Performance Evaluation of Semisynthetic Cutting Fluid in the Machining of Alloy Steel Using Pulsed Jet Minimal Quantity Lubrication System

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Abstract- *This paper presents performance evaluation of Semisynthetic cutting fluids used in a minimal quantity lubrication (MQL) system. The MQL system, was capable of delivering high velocity cutting fluid in narrow pulsed jet forms at a rate of 2 ml/min and a pressure of 20 MPa. The cutting fluid chosen was semi-synthetic cutting fluid. The experiments were designed to evaluate the performance of the fluid at various cutting velocities of 30,50 and 70 m/min and feed rates of 0.07,0.08 and 0.09mm/tooth. The results were measured in terms of the surface roughness of the machined workpiece and the cutting forces. Analysis of the result has shown that With suitable machining parameter selection, Semisynthetic cutting fluid performed well to deliver low surface roughness results.*

Keywords- Chip Formation, Cutting Fluids, Force, MQL, Wear.

I. INTRODUCTION

The primary function of the cutting fluids in metal machining operations is to serve as a coolant as well as a lubricant. It is generally agreed that the application of cutting fluids can improve the tool life and results in good surface finish by reducing thermal distortion and flushing away of machined chips. The goal in all conventional metal-removal operations is to raise productivity and reduce costs by machining at the highest practical speed along with long tool life, fewest rejects, and minimum downtime, and with the production of surfaces of satisfactory accuracy and finish [11]. Selecting the right cutting fluid is as important as choosing the suitable machine tools, tooling, speed and feed because it can always affect the output parameters. The use of cutting fluid permits higher cutting speeds, higher feed rates, greater depths of cut, lengthened tool life, decreased surface roughness, increased dimensional accuracy, and reduced power consumption.

Cutting fluids can be applied using various methods. The flooding method is the most commonly used in which a high volume flow is applied and floods the entire machining area, effectively removing the heat generated from the machining process [3]. However, improved production efficiency and revised regulations in the machining industry favours the reduction of cutting fluid usage. It was reported that operators who are frequently exposed to cutting fluids are susceptible to costly cases of occupational dermatitis and other skin diseases such as sensitization to specific irritants, oil acne, and hyperpigmentation [4, 5]. In addition, improper disposal of used cutting fluids may cause serious impact to the environment through contamination of the soil, water and air.

Furthermore, cutting fluid usage can account for 7-17% of the total production costs through its procurement, storage, maintenance and disposal [6-9]. Minimal quantity lubrication (MQL) encompasses various techniques in which the cutting fluid is applied in very small quantities during machining. An example of an MQL technique is the mist coolant application. In this method, very small droplets of the cutting fluid are dispersed in a gas medium, generally air, and applied at the cutting zone [3]. This research will focus on the performance evaluation of semisynthetic cutting fluid used in the pulsed jet MQL system.

II. METHODOLOGY

Apparatus

Pulsed Jet MQL System

The pulsed jet MQL system, consists of a variable speed control drive which regulates an injection pump to deliver cutting fluid in the form of a high pressure pulsed jet stream.

Experiment Setup

Experiments were conducted on a high-speed vertical machining centre .The cutting tools selected were PVD coated carbide inserts .The workpiece chosen was Alloy steel. The size of the workpiece was 60 mm x 110 mm x 260 mm. The cutting fluid chosen was semi-synthetic cutting fluid (ECOCOOL 68 CF2). Prior to usage, the semi-synthetic cutting fluid was mixed with water in a volumetric concentration of 1:10.

Design of Experiments

Table 1 shows the variable and constant parameters for the experiments. The depth of cut and pick feed were kept constant at 0.2 mm and 4 mm respectively. The MQL was set at a pulsing rate of 400 pulse/min, a pulsing pressure of 20 MPa and a delivery rate of 2 ml/min [11] with the fluid injected against the feeding direction.

Table 1. Experimental Parameters

S.N.	Variables	Exp. 1	Exp. 2
1	V, cutting speed, m/min	30, 50, 60	30
2	fz, feed rate, mm/tooth	0.07	0.07, 0.08, 0.09
3	D, cutter diameter, mm	25	25
4	fm, table feed	40, 80, 119	60, 72, 84
5	DOC, axial depth of cut, mm	0.2	0.2
6	fp, Pick feed, mm	4	4
7	l, cutting length, m	1	1
8	Pulsing rate, pulse/min	400	400
9	Pulsing pressure, MPa	20	20
10	Lubricant delivery rate, ml/min	2	2
11	Pulsing direction	Against feeding direction	Against feeding direction

Experimental Procedures

The experimental runs consisted of 4 down milling passes along the 260 mm length of the workpiece. After finishing one milling pass, the tool was shifted 4 mm inwards (pick feed) to start the next pass. The total cutting length was set at 1 m or equivalent to 4 milling passes along the workpiece.

Result and Discussion

The result obtained showed the performance of the semi synthetic cutting fluid in terms of cutting forces and surface roughness. The following discussion will describe the influence of cutting velocities and feed rates on the measured outputs. The desirable outputs for good machining performance are low cutting forces and low surface roughness.

Cutting Forces

Figure 1 shows the effect of cutting velocity on the cutting force. From 30m/min to 50m/min,the cutting force for semi synthetic cutting fluid decreases and from 50m/min to 70mmin cutting force increases slightly. It was observed that semi synthetic fluid had achieved the lowest cutting force at cutting velocity of 50m/min.

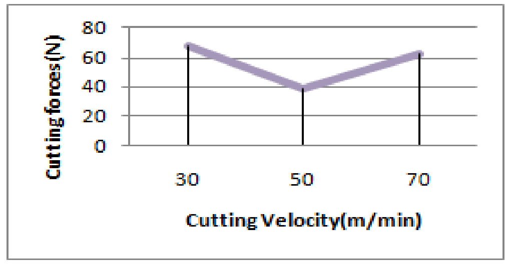

Figure 1: Effect of cutting velocity on cutting force (feed rate 0.07 mm/tooth)

Figure 2 shows the effect of feed rate on the cutting force. It was observed that for semi synthetic cutting fluid at cutting velocity 30m/min, cutting force increases with the increase in feed rate.

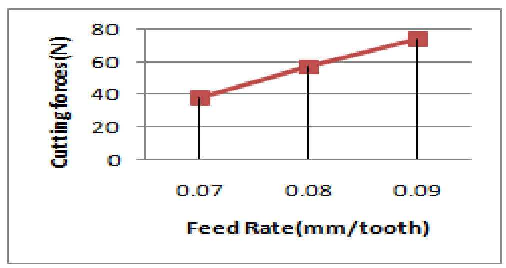

Figure 2: Effect of Feed Rate on cutting force (Cutting velocity 30 m/min)

Surface Roughness

Figure 3 shows the effect of cutting velocity on the surface roughness. It was observed that for semi synthetic cutting fluid at 0.07 mm/tooth feed, the surface roughness decreases with the increase in cutting velocity.

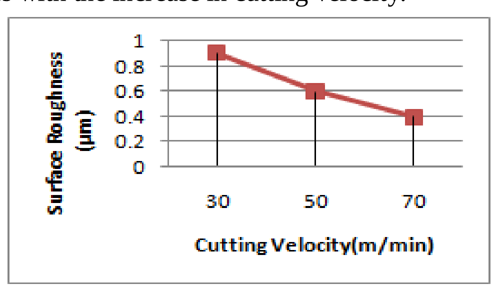

Figure 3: Effect of cutting velocity on Surface Roughness (feed rate 0.07 mm/tooth)

Figure 4 shows the effect of feed rate on surface roughness. In general, the surface roughness decreases with an increase in feed rate.

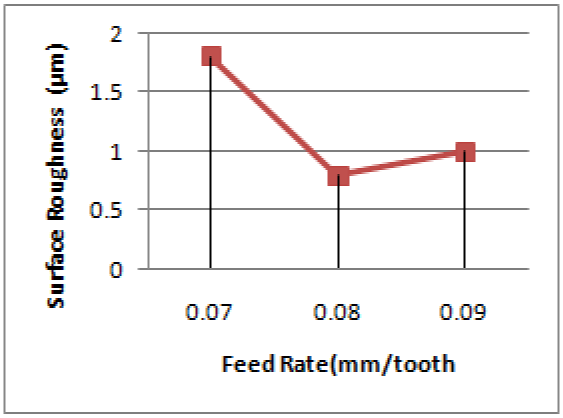

Figure 4: Effect of feed rate on surface roughness (Cutting velocity 30 m/min)

III. CONCLUSION

With proper machining parameter selection, water mixed cutting fluid (Semi synthetic) performed well to deliver low surface roughness results. Thus, it can be an economical choice in the selection process.

REFERENCES

[1] E.J. Oberg, F.D.; Horton, H.L.; Ryffell, H.H. , Machinery’s Handbook (26th Edition),Industrial Press Inc, New York, 2000.

[2] K.A. Abou-El-Hossein, "Cutting fluid efficiency in end milling of AISI Stainless Steel",Industrial Lubrication and Tribology, Vol. 60, pp. 115-120, 2008.

[3] P.N. Roa, Manufacturing technology: metal cutting and machine tools, Tata McGraw Hill Publication, New Delhi, 2000.

[4] M. Sokovic and K. Mijanovic, "Ecological aspects of the cutting fluids and its influence on quantifiable parameters of the cutting process", Journal of Material Processing Technology, Vol. 109, pp. 181-189, 2001.

[5] A. Michael, "Occupational health and safety", Waco, Vol. 63, pp. 82-84, 1994.

[6] F.a.E. Klocke, G. , "Dry cutting", Annals CIRP, Vol.46, pp. 519-526, 1997.

[7] M.A.S.K.a.M.-U.-S. Rahman, "Evaluation of Minimal Quantities of Lubricant in End Milling", The International Journal of Advanced Manufacturing Technology, Vol. 18 , pp. 235-241, 2001.

[8] M.G. A. Attanasio, C. Giardini and C. Remino, "Minimal quantity lubrication in turning: effect on tool wear", Wear, Vol. 260, pp. 333-338, 2006

[9] C. Bruni, A. Forcellese, F. Gabrielli and M. Simoncini, "Effect of the lubricationcooling technique, insert technology and machine bed material on the workpart surface finish and tool wear in finish turning of AISI 420B", International Journal of Machine Tools and Manufacture, Vol. 46, pp. 1547–1554, 2006

[10] A.S. Varadarajan, P.K. Philip and B. Ramamoorthy, "Investigation on hard turning with minimal cutting fluid application (HTMF) and its comparison with dry and wet turning", International Journal of Machine Tools and Manufacture,Vol 42, pp. 193-200, 2002.

[11] T. Thepsonthi, M. Hamdi, K. Mitsui, "Investigation into minimal-cutting-fluid application in high-speed milling of hardened steel using carbide mills", International Journal of Machine Tools and Manufacture, Vol 49, pp. 156-162, 2009