

Experimental Investigation on Wet Lubrication System in Turning Operation of Mild Steel by Minimizing the Flow Rate of Cutting Lubricants

S. S. Bhambale, C. V. Patil, S. R. Nirmal

Abstract- In present study it has been surveyed that, the metal industries using the cutting fluid has become more problematic in terms of both employee health and ecological pollution. But the use of cutting fluid generally causes economy of tools and it becomes easier to keep tight tolerances and to maintain work piece surface properties without damages. Because of them some alternatives has been sought to minimize or even avoid the use of cutting fluid in machining operations. This paper deals with experimental investigation on the role of wet lubrication system on cutting temperature, tool wear in turning of mild steel at industrial speed-feed combinations by H.S.S cutting tool. The encouraging results include significant reduction in cutting temperature, tool wears by wet lubrication system mainly through favorable chip-tool and work-tool interaction.

Index Terms- Chip-tool, Dry machining, H.S.S, Wet Lubrication System, Work-tool interface.

I. INTRODUCTION

High production machining of steel inherently generates high cutting zone temperature. Such high temperature causes dimensional deviation and serious failure of cutting tools. It also impairs the surface integrity of the product by inducing tensile residual stresses and surface and subsurface micro cracks in addition to rapid oxidation and corrosion. Now a day, this problem is tried to be prohibited by reducing heat generation and removing heat from the cutting zone through optimum selection of machining parameters, proper cutting fluid application and using heat resistant cutting tools. For the companies, the costs related to cutting fluids represent a large amount of the total machining costs. Several research workers state that the costs related to cutting fluids are frequently higher than those related to cutting tools. In reality, however, they are sometimes less effective when higher machining efficiency, better surface finish quality and severe cutting conditions are required. For these situations, semi-dry operations utilizing very small amounts of cutting lubricants are expected to become a powerful tool and, in fact, they already play a significant role in a number of practical applications. Wet lubrication system refers to the use of cutting fluids of only a minute amount-typically of a flow rate of 50 ml/hour which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition, here, for example, up to 10 liters of fluid can be dispensed per minute. [1,5,9].The

concept of minimum quantity lubrication, sometimes referred to as near dry lubrication, has been suggested since a decade ago as a means of addressing the issues of environmental intrusiveness and occupational hazards associated with the airborne cutting fluid particles on factory shop floors. The minimization of cutting fluid also leads to economical benefits by way of saving lubricant costs and work -piece/tool/machine cleaning cycle time. The present work experimentally investigates the role of wet lubrication system on surface roughness, tool flank wear in turning at various speed combinations by high speed steel tool.

II. WET MACHINING

Several research workers state that the costs related to cutting fluids are frequently higher than those related to cutting tools. Consequently, elimination on the use of cutting fluids, if possible, can be a significant economic incentive. Considering the high cost associated with the use of cutting fluids and projected escalating costs when the stricter environmental laws are enforced, the choice seems obvious. Because of them some alternatives has been sought to minimize or even avoid the use of cutting fluid in machining operations. Some of these alternatives are dry machining and machining with wet lubrication system. High cutting zone temperature is generally tried to be controlled by employing flood cooling by soluble oil. In high speed-feed machining, conventional cutting fluid application fails to penetrate the chip-tool interface and thus cannot remove heat effectively and the use of cutting fluid has become more problematic in terms of both employee health and environmental pollution. Addition of extreme pressure additives in the cutting fluids does not ensure penetration of coolant at the chip-tool interface to provide lubrication and cooling. Wet lubrication system is based on the principle that a drop of liquid is split by an air flow, distributed in streaks and transported in the direction of flow of air. The consumptions of oil in industrial applications are in the range of the length of machining was increased wear by the tool increased. Wet lubrication system consists of a mixture of pressurized air and oil micro- droplets applied directly into the interface between the tool and chips. However, the question of how the lubricants can decrease the friction under very high temperature and loads is still not answered especially for long engagements times. Wet

lubrication system decreased the contact length compared to dry cutting for both short and long engagement time. Addition of extreme pressure additives in the cutting fluids does not ensure penetration of coolant at the chip-tool interface to provide lubrication and cooling. However, high-pressure jet of vegetable oil, when applied at the chip-tool interface, could reduce cutting temperature and improve tool life to some extent.

In wet lubrication system machining, a small amount of vegetable oil or biodegradable synthetic ester is sprayed to the tool tip with compressed air. The mild steel work-piece machining with wet lubrication system arrangement as shown in fig.1, and fig.2 as the experimental set up.



Fig.1 Photographic view of the experimental set-up for turning steel with DRY MACHINING



Fig.2 Photographic View of The Experimental Set-Up For Turning Steel With Wet Machining

WET LUBRICATION SYSTEM machining is nearly equal or often better than the traditional wet machining in tool life and surface finish when cutting steels and aluminum alloys. A recent survey conducted on the

production of the European automotive industry revealed that the expense of cooling lubricant comprises nearly 20% of the total manufacturing cost. In comparison to cutting tools, the cooling lubricant cost is significantly higher. As a result, the need to reduce cutting fluids consumption is strong. Furthermore, the permissible exposure level for metal-working fluid aerosol concentration is 5 mg/m³, according to the U.S. Occupational Safety and Health Administration (OSHA) [17], and is 0.5 mg/m³ according to the U.S. National Institute for Occupational Safety and Health (NIOSH) [17]. The oil mist level in U.S. automotive parts manufacturing facilities has been estimated to be generally on the order of 20-90 mg/m³ with the use of traditional flood cooling and lubrication [10]. This suggests an opportunity for improvement of several orders of magnitude. The wet lubrication system is probably the most representative application of semi-dry machining. The purpose of this research work is to experimentally investigate the influence of wet lubrication system on cutting tool wear in turning mild steel at industrial speed-feed conditions by H.S.S. tool and compare the effectiveness of wet lubrication system with that of dry machining.

III. EXPERIMENTAL CONDITIONS AND PROCEDURE

The present investigation used, mild steel of initial diameter (size: Ø20mm×80mm) is plain turning, 3hp Lathe HSS (Miranda S-500) at industrial speed-feed combinations under dry, wet and wet lubrication system conditions. The experimental conditions are given in Table-1. The ranges of the cutting velocity (V_c) and feed rate (S_o) were selected based on the tool manufacturer’s recommendation and industrial practices. Depth of cut, being a less significant parameter, was kept fixed.

Table1. : Experimental conditions

Machine Tool:	3hp Lathe
Work-piece:	Mild Steel (size: Ø20mm× 80 mm)
Cutting Tool	HSS ,Miranda S-500
Working Tool Geometry	8°, 8°, 6°, 6°, 8°, 12°, 0.6 (mm)
Cutting Velocity, V_c	63, 80, 93 m/min
Feed rate, S_o :	0.035,0.050 and 0.820 mm/rev
Depth of cut, t :	0.8,0.85 and 1.0 mm
Wet Lubrication System Supply	Air: 6 bar, Lubricant: 200 ml/h
Environment:	Wet (flood cooling)

A. Flank Wear

Productivity and economy of manufacturing by machining are significantly influenced by life of the cutting tools. Cutting tools may fail by brittle fracturing, plastic deformation or gradual wear. Turning steel having enough strength, toughness and hot hardness generally fail by gradual wears. With the progress of machining the tools attain crater wear at the rake surface and flank wear at the clearance surfaces, as schematically .due to continuous interaction and rubbing with the chips and the work surfaces, respectively. [7, 8] .The crater wear is usually avoided by selecting a cutting speed and tool material that does not have an affinity to diffusion with the work material. The flank wear, on the other hand, leads to loss of cutting edge, and affects the dimension and surface finish quality. Crater wear occurs on the rake face of the tool where the chip moves under friction and normal loads at elevated temperatures, leading to wear. Since all cutting edges have a finite sharpness, the friction between the flank face of the cutting tool and the freshly cut work surface causes flank wear. The cutting tool wear is well-known affecting the tool life and the surface quality of the finished product. When tool wear is beyond a certain threshold, the tool fails catastrophically due to excessive stresses and rising thermal within the tool edge caused by large friction forces. The wet lubrication system has reduced tool wear, remarkably in machining mild steel. This is reasonably attributed to extremely lubrication provided by the wet lubrication system jet, which could, at least partially, reach the work-tool interfaces, unlike chip-tool interface is shown in fig.4. The deep grooves parallel to the cutting edges of the insert are likely to help entry of larger fraction of the wet lubrication system jet at the flank surfaces.

Among the aforesaid wears, the principal flank wear is the most important because it raises the cutting forces and the related problems. The life of carbide tools, which mostly fail by wearing, is assessed by the actual machining time after which the average value (VB) of its principal flank wear reaches a limiting value, like 0.3 mm. Therefore, attempts should be made to reduce the rate of growth of flank wear (VB) in all possible ways without sacrifice in MRR. During the machining process, the cutting tools are loaded with the heavy forces resulting from the deformation process in chip formation and friction between the tool and work-piece. The heat generated at the deformation and friction zones overheats the tool, the chip and partially the work-piece. All the contact surfaces are usually clean and chemically very active; therefore the cutting process is connected with complex physical-chemical processes. Wear on the tool, which occurs as the consequence of such processes, is reflected as progressive wearing of particles from the tool

surface. In machining research, a cutting tool is generally said to have failed when its V reaches a specific value, mostly 0.3 mm. It is very important to note in Fig.3 that tool life has improved from 31 min to 48 min, i.e. almost by one and half times increase in tool life have been possible by wet lubrication system. Fig.3 also depicts how flank notch wear, V remarkably decreased due to wet lubrication system. Deep notching, if forms, not only raises cutting forces but also may cause catastrophic tool failure prematurely and randomly, which is extremely harmful and undesirable for the present days' sophisticated and expensive manufacturing systems. So, proper wet lubrication system is expected also to enhance reliability and safety of machining processes and systems.

IV. RESULT AND DISCUSSION

WET LUBRICATION SYSTEM in the form of thin but high speed was impinged from a specially designed nozzle along the auxiliary cutting edge of the H.S.S. cutting tool and mild steel round work piece interface. The wet lubrication system jet has been used mainly to target the rake surface and flank surface along the auxiliary cutting edge and to protect the auxiliary flank to enable better dimensional accuracy. Wet lubrication system is expected to provide some favorable effects mainly through reduction in cutting temperature by making the thermal conductive film at work-tool chip interface at experimental trial on wet and wet lubrication system condition. With the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design. In this paper, the cutting parameter design by the Taguchi method is adopted to obtain optimal machining performance in turning. The reliable tool-work wet lubrication system technique with proper combination has been employed to measure the average tool wear, surface roughness during turning of mild steel by the HSS as shown in Table.2, Table.3.

A. Experimentation Results of Mild Steel Turning Tool Wear Dry, Wet System Condition

Table 2. Experimentation results of Dry condition

Ex. No.	Cutting Speed (m /min)	Feed Rate (mm /rev)	Depth of Cut (mm)	Tool Wear VB (mm)
1.	63	0.16	0.8	0.35
2	80	0.55	0.85	0.39

3	93	0.24	1.0	0.43
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Table 3. Experimentation results of Wet condition

Ex. No.	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)	Tool wear V_B (mm)
1	63	0.16	0.8	0.2
2	80	0.55	0.85	0.24
3	93	0.24	1.0	0.31

B. Graphical Representation of an Experimental Results for Dry, Wet System Machining

The reliable tool-work wet system machining technique with proper combination has been employed to measure the average tool wear, surface roughness during turning of mild steel by the HSS as shown in figure.3

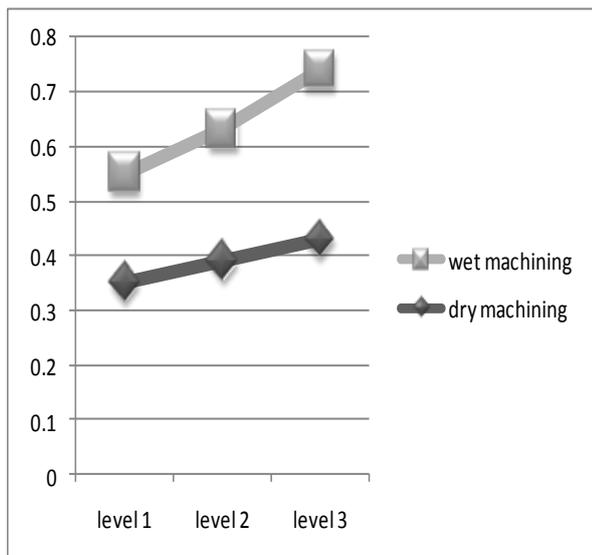


Fig.3 Graphical Relationship between Tool Wear and Machining Level

V. CONCLUSION

The present wet lubrication system allows reduction in average tool wear for significant improvement in the major machinability. The most significant contribution of wet lubrication system in machining the steel by H.S.S tool undertaken is high reduction in flank wears, which enables remarkable improvement in tool life. Wet lubrication system has provided better surface finish due to significant reduction of wear and damage at the tool tip hence ultimately increases dimensional accuracy. The cutting performance of wet lubrication system machining is better than that of conventional machining with flood cutting fluid supply.

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