Development of High Strength Steel Resistance Spot Welding Parameters and Failure Analysis

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Over the past 20 to 30 years the automotive industry has struggled to reduce weight and increase fuel economy, while at the same time meeting strict crash test standards. This struggle initiated the application of high strength low alloy (HSLA) steels in production and the need for welding processes to efficiently produce quality spot welds. An examination of some failures of sample welds, made using the same operating parameters, of the HSLA steel showed that most samples failed in the base metal, while a few failed through the weld. This project will develop optimum operating parameters for resistance spot welding HSLA steel, taking into the time demands of a high production environment. The effects of post weld heat treatment (PWHT) and varying hold times will also be examined, along with the cause of the varying failure mode.

Nugget diameter and tensile force vs. weld current curves were developed keeping the electrode tips, materials and squeeze pressure fixed, while varying the current, weld time, hold time, and post weld heat treatment (PWHT). From this data a lobe curve was developed, from which optimum operating parameters can be chosen. The acceptable welds were tested for tensile strength and hardness traverses were performed to determine weld and heat affected zone hardening. Scanning electron microscopy (SEM) and optical microscopy was performed on the fracture surfaces to determine the reason for varying failure modes.

From the welding lobe curve, it was determined that the optimum operating parameters of this particular HSLA steel was 15 weld cycles at 8700 amps. From the PWHT and hold time study, it was determined that PWHT has no effect on weld metal properties and varying hold time only has a negligible effect.

Using the SEM it was found that a weld that failed through the weld metal contained the following defects: 1) cleavage fracture, 2) weld centerline cavity, 3) lack of fusion, and 4) solidification crack, all indicative of inadequate squeeze force. It is therefore concluded that the squeeze force needs to be increased from the current value of 250 kgF.

The final cost of the project was $11,910, with a return on investment of $283,964/year.