

Liquid Metal Embrittlement in Resistance Spot Welds of AHSS Steels

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Introduction

Advanced high strength steels (AHSS) are of considerable interest for automotive industries due to their potential to fulfill the requirements for both fuel economy and crash-worthiness. However, weldability studies from different sources indicated that coated AHSS may develop liquid metal embrittlement (LME) during resistance spot welding if improper process set-up and/or welding schedules were used. Some work had been done on LME in arc welded joints of galvanized steels. Only one published paper mentioned LME in IF steels, and no publications were found regarding LME in resistance spot welds of steels, including AHSS.

Procedure

This work studies possible factors affecting the formation of LME, and the impact of LME on the static performance of AHSS spot welds. Three AHSS, one mild steel and one HSLA (for comparison purpose) were included for the investigation. Spot welding was done using an AC resistance spot welder with various process set-up and welding schedules. Optical microscopy, scanning electronic microscopy (SEM) and energy dispersive spectroscopy were used to examine the location, morphology, orientation and composition of the constituents found in the LME areas. Peel and tensile shear tests were conducted to show the effect of LME on the static strength of resistance spot welds. One tear down sample with LME of a real production part was also introduced to show the similarity in the static performance of resistance spot welds.

Results and Discussion

It was observed that all the galvanized steels developed LME with improper process set-up and welding schedule, which indicates that LME is not generally material dependent. Weld tip misalignment, excessive heat input, excessive tip wear and insufficient tip cooling are four main contributing factors to LME. All the LME was observed in the indentation area. Microstructure was heat-affected for all the crack initiation sites, which may be due to high heat input and/or insufficient tip cooling. The EDS study indicated that the composition of the constituents found in the LME areas are comprised of both copper and zinc. For uncoated steels with similar levels of misalignment, expulsion and tip cooling, no LME was observed. It is thought that the coupling effect of copper and zinc is the

key crack-inducing agent in developing LME in sheet steels. Peel and tensile shear tests in this study indicated that LME neither promote interfacial failure nor undermine tensile strength of a spot weld. It should be noted that if a material has hold time sensitivity, LME may promote a partial interfacial failure. In this case, it may undermine the tensile strength of a spot weld. However, no hold time sensitivity has been observed for most of the AHSS thus far, especially for coated DP600. Generally speaking, most spot welds develop interfacial failure when the nugget is too small. When a nugget is too small, there is no overheating issue, so LME will not occur.

Conclusions

1. LME is not material dependent in general. It can be found in coated material, especially galvanized steels when improper process set-up and/or abnormal welding schedule are applied.
2. Key factors contributing to LME are tip misalignment, excessive heat input, excessive tip wear and insufficient tip cooling.
3. The coupling effect of zinc and copper is the main crack-inducing agent in developing LME.
4. LME does not have negative impact on the static performance of a spot weld.
5. It is recommended that the effects of LME on impact and fatigue performance of spot welds be evaluated.