Resistance Spot Welding of NanoSteel NXG™ 1200 to Other Materials

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Introduction

NanoSteel has a newly developed advanced high-strength steel alloy, NXG™ 1200, designed to address the need for weight reduction and safety enhancement in the automotive market. It gains its strength and formability from the "mixed microconstituent structure" generated during a controlled production process using standard steel-making equipment. EWI was engaged by NanoSteel to evaluate the weldability of this new sheet steel both to itself and to other commonly used sheet steels.

From a structural perspective, the NXG™ 1200 alloy avoids creation of brittle martensitic phases through austenite stability during solidification and low carbon content. This feature significantly reduces the risk of interfacial failures due to low ductility in resistance spot welds associated with rapid cooling rates.

Spot Welding

Welding trials with the alloy employed resistance welding parameters like those used on other advanced high-strength steels to produce typical spot weld button sizes. Similar to other advanced high strength steels, NanoSteel's NXG™ 1200 requires higher weld forces than standard strength sheet steel.

The most challenging aspect of resistance spot welding with this material is the destructive testing of the resulting spot welds. The combination of extremely high strength and ductility for this new alloy requires high force over a long distance to fracture the weld around its periphery to measure the button size. While this is a challenge for testing, these attributes make this new high-strength steel attractive for modern automotive construction where strength and ductility of a welded structure can enhance its safety.

The NXG™ 1200 welding trials showed current ranges in excess of 2.0 kAmp when welded to itself with modern equipment. The alloy showed even wider current ranges when welded to other steels in use today, such DP 980, typical low carbon steels, and TRIP steels.

Although NanoSteel's sheet steels are quite different than other automotive steels, no heat balance adjustments in electrode geometry were required to offset the alloyed chemistry of the NXG™ 1200. The fusion zones typically appeared nearly centered even though the material has a slightly reduced melting point.

Mixed-Material Spot Welding

When assessing the resistance spot weldability of a steel, its ability to weld to other materials is a key attribute that may not be assessed in standard practice qualification tests. When mixing with the other steels and their specific alloy systems, NanoSteel's NXG™ 1200 appears to reduce the peak hardnesses in the fusion zone of the spot weld. A cross section and corresponding micro-hardness traverse of a weld between NXG™ 1200 and DP980 is shown in Figure 1a and Figure 1b. In Figure 1, the hardened area in the fusion zone and heat-affected zone (HAZ) is less severe than typically associated with spot welds in these moderate carbon fusion zones. The hardness remains relatively unchanged between the base metal in the NanoSteel sheet and its corresponding HAZ. In dissimilar welds, the fusion zone may be slightly harder depending on the composition's reaction to the rapid cooling rate associated with resistance spot welding.

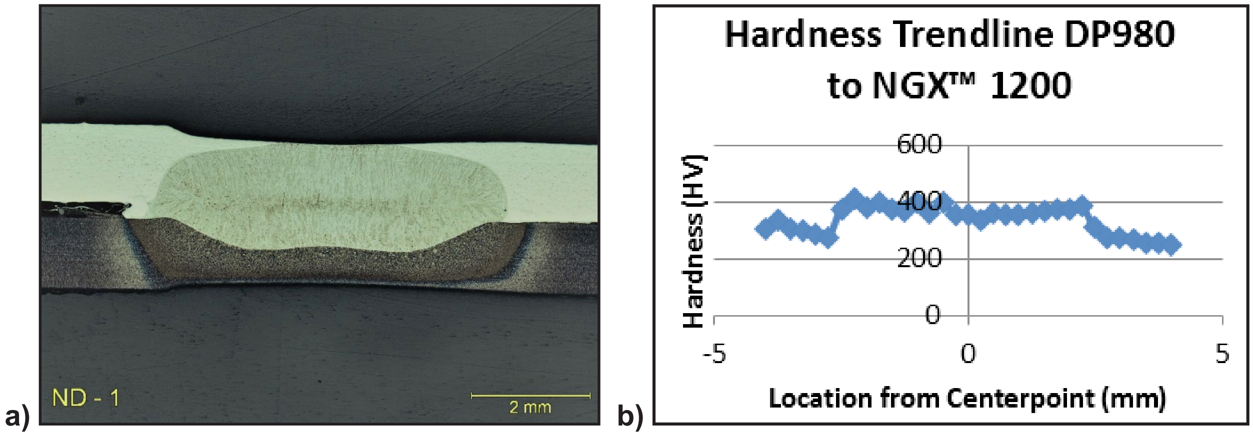

Figure 1. Dissimilar Weld Joint between DP 980 (L/S) and NXG™ 1200 (R/S)

Liquid Metal Embrittlement Risk Assessment

A reported risk associated with emerging high strength and even more so high manganese and Generation III high-strength steels is liquid metal embrittlement from zinc galvanized coatings.[1] Tests of NXG™ 1200 welded to galvanized steel show very shallow zinc penetration, such as is occasionally observed in standard steel resistance spot welds. Figure 2a shows no visible LME which was the bulk of the observations during the LME testing, and Figure 2b shows the deepest area of liquid metal embrittlement produced during an LME test. These cross sections show several interesting features of a NanoSteel NXG™ 1200 resistance spot weld. First, the LME is very shallow, less than 10% of the metal thickness. Second, the HAZ is extremely narrow. In fact, the LME only occurs in the very narrow region of grain growth in the NanoSteel weld. The grain size in the bulk of the weld and HAZ are finely sized. The observed LME is quite small in size when observed compared to GENIII steels discussed in other literature.

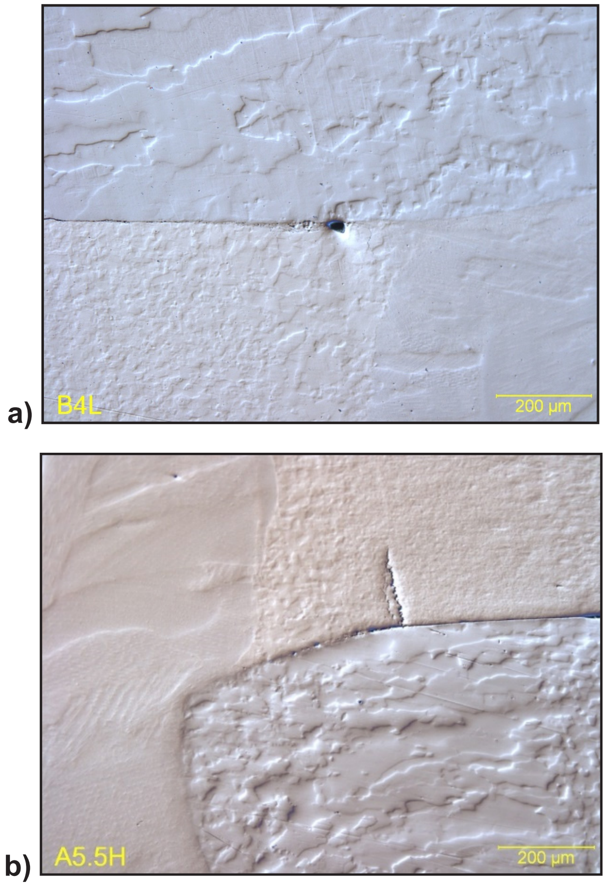

Figure 2. High Magnification of Fusion Boundary in LME Test of NXG™ 1200 Resistance Spot Weld Showing Typical Results in a) and Worst Case b)

[1] http://www.voestalpine.com/division_stahl/content/download/52624/655464/file/VAST-W17008A%20White%20Paper%20Sierlinger.pdf

Conclusion

Resistance spot welding of NXG™ 1200 is straightforward when compared to the other advanced high-strength steels emerging. No significant deleterious phases are observed in the resistance spot weld in self-to-self welds or when welded to other current automotive sheet metal materials. The reduction of welding process risk should aid in acceptance of the material to the automotive industry.

Changing Needs in Weldability Testing

Many current automotive steel qualification tests focus on welding the steel under consideration to itself. In today's modern automotive structures, mixed materials are welded together in order to optimize design. The ability of a new material to be welded to other materials should be assessed as part of standard weldability testing. Changing weldability testing to incorporate these tests may be more critical than testing the alloy's ability to weld to itself.

Dave Workman, Senior Engineer, specializes in using friction stir and resistance welding processes to join similar and dissimilar materials. He is experienced with resistance spot welding, projection welding, seam welding, flash welding, butt welding, resistance brazing, and drawn arc stud welding, having successfully worked with aluminum, steel, aerospace alloys, copper alloys, and railroad materials.