THE INFLUENCE OF COOLING FLUIDS TYPES ABOVE CUTTING TOOLS DURABILITY

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ABSTRACT
Paper presents the tests made on 4-balls machine on cooling fluids with different additive types and concentrations, in order to establish the proper composition. In the presence of selected cooling fluids, on Amsler machine, were determinate the tribological behavior of linear couple’s carbon steel- high speed steel. The obtained friction coefficient and wear curves for tested materials couple were used to evaluate EP proprieties for proposed oil cooling fluids samples.

KEYWORDS: cooling fluids, wear, cutting tools, friction coefficient

1. INTRODUCTION
From manufacturing processes, cutting leads at severe friction regimes and cooling-lubrication of chips formation zone is different from classic lubrication.

Lubricants used as technologic mediums in metal cutting processes should complete some main specific demands as:

- to reduce friction between working piece and cutting tool and between cutting tool and chips in order to rise tool durability and to improve machined surface;
- to remove the heat and the material resulted from the cutting zone;
- to assure lubrication in limit condition between cutting tool, piece and chips;
- to be stable (chemical and structural);
- to be, as possible, environmentally friendly;
- to not react with materials and even to assure a short corrosion protection till the next operation;
- resistance at microorganisms which develops in cutting medium and to assure a small toxicity;
- to be, in special cases, compatible with the other machine-tools lubricants;
- to be chopper.

Each cutting operation type is characterized by some specific factors and so cutting fluids must complete specific demands and, as a result, there are many cutting fluids types. Depending of cooling and lubricating proprieties the cutting fluids could be divided in two main groups [1, 2].

First group are water soluble fluids characterized by small viscosity and great values for specific heat and thermal conductivity.
Second group are oil based fluids with very good lubricating, deforming and detaching chips proprieties. As surface active additives which form adsorption resistant films at high pressures, reduce friction coefficient and enter in microcracks making cutting easier are used stearic and oleic acids and organic compounds containing sulfur, chlorine or phosphor. As synthetic based oils are mostly used esters and poly-alpha-olefins [2, 3]. Because cutting oils are in contact with operator skin, the toxicological proprieties are very important. Very important are also oil thermal-oxide stability. At cutting electro-chemical potential of machined material became more electropositive and cutting fluids should contain also anticorrosive additives. Antioxidant additives such as phenols, amines and anticorrosive additives such as zinc dithiophosphates or dithiocarbamates, esters, fat amides, amides of dodecisuccinic acid, fatty acid derivatives etc. are mainly used [2].

This paper presents a part of tests made in order to formulate a cooling fluid for cutting and rolling.

2. EXPERIMENTS

Lubricating cooling fluids proprieties were considered as a main criterion. In this order the 15 selected esters were tested on 4 balls machine presented in Figure 1.

The rotation speed of upper ball was 1375 r.p.m. In Table 1 are presented the obtained results.

Table 1: 4 balls machine results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ester type</th>
<th>Normal force, before welding, N</th>
<th>Friction torque, before welding, Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monoester of oleic acid with isodecyl alcohol C13</td>
<td>536,5</td>
<td>0,656</td>
</tr>
<tr>
<td>2</td>
<td>Monoester of oleic acid with isodecyl alcohol C10</td>
<td>536,3</td>
<td>0,225</td>
</tr>
<tr>
<td>3</td>
<td>Monoester of oleic acid with 2 etoxylated p-nonylphenol</td>
<td>536,5</td>
<td>1,379</td>
</tr>
<tr>
<td>4</td>
<td>Monoester of oleic acid with 2 o-secondary butyl phenoxyethanol</td>
<td>1223,2</td>
<td>0,164</td>
</tr>
<tr>
<td>5</td>
<td>Monoester of oleic acid with 1 o-secondary butyl phenoxyethanol</td>
<td>765,7</td>
<td>0,400</td>
</tr>
<tr>
<td>6</td>
<td>Monoester of caprylic acid with isodecyl alcohol C13</td>
<td>536,5</td>
<td>0,492</td>
</tr>
<tr>
<td>7</td>
<td>Monoester of caprylic acid with isodecyl alcohol C10</td>
<td>536,5</td>
<td>0,480</td>
</tr>
<tr>
<td>8</td>
<td>Monoester of caprylic acid with 2 etoxylated p-nonylphenol</td>
<td>765,7</td>
<td>0,656</td>
</tr>
<tr>
<td>9</td>
<td>Monoester of caprylic acid with 2 o-secondary butyl phenoxyethanol</td>
<td>2070,8</td>
<td>0,820</td>
</tr>
<tr>
<td>10</td>
<td>Monoester of caprylic acid with 1 o-secondary butyl phenoxyethanol</td>
<td>2070,8</td>
<td>0,175</td>
</tr>
<tr>
<td>11</td>
<td>Monoester of butyric acid with isodecyl alcohol C13</td>
<td>994,5</td>
<td>0,187</td>
</tr>
<tr>
<td>12</td>
<td>Monoester of butyric acid with isodecyl alcohol C10</td>
<td>994,5</td>
<td>0,673</td>
</tr>
<tr>
<td>13</td>
<td>Monoester of butyric acid with 2 etoxylated p-nonylphenol</td>
<td>2070,8</td>
<td>0,525</td>
</tr>
<tr>
<td>14</td>
<td>Monoester of butyric acid with 2 o-secondary butyl phenoxyethanol</td>
<td>2553,5</td>
<td>0,350</td>
</tr>
<tr>
<td>15</td>
<td>Monoester of butyric acid with 1 o-secondary butyl phenoxyethanol</td>
<td>994,5</td>
<td>0,656</td>
</tr>
</tbody>
</table>

Figure 1: 4 balls machine
1- engine; 2- pin coupling; 3- bearings body; 4- main ax; 5- upper ball; 6- lower balls; 7- box with lower balls; 8- step bearing; 9- load system; 10- elastic blade; 11- strain gauge; 12- support for elastic blade; 13-arm fixed on box with lower balls; 14-intermediate plate; 15- upper plate; 16- base plate; 17- upper rods; 18- lower rods.
Figure 2 present a histogram of maximum normal force applied on 4 balls couple before balls welding.

![Figure 2: Histogram of normal force](image)

The 5 ester of soybean and oleic acid type samples 4, 9, 10, 13 and 14 (with the best results so it is shown in Fig.2) were selected to produce 5 cooling oil with min. 70% biodegradability according to CEC L-33-T-82. The 5 oil cooling fluid samples were tested on Amsler A135 machine to establish the tribological behavior of linear couple’s carbon steel- high speed steel. In Figure 3 are presented the dimensions of samples [4]. Cylinder material was carbon steel with hardness 190HB2.5/187.5 and disk plate of high speed steel with hardness 68.5HRC.

![Figure 3: Sample dimensions](image)

For sliding speed 0.523 m/s the friction coefficient variation with normal load for the 5 oil cooling fluid samples is presented in Figure 4. Oil cooling sample number:
- 1 contains monoester of butyric acid with 2 etoxylated p- nonylphenol;
- 4 contains monoester of oleic acid with 2 o-secondary butyl phenoxyethanol;
- 5 contains monoester of caprylic acid with 2 o-secondary butyl phenoxyethanol.

![Figure 3: Friction coefficient vs. normal load](image)

In the presence of oil cooling fluid samples number 1, 4 and 5 were made wear tests at normal load 1000 N and with sliding speed 0.523 m/s. In Figure 4 is presented the volumetric wear curves for HSS disk plate.

![Figure 4: Volumetric wear curves for disk plate](image)

In Figure 5 it is shown the volumetric wear curves for carbon steel cylinder.

![Figure 5: Volumetric wear curves for cylinder](image)
3. CONCLUSIONS

The proposed oil cooling fluids are designed for use in moderate to severe machining operations. These cutting oils are available in different EP levels and viscosity grades to cover a wide variety of machining operations and metals. The oils will be used as metalworking neat oils for industrial applications: deep hole drilling, broaching and tapping, gear cutting and shaving, grinding, honing and lapping, turning, planning, shaping, milling e.g.

The cutting oils contain unique synergistic extreme pressure additive systems that readily react at chip-tool interface to form extremely effective lubricating films which reduce frictional heat and prevent meta-to-metal contact between the tool and workpiece and chip. The cooling fluid samples were made with various percent from soybean oil, low esters of soybean oil, oleic acid esters, sulfurized soybean oil and additives. The tests presented in this paper were made to select the proper oil cooling fluids sample and composition in order to obtain good EP proprieties which are important for the metalworking process.

Tests on 4 balls machine for the initial 15 ester samples let us to conclude that monoester of butyric acid with 2 ortho secondary butyl phenoxy ethanol is the best.

In Fig.3 could be was observed that the additive effect begin at different loads for the 5 oil cooling fluids samples presented. For oil samples 5 and 4 were obtained the smallest values of friction coefficient. This means that formulas with monoester of butyric acid with 2 ortho secondary butyl phenoxy ethanol and formulas based on monoester of butyric acid with 2 etoxylated para nonylphenol are better than the rest.

From Fig. 4 of HSS wear it could be observed that oil sample 5 assure the smallest volumetric wear values. In the mean time for the workpiece, similar with carbon steel cylinder the wear should be maximum values. In fig. 5 it is shown that oil sample 5 assure the greatest wear values. These results obtained for oil cooling fluid samples on universal machines testing machines shows that formula for oil sample 5 is better than the rest of oil samples.

With this oil sample the tests will be continued on cutting machines with special devices [4, 5, 6] in order to establish axial cutting force, cutting torque and cutting tools wear.

REFERENCES