Introduction

- In these experiments, Aluminum alloy 6022 was friction stir spot welded to CR-EG60G60G-E Steel using a refill friction stir spot welding technique and scribe technology.

Background

- Friction Stir Spot Welding is a solid-state welding technique that is able to bond materials resistant to traditional welding techniques.
- FSW is a technique that can form strong bonds between aluminum and steel that are very difficult to weld together due to the differences in their mechanical properties.
- Refill Friction Stir Spot welding is a method of FSSW that fills in the keyhole left by traditional FSSW during the welding sequence.

Broader Impact

- One main goal in current automotive manufacturing is increasing the fuel economy of vehicles.
- One way to increase fuel economy is to reduce the weight of vehicles by replacing steel structural components with components made of a material with a higher strength to weight ratio, namely Aluminum and Magnesium Alloys.
- FSSW is also attractive to industry because it consumes less energy than other welding techniques and generally requires no pretreatments or special environments.

Procedures

- Wreys have been made using a sleeve plunge sequence and a pin plunge sequence.
- A laser deposition of Tungsten Carbide (WC) in a nickel matrix mixed up the steel during the pin plunge sequence while the sleeve plunge sequence did not touch the steel.
- Welds were tensile tested.
- Macrographs were taken and an SEM analysis was performed.
- These tests were used to:
  - Analyze the formation of intermetallic compounds
  - Observe the performance of the laser deposition
  - Determine the effect of the zinc coating on the galvanized steel.

Objectives

- To investigate the feasibility of using laser deposited tools to successfully weld Al to steel using friction stir spot welding techniques for automotive applications.
- To optimize processing parameters to achieve a strong bond and evaluate the mechanical properties and microstructure of welds.

Results

- As seen in Table 1, the welds made with the galvanized steel could bear a higher shear load than those welds made using the uncoated steel although there were more sticking problems with the galvanized steel.
- The laser deposition of WC on the pin did stir up the steel as can be seen by the mass of steel in the aluminum sheet in figure 7.
- An intermetallic layer greater than 500nm thickness could not be detected in the Scanning Electron Microscope (SEM) analysis.

Future Work

- To further study the effect of the zinc coating on the galvanized steel on welding parameters and performance.
- To adjust the location of and material used in the laser deposition in an effort to increase weld strength and eliminate the problem with sticking.
- To continue making welds and adjusting parameters to find the best combination and the strongest welds.

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Table 1: Results table of the tensile tests performed on spot welds

<table>
<thead>
<tr>
<th>Weld type</th>
<th>Ultimate tensile strength</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleeve plunge - galvanized steel</td>
<td>618 ± 12 lbf</td>
<td>2.75 ± 0.06kN</td>
</tr>
<tr>
<td>Sleeve plunge - uncoated steel</td>
<td>533 ± 15lbf</td>
<td>2.37 ± 0.068kN</td>
</tr>
<tr>
<td>Pin Plunge - uncoated steel</td>
<td>350 ± 26 lbf</td>
<td>1.56 ± 0.12kN</td>
</tr>
<tr>
<td>Pin plunge - galvanized steel</td>
<td>Welds were not completed or tested due to the sticking of the tool to the material</td>
<td></td>
</tr>
</tbody>
</table>