The Study of High Speed Turning Using MQL

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Abstract

The aim of study is experimentally investigate the influence of cutting speed, depth of cut and feed rate on surface roughness and cutting forces in high speed turning of monel k-500 in dry and MQL conditions. Cutting fluids have a reasonably low cost, their handling and carrying costs are very high and also, owing to their toxic nature, dumping of used fluids is a big problem because it can be hazardous to workers and also to the environment. To avoid these problems, a minimal-cutting-fluid technique called minimum quantity lubrication (MQL) was used in machining. The results indicated that MQL can decrease surface roughness 38 percent and it can decrease cutting force 59 percent.

Keywords: Minimum quantity lubrication, Monel k-500, Dry condition, High speed turning

1. Introduction

In view of green manufacturing, dry machining has drawn much attention from industries recently. Remarkable improvement on tool coating technology has facilitated the complete elimination of cutting fluid in some machining processes. In most applications; however, the cutting fluids are still required due to the high friction and adhesion tendency between work and tool materials and the difficulty of chip and heat removal (Sreejith et al., 2000; Kelly et al., 2002)

Therefore, in some applications, an optimal solution for lubrication condition can be found between dry machining and flood cooling. In this regards, minimum quantity lubrication (MQL) is a viable solution to overcome the disadvantages of both dry and flood cooling machining processes.

The effectiveness of MQL process has been identified in turning (Dhar et al., 2006), milling (Lopez et al., 2006) and etc. In addition, MQL process parameters, such as nozzle distance and direction, discharge pressure, flow rates, etc., have been studied to optimize the machining conditions (Park et al., 2010)

The aim of study is experimentally investigate the influence of cutting speed, depth of cut and feed rate on surface roughness and cutting forces in high speed turning of monel k-500 in dry and MQL conditions.

2. Experimental Design

In this study compares surface roghness and cutting force in dry machinig and MQL in high speed turning of monel k-500. Cutting speed higher than 60 m/min is high speed turning (kamata et al., 2007).

2.1 Dry machining

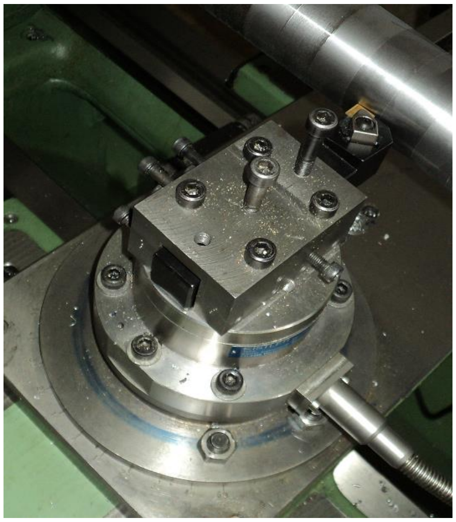
In the study, three parameters, namely cutting speed (V_c), depth of cut (a_p), feed rate (f) was identified and the ranges of the cutting conditions were determined through preliminary experiments. Each parameter was investigated at three levels to study the non-linearity effect of the parameters. Design of the experiments was chosen full factorial and the identified parameters and their associated levels are given in Table 1.

Table 1. *Machining parameters*

Parametrs	1	2	3
Cutting speed (m/min)	80	100	120
Feed rate (mm/rev)	0.16	0.20	0.24
Depth of cut(mm)	0.8	1.2	1.6

Turning machine used in this experiment was TN50D manufactured by Tabriz –Iran Technologies with the power of 5.5kw in the spindle motor with a maximum spindle speed of 2000 rpm. The monel k-500 specimen (super alloy steel) with the following chemical composition were used for high speed turning: Ni: 64.9 %; Cu: 29.77%; Mn: 0.64%; W: 0.26%; Nb: 0.05%; Ti: 0.57%; Fe: 0.97%;Cr: 0.06%; Co:0.08%;Al:2.56%; Mo:0.01%; Zr:0.02%. The work material has an average hardness of 35 HRC and this specimen was prepared as a bar with a diameter of 60mm and a length of 600mm and the lengh of machining in per level is 30mm. The K05 carbide inserts of ‘SNMA 12 04 08-K05’ (Sandvik, 2009) were used to machine the monel k-500 workpiece. The ‘PSBNR 2525M12’ type tool holder was used throughout the study. The experimental set up has been presented in figure 1.

Fig.1. *Experimental set up in dry machining*



2.2 Results of dry machining

Surface roughness plays an important role in the performance of mechanical and economical issues. Therefore, measuring and discussing the average surface roughness is utmost important. The average surface roughness (Ra) on the machined surface was measured perpendicular to the feed marks after every cut. A Perthometer (Divate) for measuring the surface roughness was used in this study. The accuracy of this equipment was 0.001 microns. There is various simple surface roughness amplitude parameters used in industry. Measurements was based on R_a method and the sampling length (L_c=0.8 mm), measuring length (L_m= 4 mm) and traverse length (L_t= 5.6 mm) are taken, respectively. Cutting forces were measured online by a Kistler 9272 three component dynamometer.

Surface roughness was measured three times and its average value was calculated. The results were concluded in Table 2 such as surface roghness and cutting force.

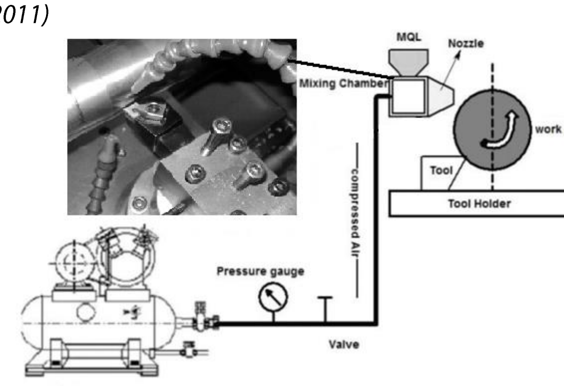
Table2. *The results of expriment in dry machining*

Tests	V_c(m/min)	f(mm/rev)	a_p(mm)	R_a(μm)	F_t(N)
1	80	0.16	0.8	0.905	308.3
2	80	0.16	1.2	0.913	582.5
3	80	0.16	1.6	0.919	862.8
4	80	0.2	0.8	1.110	418.7
5	80	0.2	1.2	1.129	826.5
6	80	0.2	1.6	1.130	1161.9
7	80	0.24	0.8	1.362	369.8
8	80	0.24	1.2	1.381	754.2
9	80	0.24	1.6	1.372	1071.6
10	100	0.16	0.8	0.950	271.4
11	100	0.16	1.2	0.962	506.8
12	100	0.16	1.6	0.963	760.8
13	100	0.2	0.8	1.401	379.8
14	100	0.2	1.2	1.411	670.5
15	100	0.2	1.6	1.414	1104.9
16	100	0.24	0.8	1.618	395.2
17	100	0.24	1.2	1.627	717.7
18	100	0.24	1.6	1.629	1139.1
19	120	0.16	0.8	1.130	289.6
20	120	0.16	1.2	1.141	530.4
21	120	0.16	1.6	1.159	813.8
22	120	0.2	0.8	1.749	359.9
23	120	0.2	1.2	1.770	644.3
24	120	0.2	1.6	1.779	999.3
25	120	0.24	0.8	1.849	370
26	120	0.24	1.2	1.993	711.1
27	120	0.24	1.6	2.061	1073.9

2.3 Machinig applying MQL

The machinability characteristics of the work material at different conditions are considered, mainly regarding surface roughness and cutting forces. The MQL needs to be supplied at high pressure and impinged at high speed through the nozzle at the cutting zone. Air pressure of MQL is 4 bar and distance of nozzle to tip insert is 100mm with 45 degree angle. In the turning process form 2 area friction and 2 nozzles need for lubricating. The best mount of lubricant in MQL is obtained 200 ml/h in this experiment. The photographic view of the experimental set-up is shown in Fig.2.Design of experiment like dry machining and 27 tests are done on the workpiece applying MQL.

Fig.2. *Experimental set up in machining with MQL(Vasu et al.,2011)*



2.4 Results in machining applying MQL

The results were concluded in Table 3 such as surface roughness and cutting forc.

Table 3. *The results of MQL*

Tests	V_c(m/min)	f(mm/rev)	a_p(mm)	R_a(μm)	F_t(N)
1	80	0.16	0.8	0.538	200.8
2	80	0.16	1.2	0.541	210.5
3	80	0.16	1.6	0.550	215.2
4	80	0.2	0.8	0.784	239.7
5	80	0.2	1.2	0.798	259.2
6	80	0.2	1.6	0.855	260
7	80	0.24	0.8	0.928	260.8
8	80	0.24	1.2	0.938	271.8
9	80	0.24	1.6	0.956	271.9
10	100	0.16	0.8	0.614	197.2
11	100	0.16	1.2	0.613	198.2
12	100	0.16	1.6	0.589	200.8
13	100	0.2	0.8	0.989	228.1
14	100	0.2	1.2	1	239
15	100	0.2	1.6	1.001	250
16	100	0.24	0.8	1.191	229.2
17	100	0.24	1.2	1.201	239.7
18	100	0.24	1.6	1.208	258.8
19	120	0.16	0.8	0.780	184.6
20	120	0.16	1.2	0.791	190.5
21	120	0.16	1.6	0.785	192.4
22	120	0.2	0.8	1.374	189.1
23	120	0.2	1.2	1.389	229.9
24	120	0.2	1.6	1.400	248.7
25	120	0.24	0.8	1.496	190.3
26	120	0.24	1.2	1.575	220.1
27	120	0.24	1.6	1.640	250.5

3. Discussion about results

According to the figure 3a, by increasing cutting speed, surface roughness is increased in dry and MQL conditions.

According to the figure 3b, by increasing feed rate, surface roughness is increased in dry and MQL conditions.

According to the figure 3c, depth of cut is not effect on surface roughness in dry and MQL conditions.

According to figure the 4c, there is a reduction of surface roughness in the MQL condition as compared to dry and this reduction is about 38 percent.

The minimum surface roughness is in 80 m/min cutting speed , 0.16 mm/rev feed rate and 0.8 mm depth of cut and the surface roughnesses are obtained 0.905 μm in dry condition and 0.538 μm in MQL.

According to the figure 4a, by increasing cutting speed, cutting force is not effect in dry and MQL conditions.

According to the figure 4b, by increasing feed rate, cutting force is increased in dry and is not effect in MQL conditions.

According to the figure 4c, by increasing depth of cut, cutting force is increased in dry and is not effect in MQL conditions.

According to figure the 4d, there is a reduction of cutting force in the MQL condition as compared to dry and this reduction is about 59 percent.

The minimum cutting force is in 100 m/min cutting speed , 0.16 mm/rev feed rate and 0.8 mm depth of cut and the cutting force are obtained 271.4 N in dry condition.

The minimum cutting force is in 120 m/min cutting speed , 0.16 mm/rev feed rate and 0.8 mm depth of cut and the cutting force are obtained 184.6 N in MQL condition.

The MQL is more effect on cutting speed than surface roughness and MQL can resault to increse the tool life.

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Fig.3. *The effects of machinig parameters on the surface roughness*

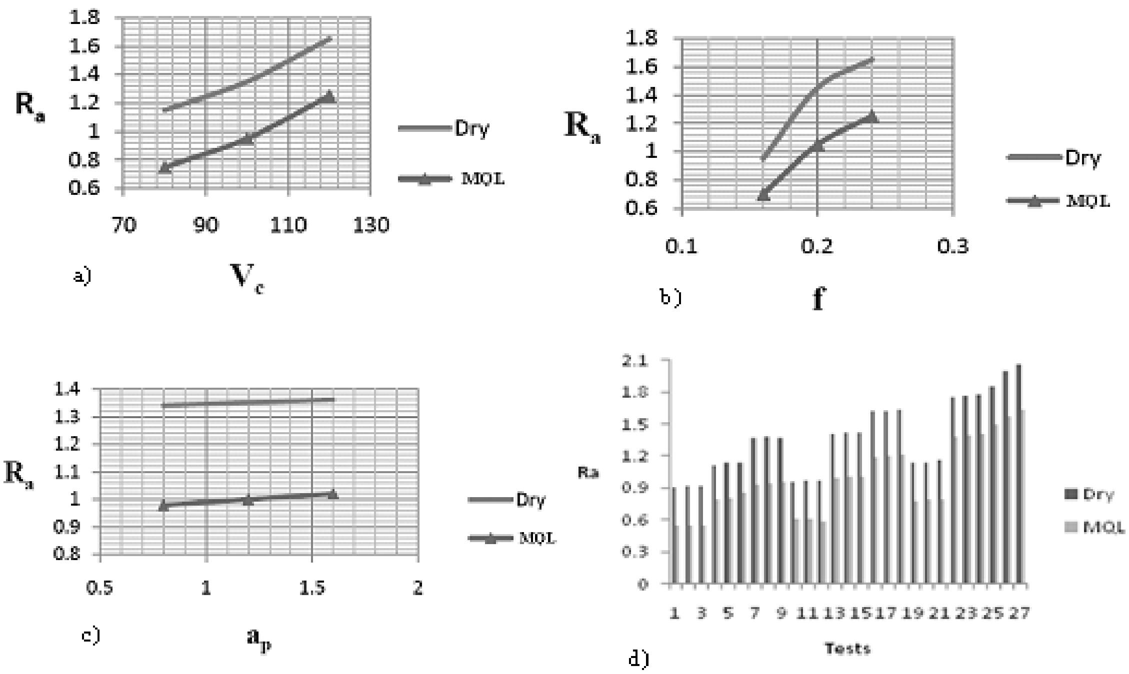
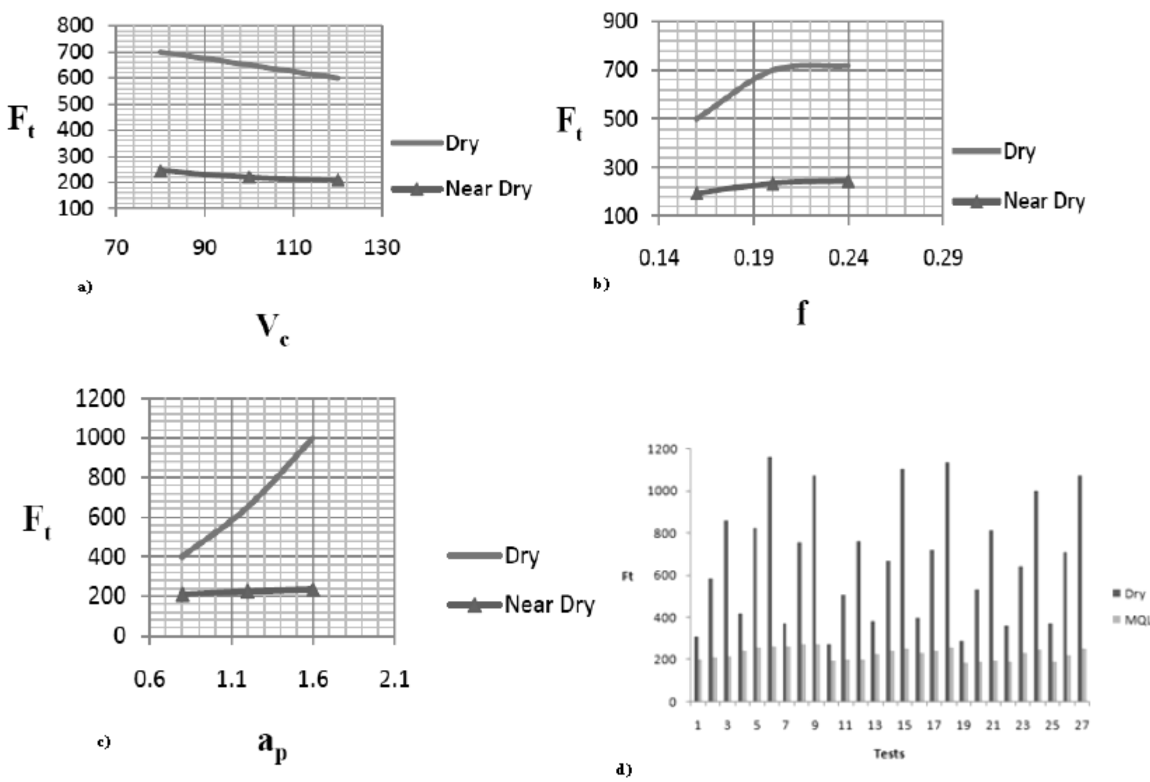


Fig.4. *The effects of machinig parameters on the cutting force*



4. Conclusion

In this study, three parameters such as cutting speed (V_c), feed rate (f), depth of cut (a_p) were identified and the ranges of the cutting conditions were determined through preliminary experiments. Each parameter was investigated at three levels to study the non-linearity effect of the parameters. Design of the experiments was chosen full factorial . The aim of this paper is to experimentally investigate the influence of cutting speed, depth of cut and feed rate on surface roughness and cutting forces in high speed turninig of monel k-500 in dry and MQL conditions. After doing expriment, above results is obtained:

1. By increasing cutting speed, surface roughness is increased in dry and MQL conditions.
2. By increasing feed rate, surface roughness is increased in dry and MQL conditions.
3. Depth of cut is not effect on surface roughness in dry and MQL conditions.
4. The surface roughness is decreased in the MQL condition as compared to dry and this reduction is about 38 percent.
5. The minimum surface roughness is in 80 m/min cutting speed , 0.16 mm/rev feed rate and 0.8 mm depth of cut and the surface roughnesses are obtained 0.905 µm in dry condition and 0.538 µm in MQL.
6. By increasing cutting speed, cutting force is not effect in dry and MQL conditions.
7. By increasing feed rate, cutting force is increased in dry and is not effect in MQL conditions.
8. By increasing depth of cut, cutting force is increased in dry and is not effect in MQL conditions.
9. The cutting force is decreased in the MQL condition as compared to dry and this reduction is about 59 percent.
10. The minimum cutting force is in 100 m/min cutting speed , 0.16 mm/rev feed rate and 0.8 mm depth of cut and the cutting force are obtained 271.4 N in dry condition.
11. The minimum cutting force is in 120 m/min cutting speed , 0.16 mm/rev feed rate and 0.8 mm depth of cut and the cutting force are obtained 184.6 N in MQL condition.
12. The MQL is more effect on cutting speed than surface roughness and MQL can resault to increse the tool life.

5. Acknowledgment

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6. References

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