INFLUENCE OF VEGETABLE OIL BASED CUTTING FLUIDS ON TOOL WEAR AND SURFACE ROUGHNESS IN MILLING EN8 STEEL USING HSS AND TUNGSTEN CARBIDE TOOL

M.V. Babu Tanneru  
Assistant Professor, Department of Mechanical Engineering  
MLR Institute of Technology,  
Hyderabad - 500 043, Telangana, India  

Dr. J. Krishnaraj  
Professor, Department of Mechanical Engineering  
MLR Institute of Technology,  
Hyderabad - 500 043, Telangana, India  

K. Vijaya Krishna Varma  
Department of Mechanical Engineering  
GITAM University,  
Hyderabad, Telangana, India  

ABSTRACT

This work deals with the performance evaluation of cutting fluid used in machining different work materials in order to improve the efficiency of any machining process. The efficiency can be evaluated based on certain process parameters such as tool wear, surface roughness, cutting force and temperature developed, etc. The objective of this work is to determine the influence of vegetable oil based cutting fluids in machining process. Palm kernel oil is mainly used for this investigation based on tool wear and surface roughness during end milling operation. The surface roughness and tool wear are compared by performing milling operations on EN8 steel using HSS and Tungsten carbide tools in presence of servo oil and vegetable oil as cutting fluid. The performance of vegetable oil based cutting oil is found better on this end milling operation due to their thermal and oxidative stability. The application of EN8 steel material includes wear resistible automobile and general structural components.

Key words: Materials, Vegetable Oil, Cutting Fluids, EN8 steel, HSS and Tungsten Carbide Tool, Tool wear, Surface Roughness.
1. INTRODUCTION

The main objective of metal cutting is to obtain a finished product with desired size, shape, and surface roughness with the efficient and precise removal of metal from workpiece. The most essential cutting performance measures, such as, tool life, cutting force, roughness of the machined surface are generally considered for experimental studies. Also, the quality of the machined surface may depends on workpiece material non-homogeneity, progressive tool wear, cutting tool chatter, etc.

One of the fundamental machining operations in several industrial machining processes is milling, in which end milling is most common for doing slots and dies. The application of end milling includes aerospace and automotive industries, where quality is an essential factor. Also the quality of the surface plays a very important role in the performance of milling which significantly improves corrosion resistance, fatigue strength and creep life. The surface roughness in milling operation is mostly influenced by various factors such as spindle speed, feed rate and depth of cut. The other factors like tool wear, chip formation and material properties of both tool and workpiece are uncontrollable.

Various researchers undergone study on tool life, surface finish and vibration and carried out various tests under various combinations of speed, feed and depth of cut. In which, a study discussed about machining of nodular cast iron using ceramic tool; resulted with tool life of 1.5 min and surface finish is constant for the flank wear at all conditions [1]. Another researcher carried out investigation on the wear behavior of alumina based ceramic cutting tool and resulted with mixed alumina cutting performs better than SiC whisker reinforced alumina cutting tool on machining martensitic stainless steel [2]. A similar work was carried out to investigate the tool wear on machining Inconel 718 nickel-based super alloy and result shown that minimum flank wear is seen at low cutting speeds [3].

For the optimization of machining parameters with respect to surface roughness on several materials can be performed by some methods like Taguchi method and mathematical modeling (t-Test and F-Test) [4, 5]. Recently, the influence of vegetable oil and emulsion based lubricants on tool wear and tool life was studied by some researchers and reported their critical assessment on various machining parameters [6, 7]. The effect of machining parameters on surface roughness of AISI 1040 Steel, EN11 alloy steel and Glass Fiber Reinforced Plastic Composites during end milling operation were studied by researchers and reported their test results [8-10].

This experimental study focus on the effect of machining parameters on the surface quality of the machined surfaces during milling operation on EN8 Steel by using Palm kernel oil as cutting fluid to test the surface roughness and tool wear.

2. EXPERIMENTAL SETUP AND PROCEDURE

The investigation on the effects of one or more process parameters like spindle speed, feed rate and depth of cut on the surface finish and tool wear are experimented in this work. Also this work is concentrated on determining the influence of cutting fluids in machining operation. Vegetable oil based cutting oil (palm kernel oil) is mainly used for investigation on surface roughness during milling of EN8 Steel with carbide tool and HSS tool. The feed rate is set to
200mm/min and different spindle speeds (750, 1000, 1500, 2000 and 2500rpm) are used for investigation.

2.1. Experimental Setup
A CNC vertical milling machine (Feeler Model, Siemens 840D Controller, Travel size in X, Y and Z directions are 1000mm, 500mm and 500mm respectively) with Carbide cutting tool and HSS is used for machining EN8 Steel. The experiment has been done under various conditions of feed rate (200mm/min) and spindle speeds (750, 1000, 1500, 2000 and 2500rpm). In this work, Palm kernel oil is used as cutting oil. Two pieces of EN 8 material is taken and different experiments are conducted on the pieces by changing feed rate and spindle speed combinations. The figure 1 shows the CNC vertical milling machine and figure 2, 3 show the cutting tools used for investigation.

![CNC Milling Machine](image1)

**Figure 1** CNC Milling Machine

![50r6 bull nose cutter](image2)

**Figure 2** 50r6 bull nose cutter
2.2. Cutting Fluid - Palm Kernel Oil

Palm kernel oil is edible plant oil derived from the kernel of the oil palm Elaeis guineensis. It should not be confused with the other two edible oils derived from palm fruits: palm oil, extracted from the pulp of the oil palm fruit, and coconut oil, extracted from the kernel of the coconut. Palm kernel oil contains highly saturated vegetable fats in it due to the 16-carbon saturated fatty palmitic acid presence in built.

Palm kernel oil is semi-solid at room temperature and more saturated than palm oil and comparable to coconut oil. It is commonly used in commercial cooking because of its relatively low cost, and because it remains stable at high cooking temperatures and can be stored longer than other vegetable oils. Other uses of palm kernel oil include the manufacture of soaps, washing powders and personal care products. The figure 4 shows the machining operation with Servo oil and vegetable oil.

3. EXPERIMENTAL RESULTS

3.1. Surface Roughness

In this work, most important performance measure in milling is surface roughness. A computer controlled surface roughness tester as shown in figure 5 was employed to find the surface finish...
value (in μm) and surface roughness from the average surface level. This instrument has many advantages like LCD display, 10 measurement conditions and additional memory card to store and evaluate the data.

**Figure 5** Surface roughness tester (Mitutoyo SJ-210)

**Table 3.1** Surface Roughness values obtained by using HSS Tool

<table>
<thead>
<tr>
<th>HSS Tool</th>
<th>Speed (rpm)</th>
<th>Feed rate (mm/min)</th>
<th>Depth of cut (mm)</th>
<th>Surface Roughness R(_a) (μm)</th>
<th>Servo Oil</th>
<th>Vegetable Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>750</td>
<td>50</td>
<td>2</td>
<td>0.495</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>150</td>
<td>2</td>
<td>0.462</td>
<td>0.389</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>200</td>
<td>2</td>
<td>0.441</td>
<td>0.375</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>250</td>
<td>2</td>
<td>0.4</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>300</td>
<td>2</td>
<td>0.389</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.2** Surface Roughness values obtained by using Tungsten Carbide Tool

<table>
<thead>
<tr>
<th>Tungsten Carbide Tool</th>
<th>Speed (rpm)</th>
<th>Feed rate (mm/min)</th>
<th>Depth of cut (mm)</th>
<th>Surface Roughness R(_a) (μm)</th>
<th>Servo Oil</th>
<th>Vegetable Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>750</td>
<td>50</td>
<td>2</td>
<td>0.44</td>
<td>0.377</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>150</td>
<td>2</td>
<td>0.422</td>
<td>0.350</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>200</td>
<td>2</td>
<td>0.413</td>
<td>0.335</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>250</td>
<td>2</td>
<td>0.381</td>
<td>0.328</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>300</td>
<td>2</td>
<td>0.361</td>
<td>0.312</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 6** Comparison of surface roughness values for Servo and Vegetable oils for HSS tool at different speeds
Influence of Vegetable Oil Based Cutting Fluids On Tool Wear and Surface Roughness In Milling En8 Steel Using HSS and Tungsten Carbide Tool

Figure 7 Comparison of surface roughness values for Servo and Vegetable oils for Tungsten Carbide tool at different speeds

Figure 8 Comparison of surface roughness values for Servo and Vegetable oils for HSS and Tungsten Carbide tools at 2500rpm

The surface roughness values measured for Servo oil and vegetable oil with HSS tool and Tungsten Carbide tool are tabulated for various speed, feed and depth of cut in Table 3.1 and 3.2. The figures 6, 7 and 8 shows that surface roughness values obtained by milling with vegetable oil using HSS tool is better than the surface roughness values obtained by Servo oil. Also at high speed (2500 rpm), the performance of vegetable oil is far better than other speed with respect to the surface roughness obtained by milling operation on EN8 Steel.

3.2. Tool Wear

While machining EN8 Steel, the tool wear is measured for every experiment at specified spindle speed, feed rate and depth of cut. Tool wear is measured for the removal of material from the edge of the tool and is shown in Figure 9 for HSS and Tungsten Carbide tools. The tool wear measured for Servo oil and vegetable oil with HSS tool and Tungsten Carbide tool are tabulated for various parameters in Table 3.3 and 3.4. The figures 10, 11 and 12 shows that tool wear obtained by milling with vegetable oil using Tungsten Carbide tool is lesser than the tool wear obtained by Servo oil. Also at 2500rpm, the tool wear during milling operation on EN8 Steel with vegetable oil and Tungsten carbide tool is lesser than tool wear caused by HSS tool.

Figure 9 Tool wear on HSS tool and Tungsten Carbide tool
Table 3.3 Tool wear resulted on HSS Tool

<table>
<thead>
<tr>
<th>Speed (rpm)</th>
<th>Feed rate (mm/min)</th>
<th>Depth of cut (mm)</th>
<th>Tool Wear (mm)</th>
<th>Servo Oil</th>
<th>Vegetable Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>50</td>
<td>2</td>
<td>0.19</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>150</td>
<td>2</td>
<td>0.21</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td>200</td>
<td>2</td>
<td>0.24</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>250</td>
<td>2</td>
<td>0.29</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>300</td>
<td>2</td>
<td>0.35</td>
<td>0.31</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.4 Tool wear resulted on Tungsten Carbide Tool

<table>
<thead>
<tr>
<th>Speed (rpm)</th>
<th>Feed rate (mm/min)</th>
<th>Depth of cut (mm)</th>
<th>Tool Wear (mm)</th>
<th>Servo Oil</th>
<th>Vegetable Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>50</td>
<td>2</td>
<td>0.12</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>150</td>
<td>2</td>
<td>0.15</td>
<td>0.115</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td>200</td>
<td>2</td>
<td>0.17</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>250</td>
<td>2</td>
<td>0.22</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>300</td>
<td>2</td>
<td>0.265</td>
<td>0.215</td>
<td></td>
</tr>
</tbody>
</table>

Figure 10 Comparison of tool wear for Servo and Vegetable oils with HSS tool at different speeds

Figure 11 Comparison of tool wear for Servo and Vegetable oils with Tungsten Carbide tool at different speeds
Influence of Vegetable Oil Based Cutting Fluids On Tool Wear and Surface Roughness In Milling En8 Steel Using HSS and Tungsten Carbide Tool

4. CONCLUSION

In this work, experiments are conducted to compare the surface finish quality of EN8 Steel during milling with HSS and Tungsten carbide tools using Servo oil and Vegetable oil. A series of experiments is carried out by varying the milling parameters like spindle speed (750rpm, 1000rpm, 1500rpm, 2000rpm and 2500rpm) and feed rate (50 mm/min, 150 mm/min, 200 mm/min, 250mm/min and 300mm/min) by keeping constant depth of cut as 2mm. The experiments are conducted on CNC vertical milling machine. By observing the surface roughness results, the use of vegetable oil gives better surface finish when compared with that of servo oil as cutting oil. Also the surface finish is improved by increasing the spindle speeds. When comparing the cutting tools used, the surface finish is better when milled using Tungsten Carbide tool than HSS tool. By observing the tool wear results, the use of vegetable oil reduces the tool wear on both cutting tools. Also it is observed that the tool wear is increased by increasing the spindle speeds on the usage of both cutting fluids.

REFERENCES


