Experimental Investigation of Surface Film Finish Time of Replicating Materials Microset 101 RT

Session 3E
Surface Engineering I

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Objective of Investigation

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Provide time vs temperature guidelines for use of replicate materials utilized to provide three dimensional cylinder bore surface finish characteristics including quantification of torn and folded material.
Process developed to provide improved method of quantifying cylinder bore finish

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Replicate material is dispensed into replicate bar utilizing a nozzle with an integral scraper to provide a uniform fill

Replicator head is inserted into bore and air pressure is applied

<table>
<thead>
<tr>
<th>Time To Set / Time to insert into Bore</th>
<th>30 seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Cure / Time Left in Bore</td>
<td>5 minutes</td>
</tr>
</tbody>
</table>

Original hone surface  
Replicate material cures

Replicate material is removed producing a negative imprint of the original surface

SEE 3-D replicate is examined with white light interferometer
Validation of Replicate Developed Surface Finish

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A significant amount of time and effort was expended to develop the 3-D surface replicating material that would:

• Repeatedly provide an accurate replication of the cylinder bore surface
• Have the required rigidity to permit handling between time of application in the replicate bar and initial loading against the cylinder (currently 30 seconds)
• Provide an accurate replicate of the surface to be rapidly developed in an acceptable time interval (currently 5 minutes)
• Avoid adherence to the cylinder bore surface with resultant modification of the replication surface during removal
• Permit use of system over an acceptable operating temperature range (currently 18°C to 35°C)
## Standard Deviation Analysis

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<table>
<thead>
<tr>
<th></th>
<th>Sa (µm)</th>
<th>Sci (µm)</th>
<th>Spk (µm)</th>
<th>Sk (µm)</th>
<th>Svk (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AVERAGE of Replicate</strong></td>
<td>0.241</td>
<td>1.335</td>
<td>0.531</td>
<td>0.643</td>
<td>0.609</td>
</tr>
<tr>
<td><strong>Standard Deviation of Replicate</strong></td>
<td>0.032</td>
<td>0.181</td>
<td>0.084</td>
<td>0.038</td>
<td>0.274</td>
</tr>
<tr>
<td><strong>AVERAGE of Direct</strong></td>
<td>0.255</td>
<td>1.290</td>
<td>0.569</td>
<td>0.668</td>
<td>0.688</td>
</tr>
<tr>
<td><strong>Standard Deviation of Direct</strong></td>
<td>0.035</td>
<td>0.141</td>
<td>0.310</td>
<td>0.060</td>
<td>0.217</td>
</tr>
<tr>
<td>Minimum of All</td>
<td>0.185</td>
<td>1.094</td>
<td>0.375</td>
<td>0.543</td>
<td>0.293</td>
</tr>
<tr>
<td>Maximum of All</td>
<td>0.295</td>
<td>1.586</td>
<td>1.131</td>
<td>0.715</td>
<td>0.979</td>
</tr>
<tr>
<td>Average of All</td>
<td>0.256</td>
<td>1.337</td>
<td>0.639</td>
<td>0.669</td>
<td>0.671</td>
</tr>
<tr>
<td>Standard Deviation of All</td>
<td>0.032</td>
<td>0.149</td>
<td>0.225</td>
<td>0.048</td>
<td>0.233</td>
</tr>
<tr>
<td>Std Dev of Ohlsson, et. all*</td>
<td>1.02</td>
<td>0.901</td>
<td>1.185</td>
<td>0.844</td>
<td>0.658</td>
</tr>
<tr>
<td><strong>6 σ range of Replicate values</strong></td>
<td>0.190</td>
<td>1.088</td>
<td>0.504</td>
<td>0.227</td>
<td>1.643</td>
</tr>
<tr>
<td><strong>6 σ range of Direct values</strong></td>
<td>0.207</td>
<td>0.848</td>
<td>1.861</td>
<td>0.360</td>
<td>1.305</td>
</tr>
<tr>
<td><em><em>6 σ range of Ohlsson</em> values</em>*</td>
<td>6.120</td>
<td>5.406</td>
<td>7.110</td>
<td>5.064</td>
<td>3.948</td>
</tr>
</tbody>
</table>
A main hone line is measured and marked showing the instances of Torn and Folded material appearing in each numbered cell

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Correlation between the manual Torn and Folded material analysis method and the automated Torn and Folded material analysis method for 20 reference images

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Surface Film Finish Time vs Temperature

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Min temperature @ which replicate material should be utilized

Max temperature @ which replicate material should be utilized
Curing Finish Time vs Temperature

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![Graph showing the relationship between curing finish time and temperature. The graph indicates the minimum temperature at which replicate material should be utilized and the maximum temperature at which it should be utilized.](image)
Mean Hardness and Variation vs Time at 65 deg F

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Bars indicate range of hardness values observed at each time step.

Cure time needs to be longer than nine minutes.
Mean Hardness and Variation vs Time at 75 deg F

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Bars indicate range of hardness values observed at each time step.

Cure time needs to be six minutes or longer.
Mean Hardness and Variation vs Time at 85 deg F

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Bars indicate range of hardness values observed at each time step

Cure time needs to be longer than 4.5 minutes
Curing Finish Time

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![Graph showing the relationship between temperature and hardening time.](image-url)