SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

AMP SDSM&T

Dissimilar Friction Stir Spot Welding of Aluminum to Steel for use in the Automotive Industry

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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

Figure 1: Friction Stir Spot weld using sleeve plunge sequence

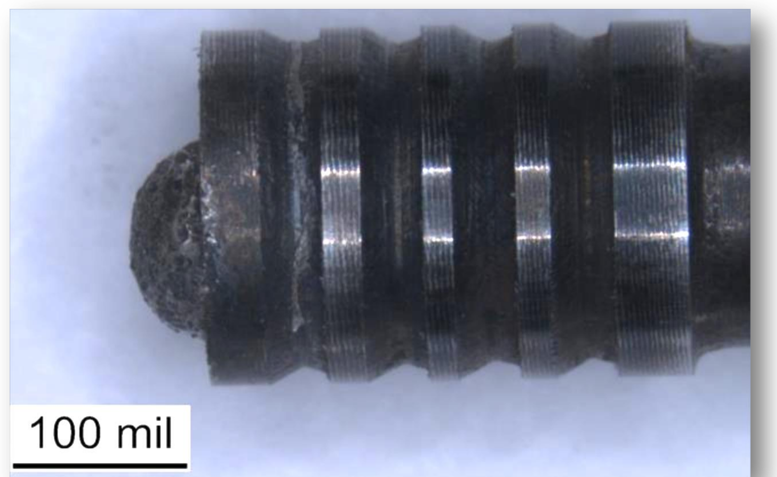


Figure 2: Pin of tool with laser deposited "scribe" Courtesy of Todd Curtis

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

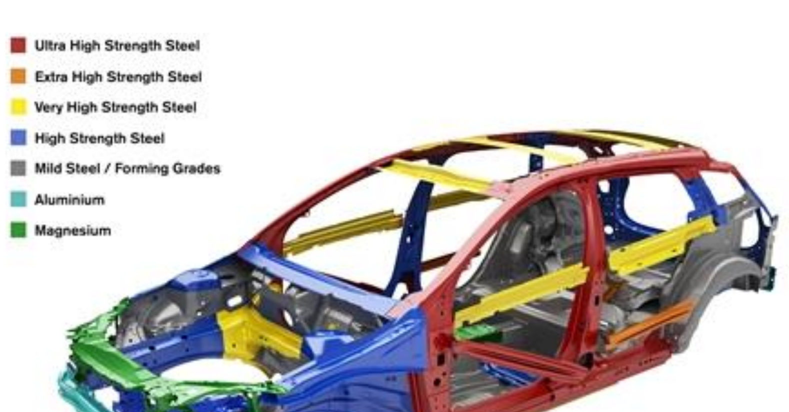


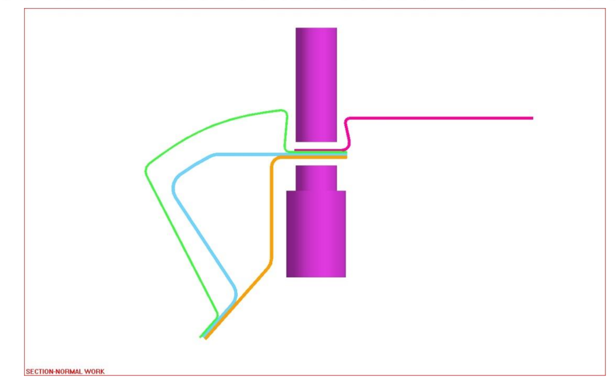
Figure 3: Example of Aluminum and Magnesium Alloys used in cars to reduce weight

http://boronextrication.com/files/2012/05/2010_Volvo_V60_Body_Structure_Safety_Cage_Extrication_UHSS_Boron.jpg

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

Figure 4: Roof joint part to be Friction Stir Welded Courtesy of GM, provided by Todd Curtis



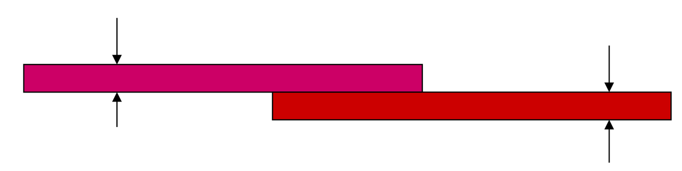


Figure 5: Weld samples of 1mm thick aluminum and 0.7 mm thick steel sheets

Procedures

- Welds 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

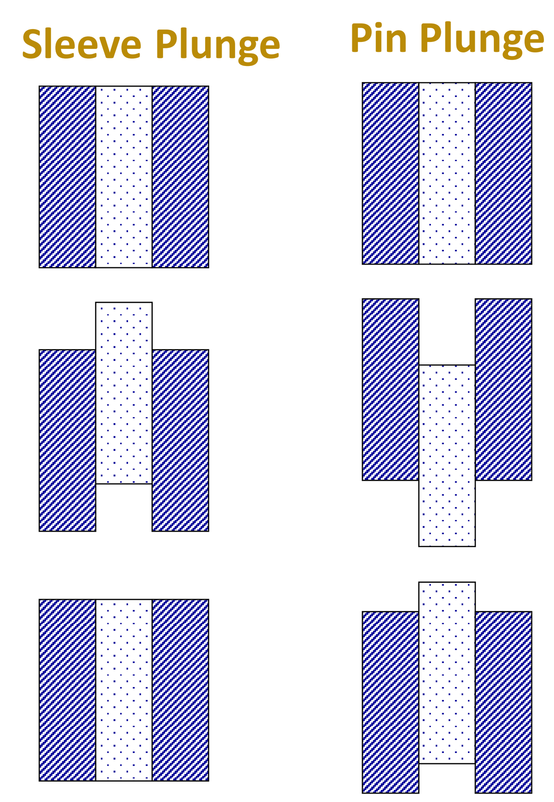


Figure 6: Simplified Welding Sequences

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

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

Results

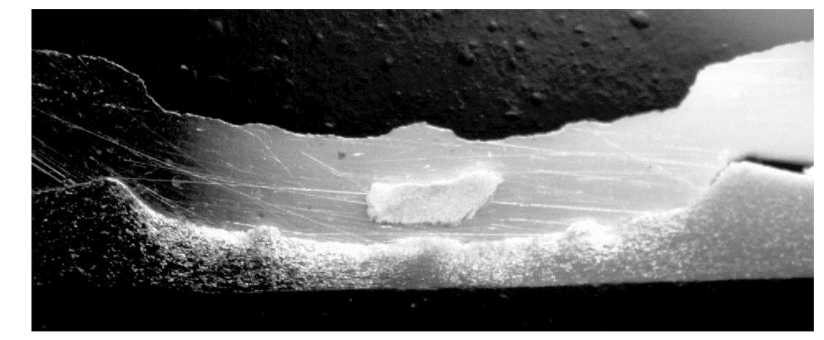
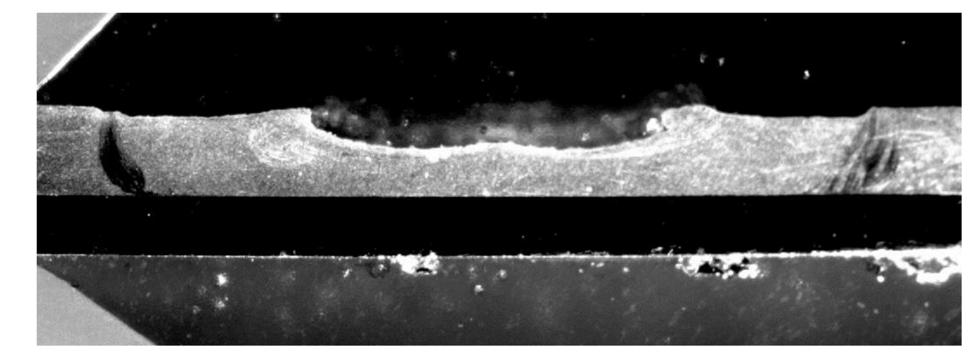


Figure 7 : Macro of the cross section of a weld made using the pin plunge weld sequence

Figure 8 : Macro of the cross section of a weld made using the sleeve plunge weld sequence



Conclusions

- 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

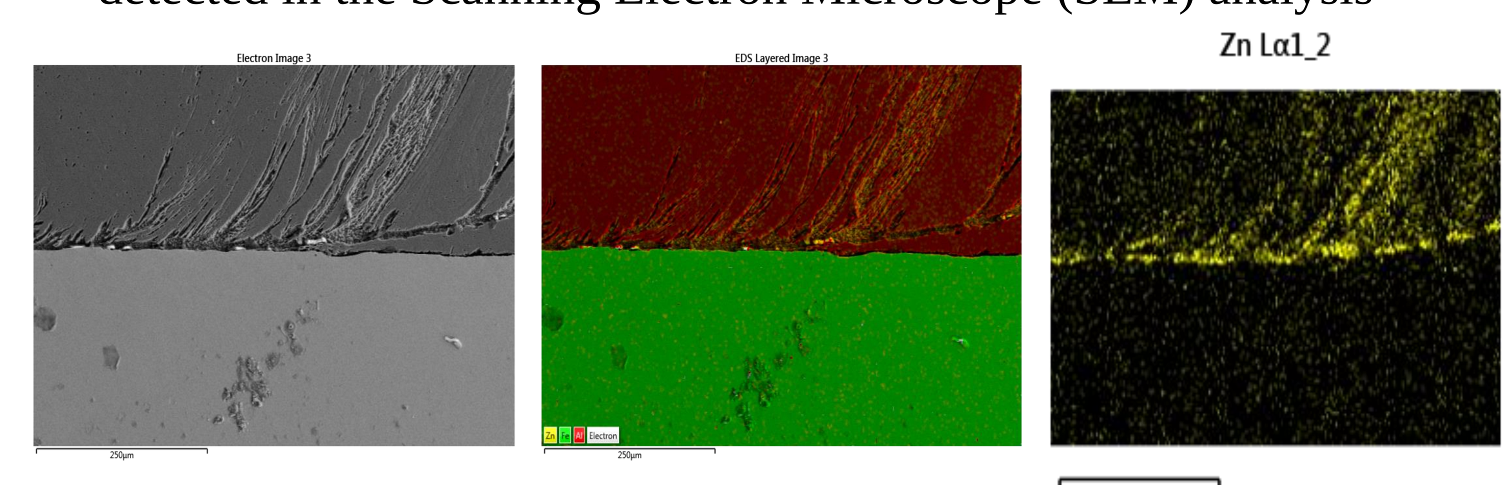


Figure 9 : Energy Dispersive Spectroscopy (EDS) image of galvanized sleeve plunge

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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