45mm, Cutting fluid (Soluble oil solution). The equipment used were carbide cutting tool inserts, the non-contact (infra-red) temperature measuring instrument, digital vernier caliper and surface roughness tester.

The experimental Procedure

The experiments were conducted on a universal lathe machine XL 400 in the department of mechanical engineering department of Nigerian Defence Academy. The process variables used were: depth of cut = 1.5 mm; speed = 125 rpm. The feed rate was varied from 0.75mm/rev to 1.75mm/rev. The factors determined were the temperature, surface roughness and the tool wear. The total machining time was 120 minutes.

The tool wear and the surface roughness values were measured after every 20 minutes of machining with the aid of the digital vernier caliper SR44 and surface roughness tester ISR-16 respectively, while the temperatures were measured with infra-red thermometer model TN408LC during machining within every 20 minutes at three different points and the average values were recorded. The results of the experiments are presented in tables 1-5

RESULTS AND DISCUSSION

Results

Table 1. Feed Rate = 0.75 mm/rev.

S/N	Time, (min)	Tool wear, (mm)	Temperature, (^{0}C)	Surface Roughness, (Ra), µm
1	20	0.01	25.39	9.45
2	40	0.02	25.38	10.75
3	60	0.03	25.37	11.00
4	80	0.04	25.36	7.29
5	100	0.05	25.34	8.75
6	120	0.05	25.33	10.55
Average		**0.03**	**25.36**	**9.63**

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Table 2. Feed Rate = 1.0 mm/rev.				
S/N	Time, (min)	Tool wear, (mm)	Temperature, (^{0}C)	Surface Roughness, (Ra), µm
1	20	0.03	28.50	14.64
2	40	0.09	28.60	14.64
3	60	0.20	28.90	13.49
4	80	0.22	29.01	16.03
5	100	0.26	29.00	15.00
6	120	0.29	28.82	16.05
Average		**0.145**	**28.82**	**14.48**

Table 3. Feed Rate = 1.25 mm/rev.				
S/N	Time, (min)	Tool wear, (mm)	Temperature, (^{0}C)	Surface Roughness, (Ra), µm
1	20	0.06	28.10	14.67
2	40	0.10	27.90	14.55
3	60	0.12	27.00	14.58
4	80	0.13	28.00	14.35
5	100	0.14	28.20	14.41
6	120	0.15	27.30	14.59
Average		**0.12**	**27.75**	**14.53**

Table 4. Feed Rate =1.50 mm /rev.				
S/N	Machining Time, min	Tool wear, (mm)	Temperature, (^{o}C)	Surface Roughness, (Ra), µm
1	20	0.12	28.0	9.0
2	40	0.14	29.10	9.55
3	60	0.15	30.20	10.12
4	80	0.15	31.10	11.3
5	100	0.16	32.60	13.5
6	120	0.17	32.90	14.1
Average		**0.15**	**30.00**	**11.30**

Table 5. Feed Rate= 1.75mm/rev.				
S/N	Machining Time, min	Tool wear, (mm)	Temperature, (^{o}C)	Surface Roughness, (Ra), µm
1.	20	0.15	29.5	13.01
2.	40	0.20	30.5	14.10
3.	60	0.23	31.5	16.01
4.	80	0.30	31.0	15.40
5.	100	0.50	31.90	15.55
6.	120	0.60	33.4	15.90
Average		**0.33**	**31.3**	**15.00**

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DISCUSSION

In all the results obtained it was established that the rate of tool wear is proportional to the increase in machining time, but the temperature at the cutting zone and surface roughness went up and down at some points of the machining time.

Feed Rate = 0.75 mm/rev.

In table 1 above as the machining time was increased from 20 minutes to 120 minutes and the feed rate was 0.75 mm/rev, the tool wear increased from 0.01mm to 0.5mm. That's there was a proportional increase in the tool wear as the machining time increased from 20 to 120 minutes. However, there was a little drop in the temperature from 25.39^{o}C to 25.33^{o}C, whereas there was increase in the tool wear from 9.45 to 10.75 μm when the machining was increased from 20 to 40 minutes. However, from 60 to 120 minutes of machining time, there was a drop and rise in the surface roughness values.

Feed Rate = 1.0 mm/rev

Table 2 presents the values of tool wear, temperature and surface roughness when the feed rate was 1.0 mm/rev. It is seen from the table that, there was a proportional increase in the tool wear as the machining time was increased, likewise the temperature at the cutting zone except when the machining time was 120 minutes that it dropped a little. However, there was fluctuation in the temperature and surface roughness values as the machining time increased from 20 to 120 minutes.

Feed Rate = 1.25 mm/rev.

The values for the measured factors (Temperature, Tool wear and Surface Roughness) are presented in table 3. As the machining time increased from the 20 minutes to 120 minutes the tool wear increased proportionally, but the temperature and the surface roughness values fluctuated. That is, there was not proportional increase in the temperature and surface roughness.

However, the average values of these obtained parameters were lower compared to when the feed rate was 1.0 mm/rev as presented in table 2, except the surface valued which was higher.

Feed rate = 1, 5 mm/rev

The performance evaluation is presented in the table 4 when the value of the feed rate was 1.5 mm/rev.

As the machining increased from 20 minutes to 120 minutes, so also all the three determined parameters viz-a-viz Tool Wear, Surface Roughness and Temperature proportionally increased from 0.12 to 0.17 mm, 9.0 to 14.1 μm and 28 to 32.90^{o}C respectively. The average values for these parameters were also higher than the values obtained when the feed rate was 0.75 mm/rev, 1.0 mm/rev, 1.25 mm/rev respectively. It was only the surface roughness value that was lower compared to when the feed rate values were 1.0 mm/rev and 1.25 mm/rev. in other words, the Ra was only higher than the Ra when the feed rate was 0.75 mm/rev.

Feed Rate = 1.75 mm/rev

The highest values for the tool wear (Tw), Surface Roughness (Ra) and the Temperature at the cutting zone (T) were established when the value of the feed rate was 1.75 mm/rev. These values also increased proportionally with increase in the machining time. When the machining time was increased from 20 – 120 minutes, Tw increased from 0.15 - .60 mm; Ra increased from 13.01 – 15.90 μm and T increased from 29.5 – 33.4^{o}C respectively.

In fact, the highest values for the tool wear, temperature, and surface roughness were obtained when the feed rate was 1.75 mm/rev. The rate of tool wear was its peak which led the poorest surface finish as a result of the high temperature at the cutting zone.

CONCLUSION

Generally, as the Feed Rate increases, its effect on the temperature of machining (turning), tool wear and surface roughness increased also. In other words, when the feed rate was increased from 0.75 mm/rev to 1.75 mm/rev, the temperature (T) of machining rose from 25.36^{o}C to 31.3^{o}C, the tool wear (Tw) increased

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from 0.03 mm to 0.33mm and the surface roughness from 9.63 µm to 15 µm.

1. The feed rate has more effect on the surface roughness and tool wear than the temperature at the cutting zone. In fact, there was no much increase in the temperature at cutting zone. However, there was a proportional increase in the surface roughness as the feed rate increases except when the feed rate value was 1.5 mm/rev which corresponded to 11.30 µm.
2. Likewise, there was a proportional increase in the tool wear 0.03 mm to 0.33 mm as the feed rate was increased from 0.75 mm/rev to 1.75 mm/rev. In fact, the increase was 100%. However, there was a little drop in the tool wear from 0.145 mm to 0.12 mm (table 3) before rising again to 0.33 mm.
3. The surface roughness increase was about 55%, while the temperature increased was about 23% when the feed rate was increased from 0.75 mm/rev to 1.75 mm/rev. It shows that rate of the surface roughness is more connected to the rate of tool wear.

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