THE IMPACT ANALYSIS OF CUTTING FLUIDS AEROSOLS ON WORKING ENVIRONMENT AND CONTAMINATION OF RESERVOIRS

Matúš Čuma, Jozef Zajac

Monitoring and maintaining fluid quality are crucial elements of a successful fluid management program. A fluid must be monitored to anticipate problems. Important aspects of fluid monitoring include system inspections and periodic measurements of fluid parameters such as concentration, biological growth and pH. Changes from optimal fluid quality must be corrected with appropriate adjustments (such as fluid concentration adjustments, biocide addition, tramp oil and metal cuttings removal, and pH adjustment). It is important to know what changes may take place in your system and why they occur. This allows fluid management personnel to take the appropriate steps needed to bring fluid quality back on-line and prevent fluid quality problems from recurring.

The new metalworking cutting fluids generation brings also higher requirements for the system of fluid performance monitoring and control.

1 Introduction

Monitoring and maintaining fluid quality are crucial elements of a successful fluid management program. A fluid must be monitored to anticipate problems. Important aspects of fluid monitoring include system inspections and periodic measurements of fluid parameters such as concentration, biological growth and pH. Changes from optimal fluid quality must be corrected with appropriate adjustments (such as fluid concentration adjustments, biocide addition, tramp oil and metal cuttings removal, and pH adjustment). It is important to know what changes may take place in your system and why they occur. This allows fluid management personnel to take the appropriate steps needed to bring fluid quality back on-line and prevent fluid quality problems from recurring.

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2 Samples and analysis

Exposure of workers to aerosols of cutting fluids was measured from samples of multi-hole filters after collecting gravimetric analysis to determine the total number of total inhalable particles (TIP). Filters were further analyzed for reconsideration of mineral oil mist content in cyclohexane solvent and the mix of water cutting fluid samples were analyzed by elementary methods. This method involves measuring the elementary particles (usually boron or potassium) by spectrometric analysis. If are available data of cutting fluid concentration in the tank for liquid then it is possible to calculate the concentration in the air. The majority of the cutting fluid samples were taken at the site of the workpiece or cutting tool. In some cases, where the central tank is used, one sample was collected. Temperature and pH of the aqueous mix of cutting fluid were measured on the spot.

Water mixes cutting fluids were analyzed to detect the bacteria content. A substantial portion of the water mixes of cutting fluids was used for calibration of aerosol samples for analysis. Bacterial contamination of fluids was determined by dip-slide analysis. This analysis lies in the fact that the agar-coated plastic rod is immersed in a liquid sample, placed into a sterile container and then placed in an incubator. At stable temperature after 48 hours the amount of bacteria on the bar is determined by comparing. Dip-slide analysis provides a simple, inexpensive and reliable method of determining bacterial growth. For evaluation was used Grubb's test, a statistical test which is used to detect outliers in a univariate data set assumed to come from a normally distributed population.

3 The results of measurements

Exposure to aerosols of cutting fluids can happen in contact with the skin (such as through contaminated areas), or inhalation of spray droplets in the air. The aerosol is created when the cutting fluid is exposed to high shear...
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strength or excess heat during the application process. Aerosol properties depend on itself, cutting fluid and the type of operation, but the fog may be relatively stable and usually does not last long. Summarized statistical results for the analyzed air samples are listed in Tab. 1, analytical results from the tank in Tab. 2 and percentiles in Tab. 3.

During the period of 8 hours neither mineral oil aerosols exceeded 5 mg/m³ on average. Results of total inhalable particles (TIP) and fog are well correlated. Regression line equation is given by: oil mist $0, 0889 + 0,892 \cdot TIP$ and the correlation coefficient $r = 0,927$, suggesting that the TIP may provide a good estimate of the impact on the environment of oil mist for these samples (Fig. 1).

$$x = 0,0889 + 0,892 \cdot TIP,$$

$x$ – equation of the regression line, mg/m³
$TIP$ – total inhalable particles, mg/m³.

A result of measurements of water mix suggests that most emissions are below the limit of 2 mg/m³. The chart of mist of cutting fluid concentrate with total and inhalable particles (Fig. 2) shows a high degree of dispersion, which

<table>
<thead>
<tr>
<th>Analyzed sample</th>
<th>Matrix</th>
<th>Samples amount</th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
<th>Mean</th>
<th>Deviation</th>
<th>Geometric mean</th>
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</thead>
<tbody>
<tr>
<td>pH in tank</td>
<td>Water</td>
<td>30</td>
<td>5,4</td>
<td>10,5</td>
<td>8,8</td>
<td>8,7</td>
<td>0,7</td>
<td>8,7</td>
</tr>
<tr>
<td>Temperature in tank °C</td>
<td>Water</td>
<td>30</td>
<td>10,7</td>
<td>44,1</td>
<td>21,6</td>
<td>21,9</td>
<td>3,8</td>
<td>21,6</td>
</tr>
<tr>
<td>Fine particles /mg/l</td>
<td>Water</td>
<td>30</td>
<td>&lt;4</td>
<td>2200</td>
<td>18</td>
<td>56</td>
<td>165</td>
<td>20</td>
</tr>
<tr>
<td>Fine particles /mg/l</td>
<td>Mineral oil</td>
<td>30</td>
<td>80</td>
<td>1230</td>
<td>395</td>
<td>464</td>
<td>291</td>
<td>385</td>
</tr>
<tr>
<td>Amount of bacteria /10⁶</td>
<td>Mineral oil</td>
<td>30</td>
<td>&lt;10</td>
<td>195</td>
<td>0,109</td>
<td>11,992</td>
<td>30,926</td>
<td>0,01774</td>
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</table>

<table>
<thead>
<tr>
<th>Analyzed sample</th>
<th>90th percentile</th>
<th>95th percentile</th>
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</thead>
<tbody>
<tr>
<td>Aerosols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral oil (TIP) /mg/m³</td>
<td>2,8</td>
<td>3,3</td>
</tr>
<tr>
<td>Mineral oil fog /mg/m³</td>
<td>2,8</td>
<td>3,4</td>
</tr>
<tr>
<td>Water mix (TIP) /mg/m³</td>
<td>1,4</td>
<td>1,9</td>
</tr>
<tr>
<td>Water mix fog /mg/m³</td>
<td>0,8</td>
<td>1,6</td>
</tr>
<tr>
<td>Tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral oil fine particles /mg/l</td>
<td>900</td>
<td>970</td>
</tr>
<tr>
<td>Water mix fine particles /mg/l</td>
<td>90</td>
<td>270</td>
</tr>
<tr>
<td>Amount of bacteria /10⁷/ml</td>
<td>4,3</td>
<td>8,3</td>
</tr>
</tbody>
</table>

Figure 1 Mineral oil mist and mist of total inhalable particles

Figure 2 Mist of cutting fluid water mix and mist of water mix with total inhalable particles

<table>
<thead>
<tr>
<th>Process</th>
<th>Samples amount</th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
<th>Mean</th>
<th>Geometric mean</th>
<th>Geometric deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning</td>
<td>30</td>
<td>&lt;0,01</td>
<td>1,82</td>
<td>0,06</td>
<td>0,15</td>
<td>0,07</td>
<td>3,32</td>
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<tr>
<td>Milling</td>
<td>30</td>
<td>&lt;0,01</td>
<td>0,92</td>
<td>0,07</td>
<td>0,13</td>
<td>0,08</td>
<td>2,84</td>
</tr>
<tr>
<td>Drilling</td>
<td>30</td>
<td>&lt;0,01</td>
<td>0,9</td>
<td>0,14</td>
<td>0,22</td>
<td>0,16</td>
<td>2,29</td>
</tr>
<tr>
<td>Grinding</td>
<td>30</td>
<td>&lt;0,02</td>
<td>13,22</td>
<td>0,35</td>
<td>0,73</td>
<td>0,29</td>
<td>3,87</td>
</tr>
<tr>
<td>Sawing</td>
<td>30</td>
<td>&lt;0,05</td>
<td>0,61</td>
<td>0,23</td>
<td>0,27</td>
<td>0,18</td>
<td>3,23</td>
</tr>
<tr>
<td>Combined operations</td>
<td>30</td>
<td>&lt;0,01</td>
<td>3,22</td>
<td>0,2</td>
<td>0,71</td>
<td>0,28</td>
<td>4,81</td>
</tr>
</tbody>
</table>
shows, with the exception of the mentioned scattered values, the correlation coefficient is $r = 0.978$.

Differences in effect during machining are characterized as turning, milling, drilling, cutting and grinding (or combination of these operations in some cases). According to the values in Tab. 4 it can be concluded that the results of measurements at various operations (geometric grinding, sawing operations and the combined operations) in the application of water mist cutting fluid mix (mg/m$^3$) lead to a higher impact of fog water mix as in turning or milling.

Further analysis of these data shows that the growth of bacteria in a water tank with a mix of cutting fluids depends on the pH and temperature of fluid (Fig. 3, Fig. 4), but also on other factors. From the previous analysis it can be stated that it is necessary to control the consumption of cutting fluids in machining processes wherever they are used. Mist and aerosols creation causes leakage of small particles of liquid into the operator working area or production line equipment.

This has implications not only for the health of working personnel, but also coating devices that come in contact with those particles. Reducing the impact can be assured not only by controlling consumption, but also constantly monitoring the quality of the media process and thus prevent their degradation and subsequent dispersal of pollutants into the workspace.

5 Conclusion

Fluid monitoring and maintenance are the key element of each successful fluid maintenance program. Fluids must be monitored to prevent problems. An important aspect of fluid monitoring is a system of controls and periodical measurements of the fluids properties, such as concentration, pH and biological growth. Changes to the optimal fluids properties must be compensated by adequate additives (such as fluids concentration increasers, biocides additives, tramp oils, metal parts removers and fluid pH increasers). It is important to know what changes may be caused in the system and what causes them. This allows the personnel in fluid management to take necessary steps to bring the fluid properties and its quality back to optimal values and avoid possible problems recurring. Bacteria have been associated with a serious lung condition, hypersensitivity pneumonitis, when inhaled as part of liquid droplet aerosols generated from large volumes of liquids serving as a culture medium. Therefore these tests are very important for exhaust systems dimensioning from cutting zone during machining in production companies.

6 References


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