Investigation on Turning of AISI H13 with applying Minimum Quantity of Lubricant

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Abstract

Minimum quantity of lubrication (MQL) in machining is an established alternative to completely dry or flood lubricating system from the viewpoint of cost, ecology and human health issues. Hence, it is necessary to select proper MQL and cutting conditions in order to enhance machinability for a given work material. In machining of parts, surface quality is one of the most specified customer requirements. The aim of this paper is to experimentally investigate the influence of cutting speed, feed rate and quantity of lubricant on surface roughness in turninig of AISI H13 with applying MQL. The optimization results indicated that MQL of 200 ml/h, cutting speed of 200m/min and a feed rate of 0.08 mm/rev is the best condition of machining to minimize surface roughness.

Keywords: Minimum Quantity of Lubricant (MQL), AISI H13, Feed Rate, Cutting Speed, Surface Roughness

1. Introduction

Historically,(Astakhov,2006) until the 19th century, water was used for centuries as a cooling medium to assist various metal working operations. Taylor (Taylor, 1907) was probably the first to prove the practical value of using liquids to aid in metal cutting. In 1883, he demonstrated that a heavy stream of water flooding the cutting zone increased the allowable cutting speed by 30–40%.

It was found however that, although water is an excellent coolant due to its high thermal capacity and availability, the use of water as a coolant had the drawbacks of corrosion of parts and machines and poor lubrication. Further developments followed quickly. Mineral oils were developed at this time as they had much higher lubricity. However, their lower cooling ability and high costs restricted their use to low cutting-speed machining operations. Finally, between 1910 and 1920 soluble oils were initially developed to improve the cooling properties and fire resistance of straight oils (Childers JC, 1994).

Other substances were also added to these to control problems such as foaming, bacteria and fungi. Oils as lubricants for machining were also developed by adding extreme-pressure (EP) additives. Today, these two types of MWFs coolants are known as water emulsified oils and straight cutting oils. Additionally, semi-synthetic and synthetic MWFs were developed to improve the performance of many machining operations (Mariani G, 1990).

Today, MWFs play a significant role in manufacturing processes, supporting their high productivity and efficiency.

Due to several negative effects, a lot has been done in the recent past to minimize or even completely avoid the use of cutting fluids. One approach towards dry machining is semidry operations utilizing very small amount of cutting fluids are expected to become a powerful tool. Minimum quantity lubrication (MQL) refers to the use of cutting fluids of only a minute amount—typically of a flow rate of 50–500 ml/h which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition. Minimum quantity of lubrication (MQL) in machining is an alternative to completely dry or flood lubricating system, which has been considered as one of the solutions for reducing the amount of lubricant to address the environmental, economical and mechanical process performance concerns (Dhara et al. ,2007).

The aim of this paper is to experimentally investigate the influence of cutting speed, feed rate and quantity of lubricant on surface roughness in turninig of AISI H13 with applying MQL.

2. Experimental Design

In the present study, three parameters, namely, quantity of lubricant (Q), cutting speed (V_c) and feed rate (f) 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 and the identified parameters and their associated levels are given in Table 1.

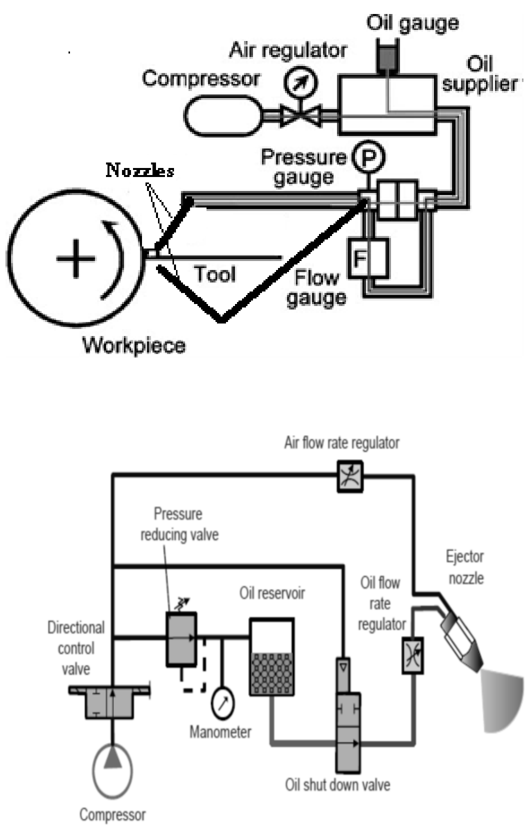
Table 1. *Machining parameters*

Parametrs	1	2	3	4
Cutting speed (m/min)	150	200	250	-
Feed rate (mm/rev)	0.08	0.11	0.16	-
Quantity of lubricant(ml/h)	100	150	200	250

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 AISI H13 specimen (Hot work steel uses in injection mould) with the following chemical composition were used for turning: C: 0.39 %; Cr: 5.15%; Mo: 1.25%; V: 1%;Si: 1%; Mn: 1%; rest iron. The work material has an average hardness of 48 HRC and this specimen was prepared as a bar with a diameter of 70mm 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 AISI H13 workpieces. The 'PSBNR 2525M12' type tool holder was used throughout the study. The depth of cut of 1.6mm was kept constant throughout the machining tests.

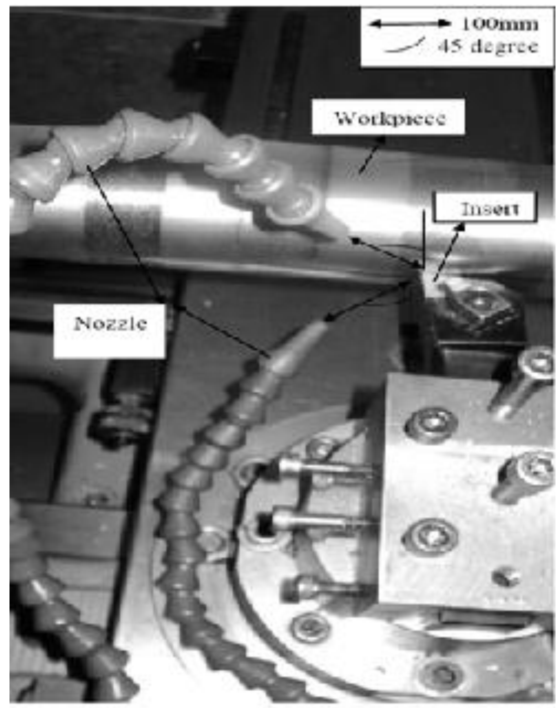
The MQL needs to be supplied at high pressure and impinged at high speed through the nozzle at the cutting zone. Considering the conditions required for the present research work and uninterrupted supply of MQL at constant pressure over a reasonably long cut, a MQL delivery system has been designed, fabricated and used. The schematic view of the MQL set up is shown in Fig.1. The thin but high velocity stream of MQL was projected along the cutting edge of the insert, as indicated in a frame within Fig.1, so that the coolant reaches as close to the chip-tool and the work-tool interfaces as possible.

Fig.1. *Schematic view of the MQL set up(Obikawa,2006)*



The MQL jet has been used mainly to target the rake and flank surface and to protect the auxiliary flank to enable better dimensional accuracy MQL is expected to provide some favourable effects mainly through reduction in cutting temperature. Air pressure of MQL is 7bar and distance of nozzle to tip insert is 100mm with 45 degree. In the turning process form 2 area friction and 2 nozzles need for lubricating. The photographic view of the experimental set-up is shown in Fig.2.

Fig.2. *Experimental set-up*



3. Result and Discussion

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 (produced by Mahr Co, Model M2) 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. Surface roughness was measured three times and its average value was calculated. The results were concluded in Table 2.

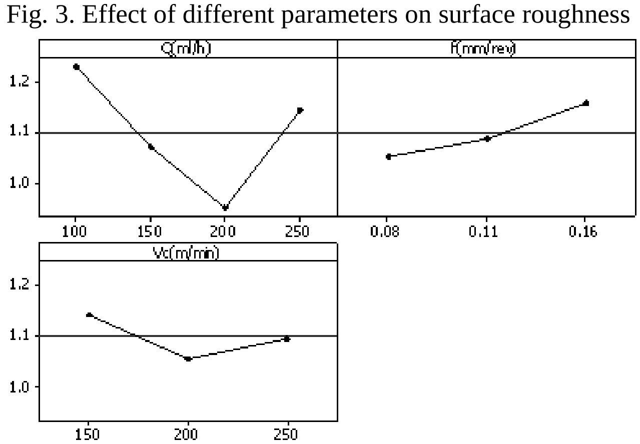
Table 2. *Results of expriment*

Tests	Q	f	V_c	R_a(μm)	Tests	Q	f	V_c	Ra(μm)
1	100	0.08	150	1.212	19	200	0.08	150	0.909
2	100	0.08	200	1.159	20	200	0.08	200	0.886
3	100	0.08	250	1.191	21	200	0.08	250	0.923
4	100	0.11	150	1.237	22	200	0.11	150	0.985
5	100	0.11	200	1.171	23	200	0.11	200	0.923
6	100	0.11	250	1.202	24	200	0.11	250	0.955
7	100	0.16	150	1.401	25	200	0.16	150	1.100
8	100	0.16	200	1.203	26	200	0.16	200	0.941
9	100	0.16	250	1.293	27	200	0.16	250	0.943
10	150	0.08	150	1.006	28	250	0.08	150	1.099
11	150	0.08	200	0.991	29	250	0.08	200	1.082
12	150	0.08	250	1.041	30	250	0.08	250	1.120
13	150	0.11	150	1.087	31	250	0.11	150	1.151
14	150	0.11	200	1.021	32	250	0.11	200	1.123
15	150	0.11	250	1.052	33	250	0.11	250	1.151
16	150	0.16	150	1.251	34	250	0.16	150	1.280
17	150	0.16	200	1.053	35	250	0.16	200	1.141
18	150	0.16	250	1.143	36	250	0.16	250	1.149

3.1 Analyses the results of experiment

Fig. 3 shows the effect of different parameters (quantity of lubricant (Q), cutting speed (V_c) and feed rate (f)) on surface roughness by carbide tool that it designed with Minitab software.

Fig. 3. Effect of different parameters on surface roughness



The result of figure 3 shows, by increasing the cutting speed from 150 to 200 m/min, surface roughness value is decreased because by increasing cutting speed in defined range that this defined range depend on the material workpiece and used tool. By increasing the cutting speed from 200 to 250 m/min surface roughness value is increased and the optimization result indicated that cutting speed of 200m/min is the best condition of machining to minimize surface roughness.

By increasing the feed rate surface roughness value is increased and the result indicated that feed rate of 0.08 mm/rev is the best condition of machining to minimize surface roughness.

By increasing the quantity of lubricant from 100 to 200 ml/h, surface roughness value is decreased. By increasing the cutting speed from 200 to 250 ml/h surface roughness value is increased and 200ml/h is the best condition of MQL to minimize surface roughness.

4. Conclusion

In the present study, three parameters, namely, quantity of lubricant (Q), cutting speed (V_c) and feed rate (f) 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, feed rate and quantity of lubricant on surface roughness in turninig of AISI H13 with applying MQL.After doing expriment, the results were obtained:

1. By increasing the cutting speed from 150 to 200 m/min, surface roughness value is decreased and by increasing the cutting speed from 200 to 250 m/min surface roughness value is increased and the optimization result indicated that cutting speed of 200m/min is the best condition of machining to minimize surface roughness.

2. By increasing the feed rate surface roughness value is increased and the result indicated that feed rate of 0.08 mm/rev is the best condition of machining to minimize surface roughness.

3. By increasing the quantity of lubricant from 100 to 200 ml/h, surface roughness value is decreased. By increasing the cutting speed from 200 to 250 ml/h surface roughness value is increased and 200ml/h is the best condition of MQL to minimize surface roughness.

4. Finally, the optimization results indicated that MQL of 200 ml/h, cutting speed of 200m/min and a feed rate of 0.08 mm/rev is the best condition of machining to minimize surface roughness.

5. Acknowledgment

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6. References

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