N. High-Strength Steel Joining Technologies Project

Project Manager: Michael S. Bzdok
Auto/Steel Partnership
2000 Town Center, Suite 320
Southfield, MI 48075-1123
(248) 945-4778; fax: (248) 356-8511; e-mail: mbzdok@a-sp.org

Co-chair: James W. Dolfi
Dolfi AWS LLC
16883 Shrewsbury
Livonia, MI 48154
(734) 427-8117; fax: (734) 427-1827; e-mail: dolfi@www.net.com

Co-chair: John C. Bohr
General Motors Corporation – Controls, Robotics, and Welding
30300 Mound Road – Mail Code 480-109-164
Warren, MI 48090-9015
(810) 602-8276; fax: (586) 947-1039; e-mail: johnc.bohr@gm.com

Technology Area Development Manager: Joseph A. Carpenter
(202) 586-1022; fax: (202) 586-1600; e-mail: joseph.carpenter@ee.doe.gov
Field Technical Manager: Philip S. Sklad
(865) 574-5069; fax: (865) 576-4963; e-mail: skladps@ornl.gov

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Objective

The objective of the High-Strength Steel Joining Technologies project team is to provide welding and joining expertise to the Auto/Steel Partnership (A/SP) lightweighting projects to facilitate the increased use of advanced high-strength steels (AHSS). Additional project objectives include augmenting the technical knowledge pertaining to welding of AHSS through applied research and development of industry standards for quality acceptance and weldability testing of AHSS.

Approach

- Determine welding parameters to produce quality welds, then statically and dynamically test welds produced at these parameters to quantify individual weld structural performance (See Figure 1). Tensile shear strength, impact energy and fatigue life are typically evaluated.
- Develop procedures for testing of AHSS and evaluating weld performance, where there is a lack of applicable standards.

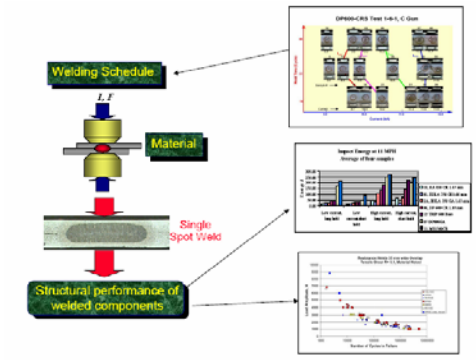

Figure 1. Resistance Spot Welding Process Approach Example

- Focus on materials classified as Group 3 and 4 (See Figure 2), as well as specific materials recommended by the A/SP Lightweight Structures Group.

Group	Min Tensile Strength	Typical Products
1	< 350 MPa	MILD 140/270 BH 180/300 BH 210/320 BH 240/340
2	350 - 500 MPa	BH 260/370 HSLA 280/350 HSLA 350/450 DP 300/500
3	> 500 - 800 MPa	DP 350/600 TRIP 350/600 DP 500/800 TRIP 500/800 CP 700/800
4	> 800 MPa	DP 700/1000 Mart 950/1200 Mart 1150/1400 Mart 1250/1520

Figure 2. IISI Steel Classifications for Welding

- Secure material in sufficient quantities from membership companies to fabricate samples and complete structural performance testing according to a predetermined project plan or matrix.
- Investigate the use of process finite element modeling to predict weld quality characteristics and optimize weld process parameters (See Figure 3). Simulate, using finite element modeling, where applicable, future projects for weld process optimization and weldability assessments. Validate simulation results with experimental data.

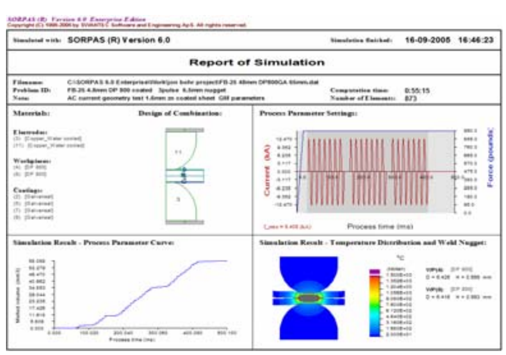

Figure 3. Process Simulation Report for RSW of DP780 Utilizing B-Nose Electrode and 3-Pulse Weld Schedule

Accomplishments

- Developed weld parameters for specified material grade and thickness combinations for the A/SP Lightweight Front End Structures Group (LWFES, report 2.U), provided technical direction, and applied welding practices to fabricate a prototype AHSS vehicle front structure.
- Provided equipment evaluation and set-up support at the prototype build shop and provided the post-crash weld performance report for inclusion in the final LWFES prototype build report (See Figure 4).

Front view showing bumper reinforcement and rail collapse. All welds were acceptable.

Left-hand side view showing integrity of spot welds on the AHSS rail assembly between bumper and dash.

Figure 4. Lightweight Front End Structures – Crash Test Photos

- Reviewed the draft report and completed additional work to support the referenced American Iron and Steel Institute (AISI)/Edison Welding Institute (EWI) project that addresses the effect of tempering welds made with dual-phase (DP), Martensitic, and transformation-induced plasticity (TRIP) steels.
- Provided technical direction and coordination for material selection to conclude the Steel Institute AISI/EWI project, Technology Roadmap Program #0114, DE-FCO7-97ID13554, which addresses the effect of tempering welds made with DP, Martensitic, and TRIP steels.
- Developed the test-plan matrix for evaluation of weld processes including metal inert gas (MIG), laser-assisted MIG, and plasma-assisted MIG. Obtained and provided the necessary materials and completed testing and review of the welds, resolved process issues, and approved process samples (See Figures 5 and 6).
- Completed projection weld fastener resistance weld process and simulation study. Worked with the University of Waterloo to model the projection welding of a hex-flanged weld nut using SORPAS with a cylindrical block model. Weld test results have correlated with the model. A final project report is under review.
- Produced and tested samples for low-temperature impact-strength study. Test data are undergoing review and analysis.
- Provided direction and post-test samples of tensile shear and impact tests for committee review, provided data to support development of AHSS resistance-weld quality standard, submitted data and participated in SAE/AWS D8 standard development of AHSS weld quality documents, and provided technical support for development of AHSS fracture classification matrix for standardization. (See Figure 7).

Future Direction

Future team activities include supporting welding development for the recently formed A/SP AHSS Application Guidelines Project Team and developing welding parameter and joint performance data for specific applications on AHSS automotive body prototypes.

- Assess capability to perform drawn-arc stud welding on AHSS.
- Develop a Design of Experiment (DoE) methodology for material characterization and for assessing manufacturing feasibility of spot-welding AHSS.
- Develop software application to support common deployment and analysis of the AHSS DoE test method.
- Develop weld process modeling and joint prediction models to reduce weld testing.
- Assess paint bake and sub-zero thermal cycle effects on welds.
- Support collaborative agreement with LeTourneau University for testing and post-mortem analysis of fracture surfaces of welds from other A/SP resistance-welding efforts.

SWSG First AHSS Sample for Approval, a Robotically Welded Section of 3.40 mm DP600 Bare to 3.40 mm DP600 Bare

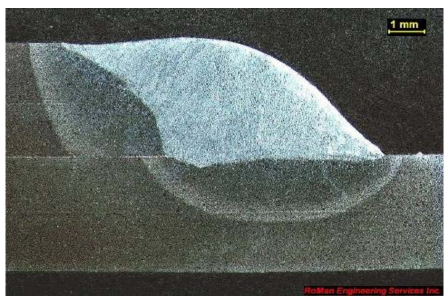

Figure 5. Approval sample cross-section 3.40 mm DP600 Bare to 3.40 mm DP600 Bare

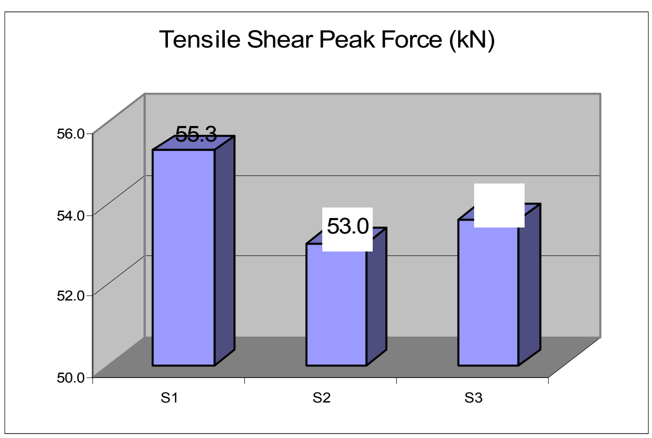

Figure 6. Structural Weld Sub-Group Stack up 1 3.40 mm DP600 Bare to 3.40 mm DP600 Bare Robotically Produced MIG Weld

PROPOSED STANDARD FRACTURE CLASSIFICATION Submitted to AWS D8 Automotive Standards Committee

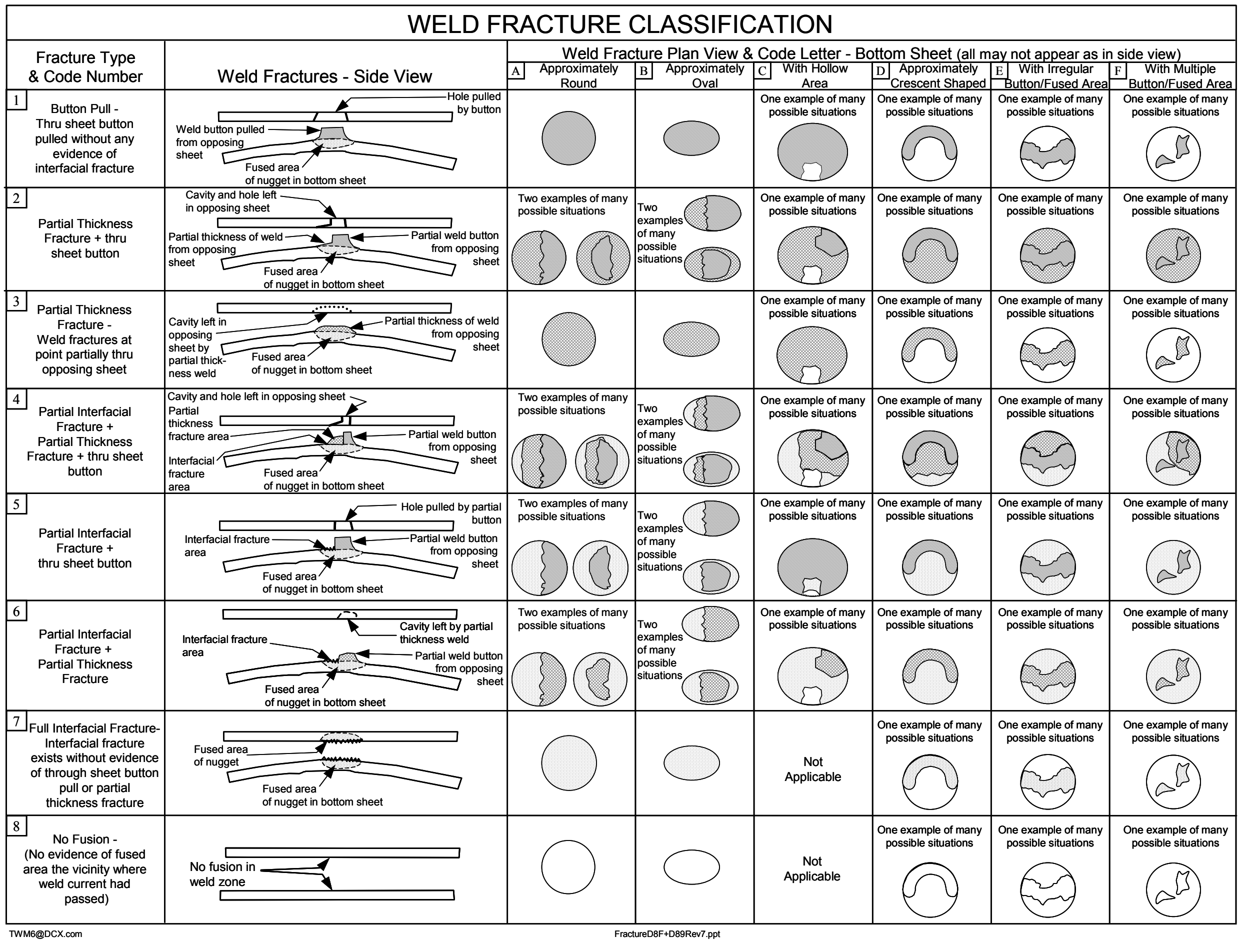

Figure 7. Proposed fracture classification matrix.