Drilling of Aluminum Alloys: Adhesion Problem

Elimination of metalworking fluids is desired due to environmental regulations and costs.

In the absence of metalworking fluid aluminum chips stick to the tool surface (steel/carbide), causing failure.

Ranking of Coatings

Diamond Like Carbon Coatings

<table>
<thead>
<tr>
<th>Coating</th>
<th>H (GPa)</th>
<th>E (GPa)</th>
<th>Thickness (µm)</th>
<th>Rz (µm)</th>
<th>Deposition Method</th>
<th>H Content (at. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-hydrogenated DLC</td>
<td>16</td>
<td>148</td>
<td>2</td>
<td>18</td>
<td>Magnetron Sputtering</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Hydrogenated DLC</td>
<td>10</td>
<td>114</td>
<td>1</td>
<td>11</td>
<td>Sputtering &amp; CVD</td>
<td>40</td>
</tr>
</tbody>
</table>

Lower and stable torque response during MQL drilling of 319 Al (non-hydrogenated DLC coated drill).

Experimental Drilling Tests

Numerical Modeling of Machining

Cross-sectional FIB images of microstructure of the substrate and the DLC coating.

TEM micrograph showing a section of DLC coating with aluminum adhered on its surface.

Optical cross-sectional microstructure of workpiece 1100 Al ahead of the tool tip

Strain distribution (kPa) in the workpiece of 1100 Al ahead of tool tip