**Results and Discussion**

**ASTM A709**

In our A709 residual stress (RS) results, there is a general trend at the weld toe (0.0 in), where the unpeened samples have RS around 0 MPa, but the shot peened (SP) has a large compressive (represented in the negative direction) stress and the ultrasonic needle peened sample has a greater compressive stress. As the measurements progress away from the weld toe, the standard deviation (error bars) of the measurements increases in the center of the sample, at around 0.8 in. This is related to how the residual stress analyzer measures the stress in our samples, as it compares our tested samples to examples of the same material. The samples underwent a phase transformation due to the heat treatment around halfway through the sample. Since there are two phases present and the machine relies on a comparison between the same material, the measurements are going to be less accurate with higher standard deviations.

**Figures**

2. Topographical profile of residual stress for 1018.

**Conclusions**

- At the weld toe, both peening methods induce an average compressive residual stress of -300 to -500 MPa.
- In the 709 samples, the ultrasonic needle peened (UNP) samples had a higher magnitude of compressive stresses than the shot peened samples. This is expected because UNP operates at a higher relative intensity than shot peening.
- As the measurements went further away from the weld toe, the effects of the peening treatments decreased. This is consistent with background research because both peening techniques focus treatment on the weld toe.

**Recommendations**

- Performing fatigue tests on T-joint samples, pre- and post-treatment would allow for a true comparison on which impact treatment would be the best option for constructing bridges and related infrastructure applications. Test may be financially prohibitive, so cost-benefit analysis should be considered.
- Additional characterization such as optical microscopy to observe the microstructure and Vickers hardness testing to corroborate the x-ray residual stress data.
- Additional testing on the shot peened S230 samples for further comparison.

**Acknowledgements**

Special thanks to:
- Empowering Technologies for provision of the STRESSVIOGAGER® Ultrasonic Needle Peener
- Progressive Surfaces for SP our samples
- Ervin Industries for donating the cast-steel shot used for shot peening our samples
- Dr. Robert Connor (Purdue), Kumar Balan (Ervin Industries), and Brandon Thornell (Empowering Technologies) for their expertise and guidance

**Tables**

1. Comparison of the different impact treatments.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ultrasonic Needle peening</th>
<th>Shot peening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>Very mobile/in situ use</td>
<td>Stationary/Facility only</td>
</tr>
<tr>
<td>Intensity</td>
<td>Higher/intensity range</td>
<td>More controlled/intensity range</td>
</tr>
<tr>
<td>Automation</td>
<td>Controlled by hand</td>
<td>Computer controlled</td>
</tr>
<tr>
<td>Weld coverage (complete/total)</td>
<td>Covers just the weld toe/total</td>
<td>Covers large area of T-Joint/Complete</td>
</tr>
<tr>
<td>Time</td>
<td>Takes time</td>
<td>Covers larger areas faster</td>
</tr>
</tbody>
</table>

**Figure 3** Close-up images of the A709 steel, (a) control, (b) UNP and (c) SP

**Figure 4** Close-up images of the 1018 steel, (a) control, (b) UNP and (c) SP