

Experimental Investigation of Effect on Surface Finishing by Minimum Quantity Lubrication [MQL] with Varying Feed Rate

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Abstract: In the present competitive environment of Machining and Manufacturing processes particularly in the mass production firms the optimistic objective is to attain the best in industry with superior quality, reliable products which exhibits better dimensional accuracy and required productivity. In many operations flooding of coolant is applied for mass production, which will receives the help in reducing heat from cutter and work piece. The usage of coolant generally causes life of the tools and it also maintains work piece surface properties without damage. In the present work the attention has focused on minimum quantity lubrication required during turning operations. The purpose of this experimentation is to set a benchmark for selecting desired lubrication conditions to varying feed rate at a constant spindle speed. This work also highlights the impact of various lubrication conditions on the surface finishing. Based upon the experimental results obtained for a given depth of cut and at a specified speed of 570 rpm the variation of surface roughness with feed has been documented.

Keywords: Feed rate [f], Minimum Quantity Lubrication [MQL], Spindle speed [rpm], Surface roughness [R_a].

I. INTRODUCTION

The most recent technique of transferring metal cutting fluid to the tool work piece interface is MQL, also known as “Micro-lubrication”, (Gugger and Gressel, MaClure, Adams, 2007) and (Eisen blatter and Klocke, 1997) “Near-Dry Machining”, “Micro-Dosing”, and sometimes even gets incorrectly referred to as “mist coolant.” By the Use of this technology, when a

diminutive fluid is opted properly and applied, can accomplish significant difference in how adequately a tool performs. In traditional machining operations using surge lubrication, cutting liquids are chosen primarily on the basis of their subscription to cutting performance. There are two fundamental types of MQL delivery system: external drip and through-tool. The external drip system comprises of a coolant tank or container which is associated with tubes fitted with at least one nozzle. By balancing coolant delivery the assemblage of the system can be done near or on the machine with a provision of adjusting air and coolant flow unrestrictedly. It is cheap, compact, and suitable for all machining operations. Two configurations are available for Through-tool MQL systems; in light of the technique for making the air-oil mist. The primary one is external mixing or one-channel system. Here, the oil and air are blended externally and channeled through the spindle and tool to the cutting zone [2]. The present work concentrates on the external drip technique where primary work material opted is aluminum for which the coolant effect on surface roughness (R_a) for various conditions are considered. It has been noticed that, at the cutting point when coolant is supplied in small measure the surface finish is improvised largely. The attrition wear mechanism on flank face, as well as diffusion and adhesion wear mechanism on the rake face cause the most failures of cutting tool. Hence, using cutting fluid is essential to remove the heat and chips produced during machining. However, flooded cutting fluids in high-speed machining are ineffective in penetrating the chip-tool interface; these fluids cannot remove generated heat [5]. Through experiments, the current work investigates the role of MQL and flooded coolant on surface roughness of machined object i.e. Aluminum during the high-speed turning at different values for depth of cut, and feed. The force exerted on cutting tool at the cutting edge and temperature developed influences

largely on tool life. Changing the values of feed rate, depth of cut and cutting speed will directly affect the temperature developed and cutting force towards tool life [5].

II. EXPERIMENTAL SETUP

The typical experimental arrangement for external drip technique of minimum quantity lubrication is as shown in the Fig. 1.



Fig. 1: Physical Orientation of Machining with MQL

Propylene glycol ester in the liquid along with triglyceride in combination was used as the coolant. Aluminum was taken as the work material throughout the machining operations under the prescribed setup. High speed steel was the material composition of cutting tool having 6° rake angle $120 \mu\text{m}$ chamfer length $30 \mu\text{m}$ horn radius and $80 \mu\text{m}$ nose radius. During experimentation 30 pieces of aluminum were made for 50 mm diameter and having 140 mm length.

Over each work piece three different surface finishing has generated by considering different conditions of machining. At an uniform speed of 570 rpm a standard depth of cut was maintained throughout the experimentation. The various feed rate opted were $700 \mu\text{m}/\text{rev}$ and $500 \mu\text{m}/\text{rev}$.

For each surfaces the roughness parameter of surface (R_a Value) was attained in micrometer and were tabulated in Table I. To attain effective final R_a value minimum of 3 roughness parameters were fetched. It was taken care for conducting all the experiments under similar measuring and experimental conditions.

The flow rate of lubrication were tabbed to the entire range right from dry to full flooding. To get the idea of flow rate quantity of coolant was noted. A burette was used to supply minimum quantity of coolant. By updating the amount of coolant in the burette it was taken care that the flow rate of coolant supply continuously on work piece without interruption.

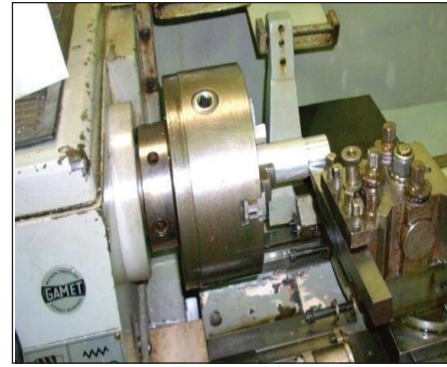


Fig. 2: Arrangement of Dry Machining

III. SURFACE ROUGHNESS MEASUREMENT

MITOTOYO Surface roughness measuring instrument SJ-201P [Fig. 3] was used to find surface roughness R_a Value. The display range was 0.01 to 100 microns.



Fig. 3: Surface Roughness Measurement

IV. COROLLARY AND DISCUSSIONS

The results of flow of lubrication with various rate of flow are listed in Table I below. For a constant speed four trial were conducted with varying feed rate for all lubrication condition. Table II consists explanation for flow rate of lubrication which are mentioned in Table I.

TABLE I: COOLANT FLOW RATES

Case #	Lubrication flow rate	
1	Dry	0 L/hour
2	Liquid 1	0.08 L/hour
3	Liquid 2	0.2 L/hour
4	Liquid 3	0.4 L/hour
5	Liquid 4	0.6 L/ hour
6	Full Flood	Flow more than 0.8 L/hour (Full Flow)

TABLE II: WORK PIECE SURFACE ROUGHNESS (R_a) FOR VARIOUS MACHINING VARIABLES

Ex N	Speed rpm	Feed mm/rev	Surface Roughness- R_a (Microns)					
			Dry	Liquid 1	Liquid 2	Liquid 3	Liquid 4	Full Flood
1	570	0.03	1.43	0.65	0.53	0.65	0.8	0.8
2	570	0.1	1.60	0.73	0.8	0.85	0.84	1.0
3	570	0.5	9.20	8.7	8.1	7.1	8.4	8.1
4	570	0.7	12.3	10.2	10.2	9.3	9.7	9.5

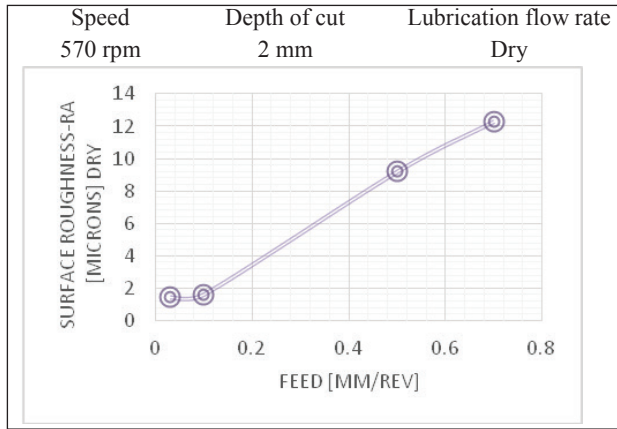


Fig. 4: Surface Roughness, Dry Lubrication Vs. Feed

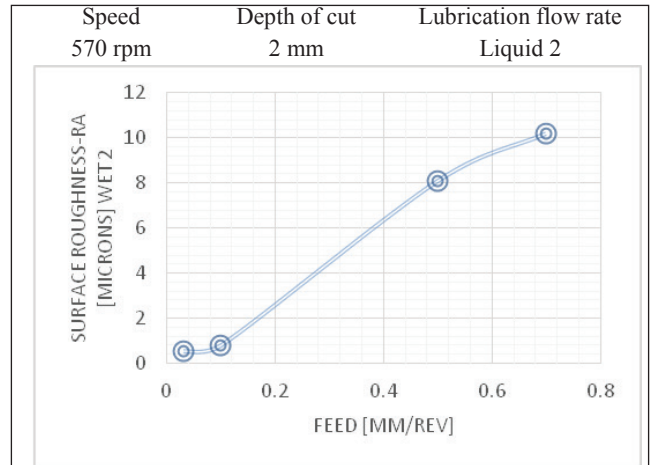


Fig. 6: Surface Roughness, Liquid 2 Lubrication Vs. Feed

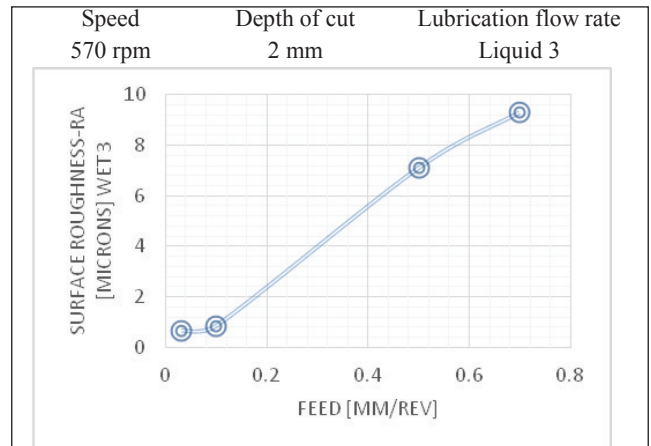


Fig. 7: Surface Roughness, Liquid 3 Lubrication Vs. Feed

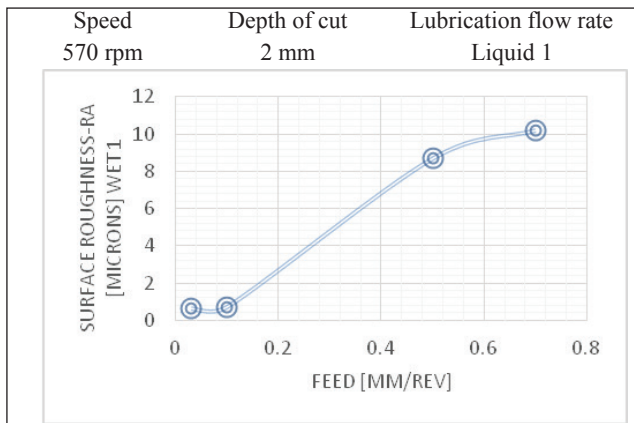


Fig. 5: Surface Roughness, Liquid 1 Lubrication Vs. Feed

Fig. 4 shows, for dry machining condition (0 l/hour) has the deviation of surface roughness versus feed by maintaining spindle speed 570 rpm as constant and depth of cut as 2 mm. From the above graph it can be noticed that for the stated condition, as the feed (mm/rev) increases there is drastic increase in roughness.

Fig. 5 shows, for Liquid 1 machining condition [0.08 L/hour] the deviation of surface roughness versus Feed by maintaining spindle speed 570 rpm as constant and depth of cut as 2 mm.

Fig. 7 shows, for Liquid 3 machining condition [0.04 L/hour] the deviation of surface roughness versus Feed by maintaining spindle speed 570 rpm as constant and depth of cut as 2 mm.

Fig. 8 shows, for Liquid 2 machining condition [0.06 L/hour] the deviation of surface roughness versus Feed by maintaining spindle speed 570 rpm as constant and depth of cut as 2 mm.

Fig. 9 shows the variation of surface roughness Vs. Feed for the Flood [>800 ml/hour] machining condition at a depth of cut of 2 mm and at a constant speed of spindle 570 rpm.

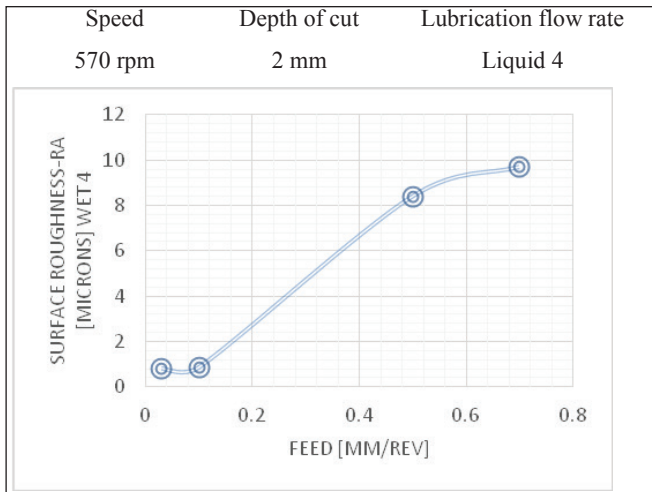


Fig. 8: Surface Roughness at Wet 4 Lubrication Vs. Feed

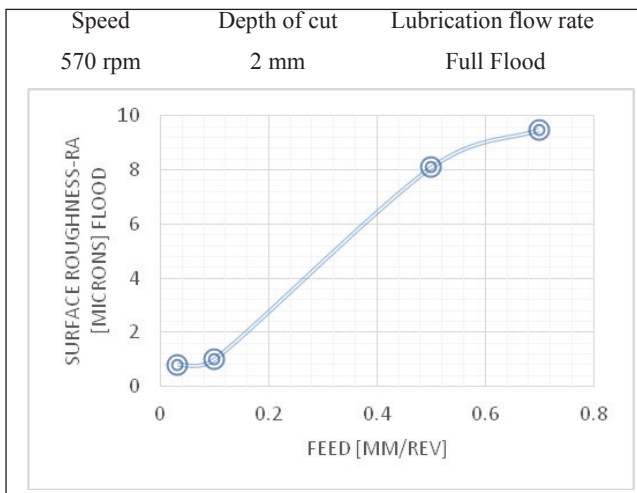


Fig. 9: Surface Roughness at Flow Flood Lubrication Vs. Feed

V. CONCLUSION

The results obtain highlights the following:

Surface roughness of 7.1 μm is observed while machining with 570 rpm and a flow rate of 400 ml/hr of lubricating oil [water based].

It is observed that higher surface finish is obtained as compare to flooding of coolant and dry lubrication for a feed of 0.5 mm/rev.

Coolant flow rate of 200 ml/hr to 400 ml/hr is showing significant improvement in surface finish as compare to dry lubrication and lubricating with a flow rate of 80 ml/hr.

As the feed increases from 0.1 to 0.7 mm/rev slightly higher flow rate of lubrication is assisting in better finish. 0.1 mm/rev with Wet [80 ml/hr] of coolant flow is giving relatively better

finish of 0.75 μm . At 0.5 mm/rev with Wet-3 [400 ml/hr] flow rate of coolant is showing significant higher finish of 9.7 μm as compare to total dry and Wet-1 flow rate of coolant [12.3 μm and 10.2 μm].

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