Friction Stir Spot Welding: Coming Soon to a Car Near You

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Introduction

Automotive original equipment manufacturers (OEMs) are under constant pressure to improve product performance. Many of these pressures are contradictory, presenting automakers with a significant challenge. Corporate average fuel economy (CAFE) standards require lightweighting and increased fuel economy, while other government regulations call for increased occupant protection during collisions. Consumers want increased frame and sheet metal stiffness for improved handling but don't want to sacrifice ride comfort. To make matters more challenging, all these improvements must be realized without increasing fabrication costs.

Using New Materials

To meet these demands, the materials used throughout a vehicle must continuously evolve. Figure 1 illustrates the increased use of aluminum in a body-in-white starting in 1975 and predicts accelerated use over the next decade. Ford's bold step of converting their flagship F-Series truck platform to an all-aluminum body will likely increase the trajectory of this use.

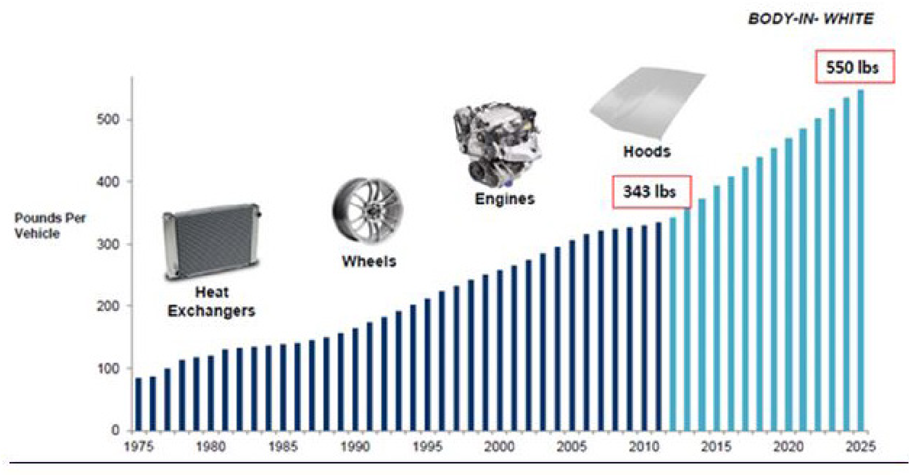

Figure 1 - Aluminum Content in Automobiles[1]

An Alternative to Resistance Spot Welds and Rivets

As the use of new materials and material combinations increases, methods of joining them must be reevaluated. Ford's new truck-construction method includes roughly 2,000 rivets, adding cost to an already expensive material change. Friction stir spot welding (FSSW) offers many of the benefits traditionally associated with friction stir welding (FSW). FSSW creates a weld in a distinct location or "spot" using a tool similar to that used in FSW, and is comprised of a plunge sequence, a stirring sequence, and a retract sequence. The sum of these sequences constitutes the total cycle time of the welding process, which is similar to the cycle times of traditional resistance spot welding (RSW) or riveting.

Three Types of Friction Stir Spot Welding

There are three main FSSW process variations: traditional, swept, and refill. In the traditional method, a single-piece rotating non-consumable tool is plunged into the material, held in-place for a pre-determined period of time, and then retracted. Swept FSSW moves the tool in a circular path after the final plunge depth is achieved. As in traditional FSW both of these process variations leave an exit hole.

Refill FSSW (R-FSSW) utilizes a tool consisting of a pin, a shoulder, and an outside clamp to capture the flash material which is extruded during the plunge sequence. This material is then deposited back into the exit hole creating a weld that is flush with the top surface. EWI's Harmes and Wende RPS100 refill friction stir spot welder is shown in Figure 2.

Key Applications for FSSW

FSSW is suitable for joining the high-strength aluminum alloys used in automotive and aerospace applications, yielding many benefits including reduced manufacturing costs, high repeatability, lower maintenance, and an improved work environment when compared to traditional RSW or riveting approaches. A number of equipment manufacturers offer FSSW equipment and the process has already been implemented by some manufacturers; most famously by Mazda on the RX-8.

Industry use of FSSW to join steel is a few years away with a major barrier to implementation being cost and tool life. As in FSW, FSSW tool design is critical to the development of suitable welding procedures. Many studies have investigated the effect of various tool features on weld quality, resultant weld microstructure, and weld strength. EWI has a long history of traditional FSW tool design and evaluation. We are now focusing these efforts on advancing R-FSSW tool design.

Current EWI Research

Based on discussions with our customers and surveys of industrial experts, EWI selected two topics for investigation and has partnered with member companies to conduct this research. The first of these projects is focused on using R-FSSW to join high-strength aluminum alloys. After developing parameters and conducting mechanical testing to evaluate joint performance, EWI will produce a demonstration component to allow our customer to conduct more extensive testing and evaluation.

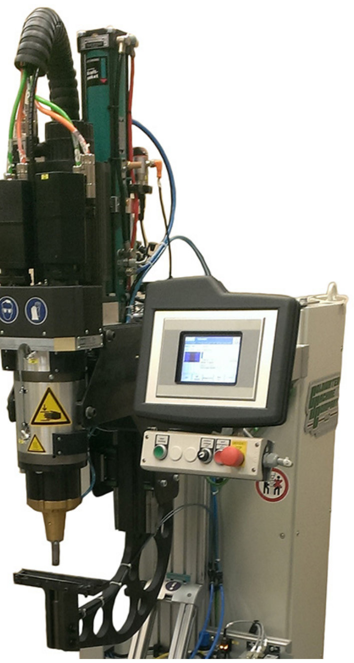

Figure 2 - EWI's RPS100 R-FSSW System

In the second project, EWI is investigating the use of a R-FSSW to join a high strength aluminum alloy to high-strength steel sheet. In addition to parameter development and mechanical testing, tool design and tool material will be evaluated.

1. http://marketrealist.com/2014/12/must-know-key-differences-steel-aluminum/

__James Cruz,__ Engineering Manager, leads EWI's Resistance & Solid-State Welding, Nondestructive Testing, and Friction Stir Welding groups. He has been the technical lead on a variety of projects in these technologies during his time at EWI, and has served as project manager on many of them. James has expertise in various resistance and solid-state welding processes, including flash-butt welding, resistance spot welding (RSW), friction welding, and friction stir welding. His materials expertise includes carbon steel and aluminum alloys. His has worked on projects involving tooling and fixturing development, welding automation, procedure optimization, and qualification of weld procedures for manufacturing and aerospace applications.

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