

B. Resistance Spot Welding Studies on Two Dual Phase Steels

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Introduction

Due to their excellent formability and better crash energy absorption compared to conventional low strength steels, several recently developed advanced high strength sheet steels (AHSS) have been specified for use in several body-in-white applications in automobile manufacturing. One of these new AHSS is dual phase steel. Because the resistance spot welding method is extensively used in the manufacture of automobile components, an examination was undertaken to study the resistance spot welding behavior of 590 MPa and 780 MPa dual phase steels. The weld tensile properties as well as weld lobes are presented to highlight the welding behavior of these two steels.

Procedure

Both the 590 MPa and 780 MPa steel coils came from heats of steel that were produced at the United States Steel Corporation Gary Works facility and coated subsequently at the PRO-TEC Coating Company of Lepsic, OH. Both the AHSS steel coils were 1.2 mm thick. The steels contained up to 0.15 weight percent carbon and were alloyed with elements, such as manganese, to achieve the desired strength level. Typical tensile properties of the steels are shown in Table 1. Hot-dipped galvanized (HDGA) steels were used in this examination. The nominal HDGA coating weights for the steels used were 45/45 g/m².

Table 1. Typical Tensile Properties of Steels Used

Grade	Yield Strength, MPa (ksi)	Ultimate Tensile Strength, MPa (ksi)	Total Elongation, percent
590	372 (54)	620 (90.0)	25
780	467 (68)	834 (121)	17

Weld lobes were determined per General Motors Welding Specification WS-5, *Weld Testing and Procedure*, to examine the resistance spot welding behavior of the two steels. The weld schedules used for various tests are shown in Table 2. These weld schedules incorporated no pulsed currents, and neither pre nor post weld tempering. All the weld tensile test samples were prepared using a Taylor Winfield alternating current pedestal-type welding machine. Static weld shear-tension and cross-tension tests were conducted as described in American Welding Society Specification D8.9M-2002. The welding current required to produce the maximum required weld sizes (or close to the electrode face diameter) without expulsion was determined separately for both steels.

Table 2. Weld Schedules Used in the Study

Electrode Material	RWMA Class II (Cu-Cr)
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Electrode Face Diameter, mm	6.0
Electrode Tip Geometry	Truncated Cone
Electrode Force, kN	4.3 kN (970 lbf) for tension test samples 6.6 (1500 lbf) for weld lobes
Squeeze Time, cycles	80
Weld Time, cycles	16, 22, and 28 for weld lobes 18 for making tensile test samples
Hold Time, Cycles	60 for weld lobes 10 for making tensile test samples
Pre-Heating	None
Post-Heating	None

Microhardness traverses were determined at room temperature using a Vicker's hardness tester. A force of 1000 g (9.8N) was used for the microhardness measurements. The hardness indentations were spaced 0.4 mm apart.

Results and Discussion

The weld lobes obtained for 590 MPa and 780 MPa steels are shown in Figure 1.

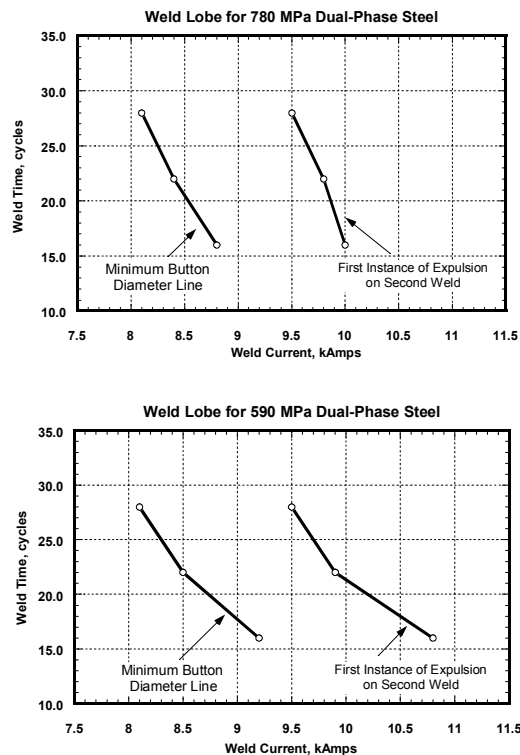


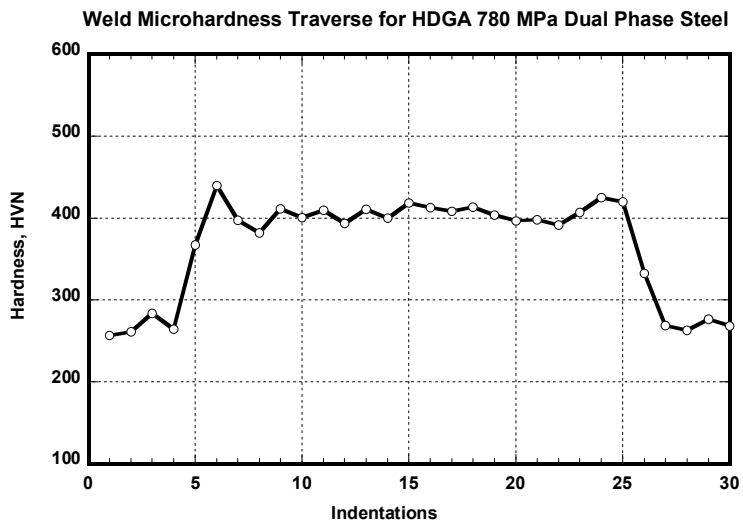
Figure 1. Weld lobes obtained for 590 MPa and 7680 MPa dual phase steels.

The weld lobes indicate the useful current range to obtain acceptable welds. Examination of the data in Figure 1 indicated that the width of the weld lobes for both steels was similar. This indicated that the welding behavior of both steels was similar. The width of the weld lobes indicated a large window of welding currents to achieve acceptable welds. This indicates that no equipment modifications from those currently used are necessary to successfully weld these two grades.

Table 3. Weld Static Shear-Tension and Cross-Tension Test Results

	Average Load to Failure, Newtons (lbf)	
	Shear-Tension Test	Cross-Tension Test
590 MPa	13522 (3040)	8274 (1860)
780 MPa	15986 (3594)	6970 (1567)

The data presented in Table 3 is based on average of five tests. Weld tension results presented in Table 3 indicated that, for the 780 MPa steel, the average load to failure in shear-tension tests increased by 2400 newtons compared to that of the 590 MPa steel. In shear-tension tests of high strength steels load to failure increases as the the base material strength increases. The average load to failure in cross-tension tests was higher for the 590 MPa steel compared to the 780 MPa steel. This difference is believed to be from the larger weld buttons obtained in the 590 MPa steel test coupons compared to those in the 780 MPa test coupons.



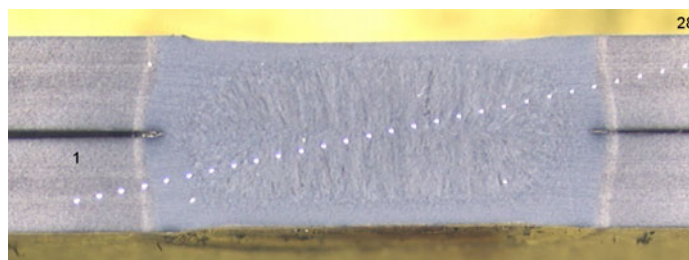


Figure 2. Weld microhardness traverses for 780 MPa dual phase steel and a cross sectional view of the weld showing hardness indentations.

Figure 2 shows an example of the microhardness traverse across a weld in 780 MPa steel. Examination of the weld hardness profile indicated that the hardness distribution across the weld was uniform. Microstructural observation of the weld in Figure 2 showed no imperfections in the welds.

Conclusions

At 590 MPa and 780 MPa strength levels, dual phase steel could be easily welded using simple welding parameters. The weld schedules used indicated that no equipment modifications from those currently employed are necessary to weld these two grades.

The weld lobes were similar between the two grades and indicated a large window of welding currents to achieve acceptable welds.

Acceptable welds with no imperfections were obtained for both steel grades.

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