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# Comparison of Dry and Wet Lubrication Techniques in Turning of EN-31 Steel Material

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**Abstract—***Ahmedabad-382481.Machining of materials has received wide attention because increased use of various machining processes in industrial application. So it is required to improve the quality of machining by various means. Turning is one of the most fundamental processes of metal removal. The heat generated in the cutting zone during turning is critical in deciding the workpiece quality and tool life. To avoid the effects of heat generated during machining, cutting fluids are applied to provide proper lubrication and cooling. In this work experiments are performed on EN 31 high carbon alloy steel material with tungsten carbide insert tool in dry and wet environment. The process performance is studied in terms of process temperature, tool wear, surface roughness and power consumption.*

**Keywords:** *Turning, surface roughness, EN 31 high carbon alloy steel.*

## 1. INTRODUCTION

The study of various methods of machining has become keen topic of research in recent times since it has acquired a prominent role as one of the primary processes in manufacturing industry. Turning is one such machining process which is most commonly used in industry because of its ability to have faster metal removal giving reasonably good surface quality. The greatest advantage of using finish turning is the reduced machining time and complexity required to manufacture metal parts. In turning, surface quality is one of the most important performance measures. Surface roughness is mainly a result of process parameters such as tool geometry and cutting conditions. In any metal cutting operation, lot of heat is generated due to plastic deformation of the work material, friction at the tool-chip interface and friction between tool and the work piece. The heat produced in hard turning adversely affectsto the quality of the products produced. Thus, the effective control of heat generated at the cutting zone is essential to ensure good work piece surface quality in machining. Cutting fluids have been the conventional choice to deal with this problem. Cutting fluids are introduced onto the machining zone to improve the tribological characteristics of the machining processes and also to dissipate the heat generated. [8]

The present study focuses on the application of SAE 40 wet lubricant, as a means to reduce the heat generated at the cutting zone and to study the process performance in turning. Comparative performance analyses of wet assisted turning with dry turning is presented.

## 2. LITERATURE SURVEY

Alabi et al. [2] has investigated the effect of process parameters on cutting forces during dry and wet machining by heat treated medium carbon steel. The results showed that the machining forces for the dry machining were higher than that of the wet machining. The effect of cutting temperature on workpiece surface was investigated [6]. It had been shown that cutting temperature had an effect on the integrity on the machined surfaces. The undesirable surface tensile residual stresses were affected to the temperature which was generated during the machining process. So that controlling the generated tensile stresses on the understanding of the effect of parameters on the cutting temperature.Abhanget. al. [8] has investigated use of MQL in alloy steel turning. In that study 10% boric acid mixed with the base oil SAE40 lubricant used as a MQL in turning operation and w/p had EN31 alloy steel material. And under different machining condition cutting force, cutting temp., chip thickness and Ra value measured. And from result concluded that there is an improvement in the parameters and machining performance with MQL assisted process compare to dry machining. Anselmo Eduardo Diniz et. Al. [1] has investigated the study on optimizing the use of dry cutting in rough turning steel operations. In that study, various parameters like cutting force, feed, DOC measured of ABNT 1045 steel in dry and wet environment. When cutting fluid was used then tough tool was required and in dry cutting was carried out then tool had high hot hardness. Subramanyam et al. [7] investigated the performance of coated tools in machining of hardened steel under dry machining. The experimental result was shown that with increase in the surface roughness was observed, it was very low.Varadarajan et al. [3] has investigated on hard turning with minimum cutting fluid application and its comparison with dry and wet hard turning under process parameters of speed, feed and Depth of cut by using of AISI 4340 and SNMG 120408 with a P30 tool combined material. Zhou et al. [5] investigated of surface damage produced by whisker-reinforced ceramic cutting tools in the finish turning of Inconel 718 (nickel-based super alloy).

## 3. EXPERIMENTAL CONDITIONS AND PROCEDURE

The experiments are performed on EN-31 alloy steel cutting speed (v) m/min, feed rate (f) mm/rev,depth of cut (d) and tool nose radius (r) mm. to obtain the values of chip tool interface temperature, cutting forces, tool wear and surface roughness during steel turning in dry and wet condition (SAE 40). Theexperimental details are given in table 1. The experimental setup with measuring temperature and cutting force isshown in Fig. The process utilized was turning operation performed onTURNMASTER 35 heavy duty lathe machine. The cutting tests were carried out on EN-31 steel using tungsten carbide insert under dry and wet lubricant.

Alloy steel work piece (EN-31 steel alloy) is machined on heavy duty lathe machine TURNMASTER 35.The work piece has a dimension of 100mm in length and 50mm in diameter. The chemical composition of work piece is shown in Table 4.

Surface roughness is measured by surface roughness tester and tool wear is measured on a sensitive single pan balance.

## 4. EXPERIMENTAL CONDITION

**Table 1: Work piece specification**

| Work material | EN 31 steel |
|---|---|
| Size | Ø50*100mm |
| Hardness | 3210.048 N/mm2 |
| Thermal conductivity | 46.6 W/m-k |
| melting pt. | 1540 ºC |

**Table 2: Machine specification**

| Lathe machine | TURNMASTER 35 |
|---|---|
| Motor capacity | 2.2 KW |
| volts | 415 V |
| Cutting tool | Tungsten carbide |
| Motor Speed | 1430 rpm |
| Spindle speed | 8/45-1120 rpm |
| Longitudinal speed | 0.045-0.63 mm/rev |

**Table 3: Work tool geometry**

| | |
|---|---|
| Inclination angle | -6° |
| Orthogonal rake angle | -6° |
| Orthogonal clearance angle | 6° |
| Auxiliary cutting edge angle | 15° |
| Principle cutting edge angle | 75° |
| Nose radius | 0.8 mm |

**Table 4: Chemical composition of (EN-31) w/p**

| composition | C | Si | Mn | Cr | Co | S | P |
|---|---|---|---|---|---|---|---|
| Wt % | 0.95-1.2 | 0.10-0.35 | 0.30-0.75 | 1 | 0.025 | 0.4 | 0.4 |

**Table 5: Mechanical property of EN 31 w/p**

| | |
|---|---|
| Hardness | 3210.048 N/mm2 |
| Rapture energy | 9 J |
| Modulus of rapture (Us) | 0.0025 J/mm3 |
| Notch impact strength (Is) | 0.1410 J/mm2 |
| Breaking strength | 1102.457 N/mm2 |
| Thermal conductivity | 46.6 W/m-k |
| Density | 7810 kg/m3 |
| Melting point | 1540 °c |

**Table 6: Cutting oil (SAE 40) specification**

| | |
|---|---|
| Viscosity index | 97 |
| Pour point | -20 °c |
| Flash point | 210 °c |
| Physical state | Green liquid |
| Odour | Mild |
| Odour threshold | NE |
| pH | NA |
| Boiling point | NE |
| Melting point | NA |
| Vapour density | >2.0 |
| Evaporation rate | NE |
| Relative density | 15/4 °c: 0.865 |
| Solubility in water | negligible |
| Partition coefficient | >3.5 |

NE- not established, NA- not applicable

**Table 7: Process parameters of dry and wet environment**

| | |
|---|---|
| Speed | 45,112,280,710 rpm |
| Feed | 0.224,0.315,0.4,0.5 mm/rev |
| Depth of cut | 0.4 mm |
| Tool nose radius | 0.8 mm |

The present experimental study involves machining of EN-31 alloy steel carried out under dry and wet environment. The experimental results of chip tool interface temperature, cutting force, tool wear and surface roughness have been compared with dry machining.

## 5. RESULTS AND DISCUSSION:

**Dry environment measurement**

| process parameter | feed / rpm | 0.224 | 0.315 | 0.4 | 0.5 |
|---|---|---|---|---|---|
| T (°C) | 45 | 63.64 | 54.80 | 63.64 | 111.102 |
| P (W) | | 80 | 80 | 120 | 120 |
| Ra (µmm) | | 6.638 | 6.323 | 6.929 | 7.978 |

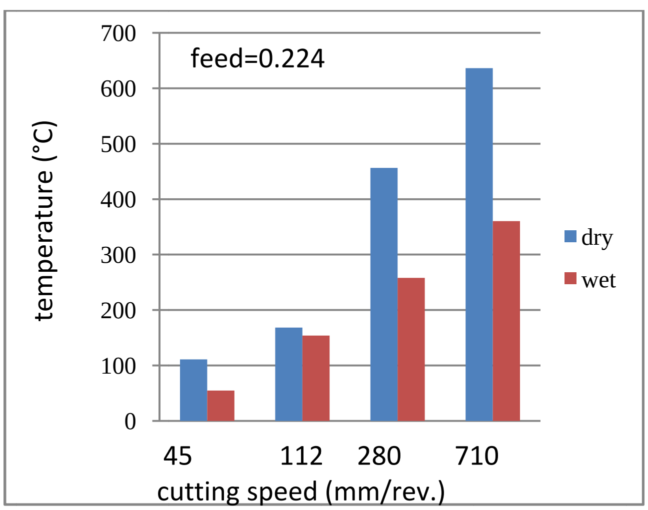
| | | | | | |
|---|---|---|---|---|---|
| T (°C) | 112 | 168.36 | 175.97 | 258.17 | 360.27 |
| P (W ) | | 120 | 120 | 144 | 160 |
| Ra(µmm ) | | 4.772 | 6.125 | 5.757 | 6.884 |
| T(°C) | 280 | 456.28 | 360.27 | 456.28 | 636.41 |
| P (W) | | 192 W | 200 W | 240 | 304 |
| Ra (µmm) | | 1.739 | 4.307 | 5.700 | 7.239 |
| T (°C) | 710 | 636.41 | 456.28 | 548.07 | 721.65 |
| P (W) | | 400 | 440 | 520 | 600 |
| Ra (µmm) | | 1.437 | 4.262 | 6.659 | 7.063 |
| Tool wear (gm) | | 9.197 | 9.185 | 9.172 | 9.163 |

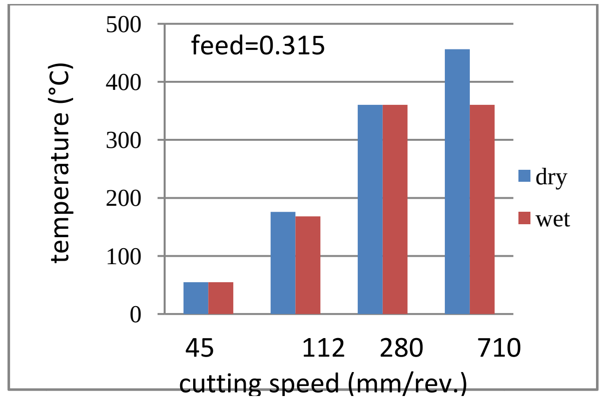
**Wet environment measurement**

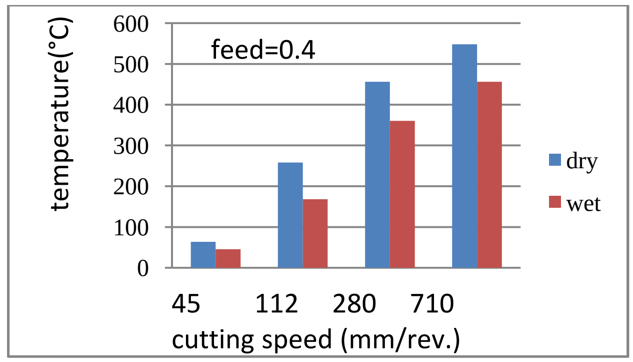
| process parameter | feed / rpm | 0.224 | 0.315 | 0.4 | 0.5 |
|---|---|---|---|---|---|
| T (°C) | 45 | 54.807 | 54.807 | 45.628 | 63.64 |
| P (W) | | 75 | 78 | 96 | 96 |
| Ra (µmm) | | 4.559 | 5.302 | 7.869 | 4.207 |
| T (°C) | 112 | 153.9 | 168.36 | 169.35 | 146.8 |
| P (W) | | 110 | 115 | 150 | 136 |
| Ra (µmm) | | 3.374 | 5.991 | 5.329 | 4.222 |
| T (°C) | 280 | 258.17 | 360.27 | 360.27 | 548.07 |
| P (W) | | 184 | 224 | 230 | 200 |
| Ra (µmm) | | 3.299 | 3.922 | 4.738 | 2.936 |
| T (°C) | 710 | 360.27 | 360.27 | 456.28 | 636.41 |
| P (W) | | 380 | 400 | 440 | 520 |
| Ra (µmm) | | 2.837 | 3.798 | 4.766 | 2.841 |
| Tool wear (gm) | | 9.199 | 9.193 | 9.185 | 9.177 |

**Performance analysis:**

**Temperature analysis**



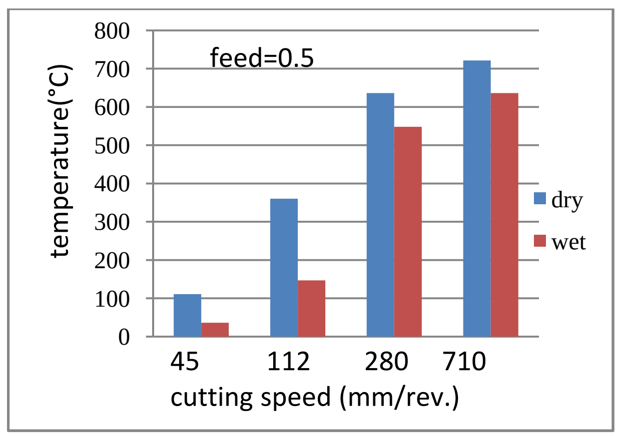
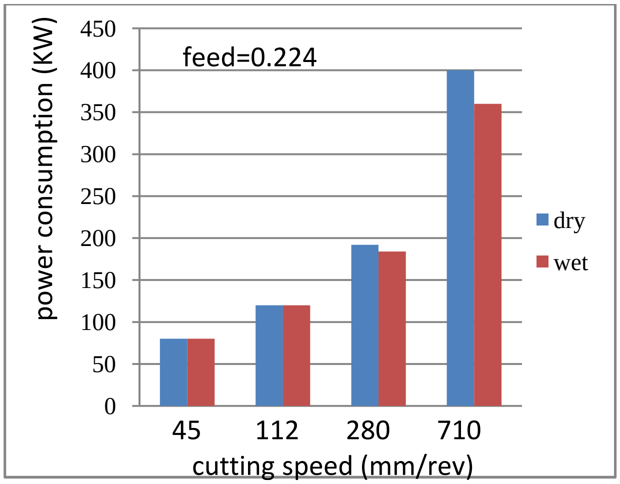



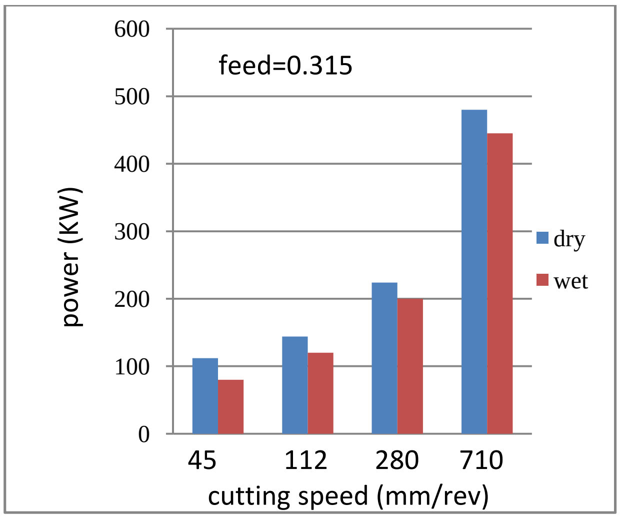

**Fig. 2: The variation is temperature with speed at different feed rate at same depth of cut under dry and wet**

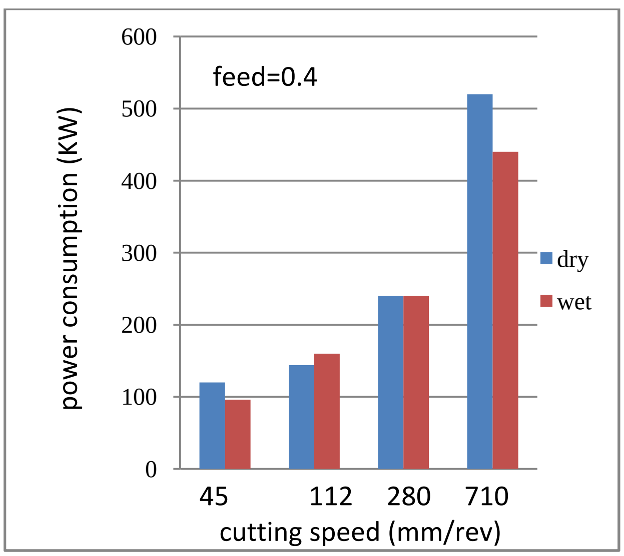
The variation of temperature with respect to cutting speed for dry and wet hard turning is shown in the Fig. The major part regarding the temperature in machining has been focused on the chip- tool interface temperature. Wear is sensitive to the cutting temperature in metal cutting zone.

Fig. shows the effect of dry and wet machining on chip- tool interface temperature under different cutting speed and feed rate with constant depth of cut (DC=0.4mm) and tool nose radius (0.8mm) throughout the experiment.

It is clear from the figures that with the increase in feed rate and cutting speed, the chip-tool interface temperature increases due to increase in cutting energy input. Wet assisted hard turning produced low values of chip tool interface temperature compared to the dry hard turning.



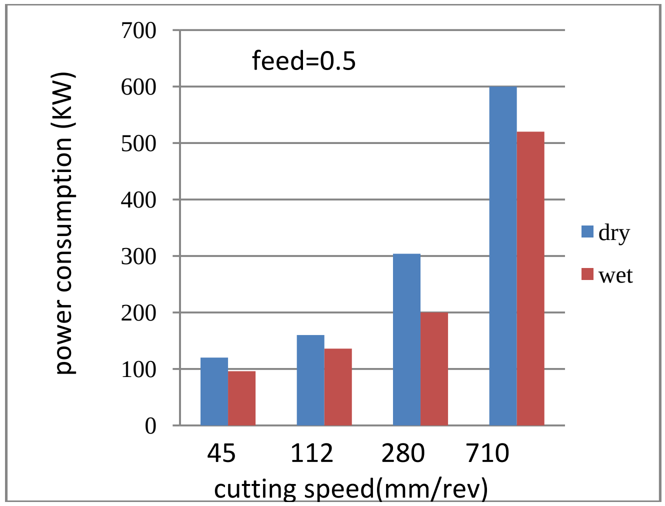
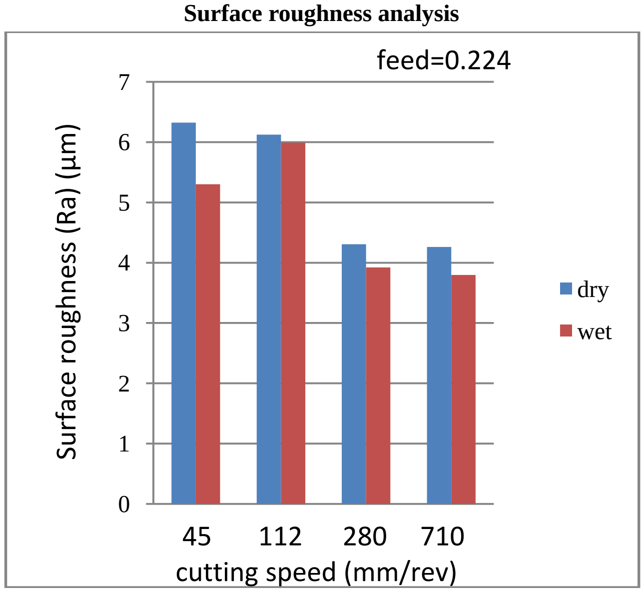




**Fig. 3: The variation is power consumption with speed at different feed rate at same depth of cut (0.4 mm) under dry and wet condition**

The variation of power consumption with respect to cutting speed for dry and wet turning is shown in the Fig. 3. To study the power consumption the power measurement carried out variation with cutting speed, depth of cut and feed. The results are shown in fig. in terms of the power consumption. From the Fig. the power consumption increases with increase in feed and cutting speed. But wet lubricant assisted turning consumed low power compared to dry machining.

The variation of surface roughness with respect to cutting speed for dry and wet hard turning is shown in the Fig. 4.From the Fig. observed that when cutting speed increasing, the surface roughness is decreasing. It could be possible because at high speed the cutting forces continuously reduced. In wet assisted turning achieved low values of surface roughness compared to the dry turning.

**Surface roughness analysis**



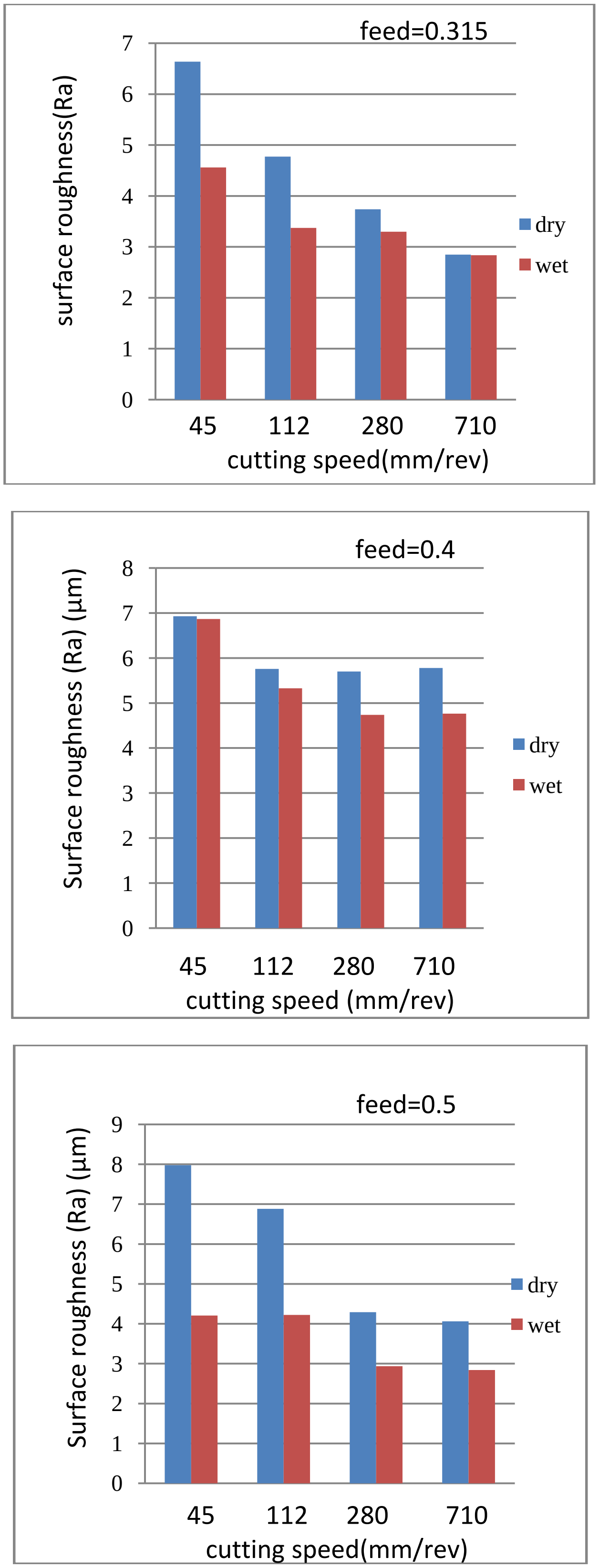



**Fig. 4: The variation is surface roughness with speed at different fee rate at sameDepth of cut (0.4 mm) under dry and wet condition**

The surface roughness value is decreased due to the lubricant properties of wet lubricants at high temperature. Due to the lubricating properties of wet lubricant reduces the cutting forces between the tool and workpiece, so that the temperature is reduced. Due to that reduce the tool wear and increase tool life. So that the surface quality is improved of the work piece. The lower value of surface roughness is produced by the SAE 40 cutting oil which can be attributed to its strong adhesion.

## 6. CONCLUSION

Using wet lubricant technique significant improvement in product quality and therefore overall machining economy, longer tool life, better work surface finish, up to certain quantity of use environmentally safer, healthier for the workers.

The major conclusions from this investigation can be summarized as follows:-

Using wet lubricant the process temperature reduced by 20 to 30%.It is depending upon the level of process parameters and workpiece material. The reduction in cutting temperature using wet lubricant is high at lower level of machining parameters and low at high level machining parameters.

Surface finish is improved due to significant reduction in wear and damage at the tool tip by the application of wet lubricant.Reduce frictional forces between the tool and workpiece. And power consumption is also reduced compare to dry machining.

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