Analysis of Surface Finish of Turning of EN-8 Steel Based on Cutting Fluids

[1]Sudhir B. Desair,[2]Sunil J Raykar

[1]Assistant Director, [2]Assistant Professor

[1]Yashwantrao Chavan School of Rural DevelopmentShivaji UniversityKolhapur, India

[1] D Y Patil College of Engineering and Technology Kolhapur, Maharashtra, India.

Abstract : Coolant plays very important role in improvement of surface roughness during machining. Variety of coolants are being used according to material and surface roughness requirements. Recently researchers are imposing questions on the use of coolants because of their hazardous effects on human health but still their is no other alternative have been identified for the coolants during machining. This paper presents investigation on use of two different coolants while turning EN 8 Steel components. Oil based and Water based coolants have been analysed for surface finish requirements of a lot of 110 components. The results indicate that water based coolants are more suitable and gives good surface finish during turning of EN 8Steel for a longer period of machining.

***Index Terms*-Coolant, Surface Roughness, Machining, EN-8 Steel**

I. INTRODUCTION

Most machining operations can be carried out advantageously by using a cutting fluid. During metal cutting heat and wear are inevitably produced due to friction and shearing action that takes place as the chip being formed. Both heat and wear are undesirable in order to obtain a reasonable tool life and surface finish. One way of improving metal cutting operation is by using a cutting fluid. The cutting fluid can benefit metal cutting in several ways but by far the most important is heat removal and reduce heat generation.

During machining, heat is generated at the primary deformation zone due to shearing of metal, secondary deformation zone and the flank (clearance) surfaces due to rubbing, but the temperature becomes maximum at the chip-tool interface. Any cutting fluid applied conventionally cannot reduce this chip-tool interface temperature effectively because the fluid can hardly penetrate into that interface where the chip-tool contact is mostly plastic in nature particularly at higher cutting speed and feed. Coolant having high cooling capacity cools the interface expectedly, effectively and lubricate between the chip-tool and work-tool contact thus reduce frictional heat generation. Reduction of friction between the chip-tool and work-tool interface is very important in cutting operation as reduction in kinetic coefficient of friction not only decreases frictional work, but also decreases the shear work. Usually cutting temperatures increases with the increase in process parameters causing decrease in hardness of the contact layer of the workpiece and also the tool material. The higher the cutting speed and feed, the higher the temperature is, due to high energy input. Machining high temperatures has detrimental effects on cutting tool and product quality. So, it is needed to control the cutting temperature to achieve effective cutting conditions and to improve machinability index.

The use of different coolants with different physical and chemical properties reduces the cutting temperatures and provides very favorable effects. Kamruzzaman and Dhar [1] in their experiment “Effect of High-Pressure Coolant on Temperature, Chip, Force, Tool Wear, Tool Life and Surface Roughness in Turning AISI 1060 Steel ” carried out by turning a hollow bar of AISI 1060 steel (O178 mm X 580 mm) on a lathe (China, 10 hp) by uncoated carbide inserts (SNMG and SNMM) at different cutting speeds (V) and feeds (f) under both dry and high-pressure coolant condition. The thin but high velocity stream of coolant was projected along the auxiliary cutting edge of the insert, so that the coolant reaches as close to the chip-tool and the worktool interfaces as possible. It is found that, the application of high-pressure coolant produces a great reduction in flank wear and hence tool life and produces a significant improvement in surface finish for both uncoated and coated inserts, in a certain range of hardness. This is because the cutting temperature and forces are reduced when using high-pressure coolant[2].

Zailani et al[3] in their research “The influence of Solid Lubricant in Machining Parameter of Milling Operation” observe that, the solid lubricant can minimized the effect of tool wear reduction and improve the surface quality.. The experimentation will be done to study and measure performance of a solid lubricant mixture in machining of mild steel. The analysis will be done in measuring the reduction in tool wear and surface roughness and compare with dry or wet machining.Liew et al [4] in their research of “Friction and Lubrication effects in the machining of aluminium alloys” observed that, at least at low cutting speeds, carbon tetrachloride, vapour was as effective a cutting lubricant as the liquid-this result underlining the potential effect of the vapour phase. The lubricating ability of the vapour is maintained to greater cutting speeds, indicating some synergistic effect between rake face activity and the way in which the copper is disbributed in the way. Raykar et al.[5] investigated dry machining of EN-8 steel using regression models their analysis showed that feed has greatest influence on surface finish. They also found very less difference between surface roughness values obtained dry machining and machining with coolant therefore recommended use of dry machining conditions when situation is favourable. Feed has greatest influence on surface roughness while turning EN-8 steel, Surface roughness increases with increase for the parameter under investigation in feed [6,7].

II. Experimental Details

Hexagonal bar of EN8 steel (Ø27mm x 55mm) on a CNC machine by uncoated inserts (DNMG) with different types of coolants at same cutting speeds (V) and feeds (f). All these parameters have been selected as per tool manufacturer's recommendation as well as industrial practices for machining steel. The depth of cut (d), being less significant parameter, was kept fixed. The experimental set-up used for the present purpose has been shown in figure.1

Fig. 1: Photographic View of the Experimental Set-Up

The machinability characteristics of EN8 material by keeping fixed parameters like Work material, Machining method, Tool, Tool Material, Cutting Conditions (speed, feed, depth of cut), Flow rate of coolant, Pressure of coolant and variables parameters like types of coolants; the effect of different coolants on surface finish of workpiece and tool wear have been investigated.

Fig. 2: Photographic View of the Calibration of Roughness Testing Set-Up

The experimental conditions are as follows:

Machine Tool:CNC machine
Make – ACE Control - Siemens
Work Specimen:Material: EN8 Steel Hardness (BHN):
Size: Ø 27mm x 55mm
Cutting Tool: Type of Tool: Single point cutting tool
Tool Material: DNMG110204330NF (IC907)
Tool Insert : DNMG (IC320)
Machining method : Turning
Process Parameters:
Cutting Speed : 2000 rpm
Feed rate : 0.1 mm/rev
Depth of cut : 0.2 mm
Cutting conditions:
Coolant Pressure : 10 bar
Flow rate of coolant: 15 litre/min
Type of Coolants:
Water-based : Ashoka LD-700
Oil-based : Servocut-S

Machining was interrupted at regular interval and the insert was unclamped to measure the width of wear land. Tool wear was monitored under Scanning Electron Microscope. Surface roughness was measured at every interruption along longitudinal direction of turned workpiece with the help of a Mitutoyo Surface Roughness Tester. As per ISO standard tool rejection criteria was selected as the growth of wear V_B= 300 µm on its principal flank. When the tool wear reaches to its limiting value or unexpectedly wear out rapidly, it was inspected under scanning electron microscope to study the wear mechanism.

The surface roughness of the machined surface after each cut was measured by Mitutoyo Surface Roughness Tester using sampling length of 0.8 mm.

III. Experimental Results

Surface roughness is one of the important factors in all areas of tribology and in evaluating the quality of a machining operation. Surface roughness is formed as a result of the repetition of the cutting tool tip moving along the work-piece at the desired feed rate during machining processes.

The nature and extent of surface roughness in turning is mainly caused by the feed marks in the longitudinal direction of the turned job depend mainly upon the value of feed, tool geometry, nose radius and condition of the auxiliary cutting edge. The level of feed So directly and almost proportionately governs the surface roughness in machining by single point tools but the value of cutting velocity also affect the nature, pattern and extent of surface finish, though indirectly through deformation of the tool nose profile, BUE formation and vibration.

The effect of water based coolant and oil based coolant on surface finish of component can be investigated from following Figures

Reading for surface finish measurements:

1. Sampling Length : 0.8 mm
2. Speed of Probe : 0.5 mm/sec

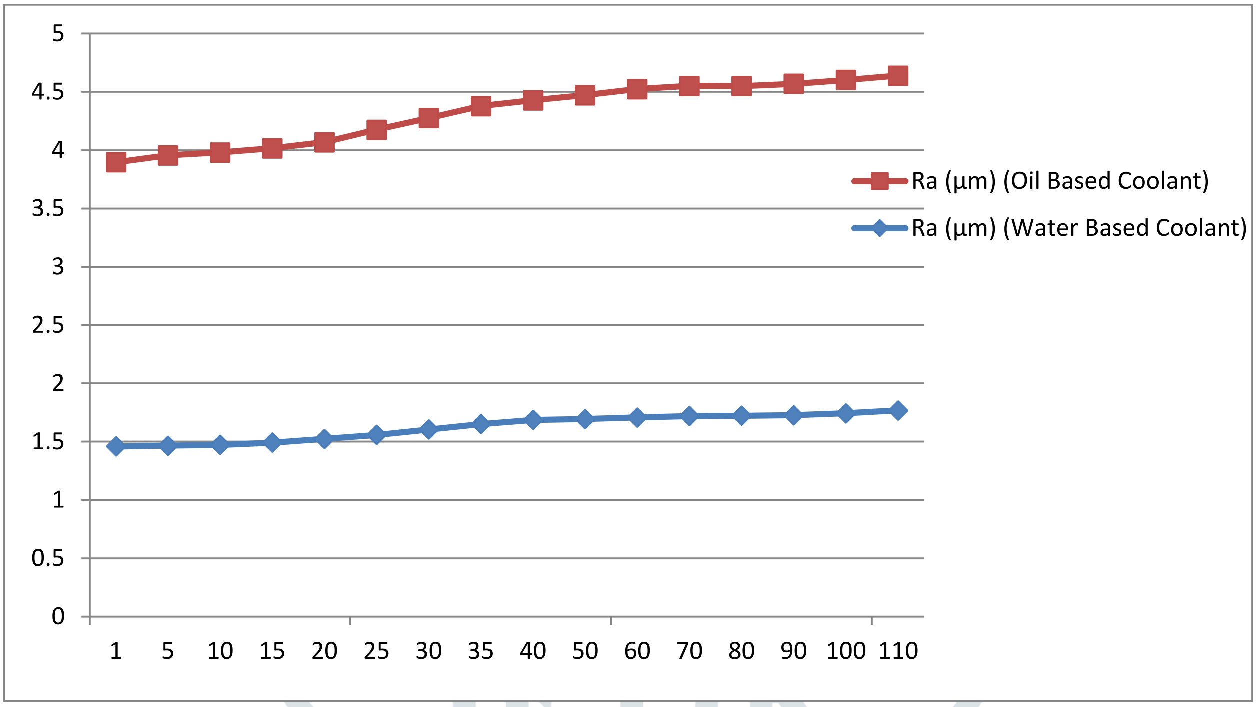
The following reading were taken from

Table No. 1: Experimental Readings

Component Number	Ra (µm) (Water Based Coolant)	Ra (µm) (Oil Based Coolant)
1	1.459	2.437
5	1.466	2.490
10	1.472	2.508
15	1.492	2.524
20	1.523	2.545
25	1.558	2.618
30	1.605	2.671
35	1.651	2.727
40	1.687	2.741
50	1.693	2.779
60	1.708	2.816
70	1.719	2.832
80	1.723	2.827
90	1.727	2.842
100	1.743	2.859
110	1.768	2.871

IV. PREPARE YOUR PAPER BEFORE STYLING

On basis of above obtained values, the following graphs were drawn. The interpretation is as follows(Ref Fig.3).



From the above graph, it can be found that the Ra values of water based coolant are lower than the Ra values of oil based coolants. For, all the workpieces machined with water based coolants (Ashoka LD-700) have better surface finish than workpieces machined with oil based coolant (Servocut-S).

The water based coolants is tends to improve surface roughness significantly because this cutting fluid is able to reduce the contact area between the chip and rake face, resulting in a reduction of frictional forces at the chip-tool interface. Water based cutting fluid possesses great cooling properties while oil based coolants possesses better lubricating properties. Therefore, the reduction of friction between the chip-tool and work-tool interface is less in cutting operation with the ues of water based coolant. As reduction in kinetic coefficient of friction not only decreases frictional work, but also decreases the shear work. This cannot be possible by the use of oil based coolants.

Also for effective cooling it is necessary to penetrate the fluid as much as possible to the chip-tool interface where the temperature is maximum. The water based cutting fluids application causes to cool the tool quickly. This affects the surface finish of the component. This is mainly because the water based cutting fluids contains some additives which helps to increase the cooling properties of the fluid.

Heat generation while machining has significant influence on machining indices. It can increase tool wear and thereby reducing tool life. It gives rise to thermal softening of cutting tool. It is commonly accepted that both the wear and failure mechanisms which develop in cutting tools are predominantly influenced by temperature and it also results in modification to the properties of workpiece and tool material such as hardness. In order to predict the wear and failure characteristics of a tool, it is necessary to quantify the temperatures which develop during the cutting operation. In machining operations, mechanical work is converted to heat through the plastic deformation involved in chip formation and through friction between the tool and workpiece or flowing chips. Three regions of heat generation in turning are the shear zone, the chip-tool interface and the tool-workpiece interface zone. During machining heat is generated at the primary deformation zone due to shearing of metal, secondary deformation zone and the flank (clearance) surfaces due to rubbing, but the temperature becomes maximum at the chip-tool interface. The cutting temperature measured in the present work refers mainly to the average chip-tool interface temperature. Any cutting fluid applied conventionally cannot reduce this chip-tool interface temperature effectively because the fluid can hardly penetrate into that interface where the chip-tool contact is mostly plastic in nature particularly at higher cutting speed and feed. High energy jet impinging beneath the flowing chip acts as a wedge that lifts up the chip facilitating chip breakage by reducing curl radius as well as plastic contact and coolant reach to the interface. Coolant having high cooling capacity cools the interface expectedly, effectively and lubricate between the chip-tool and work-tool contact thus reduce frictional heat generation. From above results, we conclude that use of water based cutting fluids is more economical as well as beneficial than the oil based fluids. This is because; it improves the surface quality of component.

V. CONCLUSIONS

Current investigation is concern with use of two different coolant while turning of EN-8 steel components.The result indicates that surface roughness obtained using water based coolant is superior than that of oil based coolants.So while machinng En-8 steel for condition under investigation one can use water based coolant for good quality machined surface which can reduce the cost of coolant also.

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