Mini-Almen Strips: A Promising New Technology

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Outline

• Introduction to the Technology
• Developing a Correlation Chart
• Performance Comparison between Standard and Mini Almen Strips
• Intensity Validation Study along Altering Geometry
• Mini Almen Strip Saturation Curve Study
• Mini Almen Strips: A Promising New Technology
Introduction

- Mini-Strip developed to replace shaded Almen strips
  - Enhance the ability to accurately and efficiently measure intensity
  - Intensity for small areas or holes
  - Eliminates masking
  - Eliminates complex testing fixtures for hard to reach areas
    - Dove-Tail slots in jet engine disks
    - Gear roots
    - Internal bore of springs
  - Provides a detailed idea of what is happening in areas previously not tested
Introduction

• Mini-Strips
  – 1” x 1/8”
  – Attached with double-sided tape
  – Attached directly to a test component or simulated fixture
Developing a Correlation Chart

• Correlation between full and Mini Almen Strips must be established before the intensity in small and hard-to-reach locations can be determined

1. Run a saturation curve using standard Almen strips at the upper intensity limit
2. Mount a mini-strip on a flat surface (using double-sided tape) and expose it for the T1 time under the parameters for the upper intensity limit
Developing a Correlation Chart

3. Run a saturation curve using standard Almen strips at the lower intensity limit

4. Mount a mini-strip on a flat surface (using double-sided tape) and expose it for the T1 time under the parameters for the lower intensity limit

- A correlation between the mini-strip and the full-size strip has been defined
  - Acceptable mini-strip arc height readings
  - Electronics Inc. found that N mini-strips work best with low intensity A values due to sensitivity
Performance Comparison

• In a study conducted by Electronics Inc.:
  – Baseline performance correlation between mini-strips and standard Almen strips
  – “A” and “N” intensities tested
  – Conducted to verify consistent performance of the mini-strip

• Mini-strips and standard Almen strips mounted on Almen holders
  – In blast cabinet with 31” diameter rotary table
  – Blast nozzle mounted 18” above holders, 90° to the strip surface
Performance Comparison

1. Pre-bow for each mini-strip and standard strip measured and recorded
2. Mini-strips and standard strips peened to desired intensity
3. Saturation curves generated with Dr. Kirk’s Curve Solver program
4. Histograms were made from results
Performance Comparison

“N” Almen Strips

- Mean
  - Standard: 12.425
  - Mini: 6.0833
- Standard Deviation
  - Standard: 0.13568
  - Mini: 0.26458

<table>
<thead>
<tr>
<th>Media:</th>
<th>S110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow:</td>
<td>10 lb/min</td>
</tr>
<tr>
<td>Nozzle:</td>
<td>0.50” dia</td>
</tr>
<tr>
<td>Pressure:</td>
<td>23 PSI</td>
</tr>
<tr>
<td>Ratio: (N to Sub N)</td>
<td>2:1</td>
</tr>
</tbody>
</table>
Performance Comparison
“A” Almen Strips

• Mean
  – Standard: 12.32
  – Mini: 4.93
• Standard Deviation
  – Standard: 0.063245
  – Mini: 0.094868

<table>
<thead>
<tr>
<th>Media:</th>
<th>CCW28</th>
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<tbody>
<tr>
<td>Flow:</td>
<td>10 lb/min</td>
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<tr>
<td>Nozzle:</td>
<td>0.36” dia</td>
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<tr>
<td>Pressure:</td>
<td>28 PSI</td>
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<tr>
<td>Ratio:</td>
<td>2.5:1</td>
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</table>
Ultrasonic Shot Peening

- STRESSONIC® Ruggedized USP is a portable system
  - Ultrasonically excites media with Sonotrode head
  - Shop floor footprint of 30 square feet
  - Weighs 210 pounds
  - Easily moved to any location with 115 volts AC and filtered shop air available

- Establishes a small peening chamber around the repair area
  - Retains and recycles media during process
  - Creates Omni-Directional media flow within chamber
Intensity Validation Study

- Correlation between the mini-strip and the full-size strip
  - Target Intensity: 8A ± 1.5A
- Attach mini-strips to test component using double-sided tape
- Develop and record process parameters to produce arc height between correlated limits

<table>
<thead>
<tr>
<th>Condition</th>
<th>Full Strip (A)</th>
<th>Mini Strip (MA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>11.6</td>
<td>4.7</td>
</tr>
<tr>
<td>20</td>
<td>8.2</td>
<td>3.3</td>
</tr>
<tr>
<td>47</td>
<td>5.8</td>
<td>1.8</td>
</tr>
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</table>

A Strip Correlation Using T1 Times

\[ y = 1.9793x + 1.9393 \]
Intensity Validation Study

• Part used during this study
  – UH-60 Tail Rotor Blade Pitch Horn

• Mini-Strips benefits during this study:
  – Validate Intensity at different distances within the chamber
  – Validate Intensity on an angled incline
  – Eliminated difficult and costly test fixtures
Mini Strip Saturation Curve Study

<table>
<thead>
<tr>
<th></th>
<th>Mini-Strips “A”</th>
<th>Standard Almen Strips “A-1S”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>1070 Steel</td>
<td>1070 Steel</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.51”</td>
<td>0.51”</td>
</tr>
<tr>
<td>Length</td>
<td>1.00”</td>
<td>3.00”</td>
</tr>
<tr>
<td>Width</td>
<td>0.125”</td>
<td>0.75”</td>
</tr>
<tr>
<td>Hardness</td>
<td>44-50 HRc</td>
<td>45-48 HRc</td>
</tr>
<tr>
<td></td>
<td>(44-50 HRc for “A”)</td>
<td></td>
</tr>
</tbody>
</table>

- With all material properties being the same, mini-strips should behave similar to standard Almen strips
  - Follow the 10% Rule
Mini Strip Saturation Curve Study

• Theoretical Correlation between a mini-strip and a standard Almen strip

\[ R = \frac{h_n}{2} + \frac{d_n^2}{8(h_n)} \]

\[ d_1 = 1.25'' \]
\[ d_2 = 1.00'' \]
\[ h_1 = \text{Measured} \]
\[ h_2 \rightarrow \text{Calculated} \]
Mini Strip Saturation Curve Study

Avion Saturation Curve Solver
Compliant with SAE AMS 5.1165 & MIL-S-13165C

This Worksheet is Proprietary to Avion Solutions, Inc.

Data Points | Time (sec) | Arc Height (in x 10^3) | Negative Pre-Bow (in x 10^3) | Corrected Arc Height | Fitted Curve | Residuals | SSE
---|---|---|---|---|---|---|---
1 | 0.0 | 0.0 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000
2 | 3.0 | 0.0 | 0.1 | 4.0000 | 4.0773 | 0.2773 | 0.0000
3 | 5.0 | 0.0 | 0.1 | 8.0000 | 8.1542 | 0.1542 | 0.0000
4 | 24.0 | 0.4 | 0.1 | 8.3000 | 8.3533 | -0.0533 | 0.0000
5 | 48.0 | 0.4 | 0.1 | 8.2000 | 8.2050 | 0.0050 | 0.0000

Arc Height = a + b Time

This Worksheet is Proprietary to Avion Solutions, Inc.

USP Parameters

Pen Size: 1" x 3"
Almen Block Adapter
Tungsten Carbide
USP Machine Serial Number
2130 (Avion)

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Almen Block Adapter
Tungsten Carbide
USP Machine Serial Number
2130 (Avion)

Arc Height = a + b Time

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Mini Strip Saturation Curve Study

- Correlation Chart between Intensity and Mini-Intensity created
  - Using “A” Standard and Mini-Strips
  - Saturation Curves allow for a more accurate and consistent reading when checking intensities in small or difficult areas
  - Mini-Intensity not true Intensity, used for correlation purposes only

- Linear relationship
  - Demonstrates mini-strips behave similar to full strips regardless of intensity or parameters
Mini Strips: A Promising New Technology

• Complex and costly test structures eliminated
  – Mini strips can be attached directly to desired surface using double-sided tape

• Eliminates need to create shaded Almen strips

• Intensity confirmation available in areas previously unattainable
  – Due to small size and ease of application
Acknowledgements

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• Electronics Inc.

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