

Special Issue of the 8th International Advances in Applied Physics and Materials Science Congress (APMAS 2018)

The Effect of Nugget Sizes on Tensile Peel Loading in Resistance Spot Welding of DP800 and TWIP950 Steel Sheets used in Automotive Industry

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This paper presents an experimental study on resistance spot welding of DP and TWIP steel sheets used in automotive industry. A timer and current controlled resistance spot welding machine having 120 kVA capacity and a pneumatic application mechanism with a single lever was used to prepare the specimens. Welding periods were chosen as 5, 10, 15, 20, 25 and 30 cycles (1 cycle = 0.02 s) and also welding currents were increased from 6.33 kA up to 15.7 kA in steps of 0.9 kA. The electrode force was kept constant at 4 kN. The prepared welding specimens were exposed to tensile-peel test and micro and macro-structures of specimens were investigated by means of an optical microscope and scanning electron microscope (SEM) in order to see the joinability of DP and TWIP steel sheets by resistance spot welding. Finally appropriate welding current and time were advised to the users.

DOI: [10.12693/APhysPolA.135.1097](https://doi.org/10.12693/APhysPolA.135.1097)

PACS/topics: RSW, DP800, dual phase steel, TWIP950, twinning induced plasticity steel

1. Introduction

Resistance spot welding (RSW) is commonly used joining technique in automotive industry due to its low cost and quick cycle time. RSW practice depends on several parameters such as the welding current, the welding cycle time, the electrode geometry, the electrode and steel materials, etc [1–4].

Twinning induced plasticity (TWIP) austenitic steels exhibit exceptional high ultimate strength and high ductility, which enables their use in the production of high performance structural parts for automotive industry and other applications [5].

Dual phase (DP) ferrite-martensite steels are multi-phase grades being widely employed in automotive industry. DP steels are frequently used in body structure applications requiring high energy absorption [6].

2. Experimental procedure

The studied materials were DP800 steel sheets having 1.2 mm thicknesses and TWIP950 steel sheets having 1.4 mm thickness. The chemical composition and basic mechanical properties of the base materials are shown in Tables I and II, respectively.

A timer and current controlled resistance spot welding machine having 120 kVA capacity and a pneumatic application mechanism with a single lever was used to

prepare the specimens. Welding was carried out by using water cooled conical Cu–Cr–Zr electrodes having a contact surface of 6 mm diameter.

TABLE I

Chemical composition [wt%] of DP800 and TWIP950 steel sheets.

C	Si	Mn	Al	Cr	Ti	W	V
DP800 steel							
0.147	0.45	1.93	0.31	0.256	0.016	0.135	0.039
TWIP950 steel							
0.654	0.039	17.605	1.712	0.007	0.06	0.129	0.004

TABLE II

Mechanical properties of DP800 and TWIP950 steel sheets.

Materials	DP800	TWIP950
Yield strength [MPa]	448	541
Tensile strength [MPa]	785	966
Total elongation [%]	16.8	56

The welding specimens were overlapped with 30 mm. Welding periods were chosen as 5, 10, 15, 20, 25 and 30 cycles (1 cycle = 0.02 s) and also welding currents were increased from 6.33 kA up to 15.7 kA in steps of 0.9 kA. Clamping and holding time (25 cycles) were kept constant.

All welded specimens were exposed to tensile-peel tests in a testing machine in laboratory conditions. Nugget widths (d_1), nugget heights (d_2) were measured and also nugget size ratios (d_2/d_1) were calculated by

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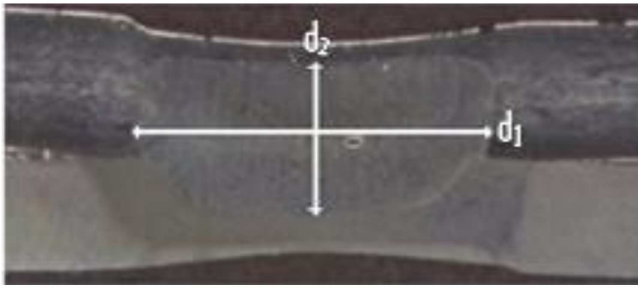


Fig. 1. Weld nugget geometry.

means of an optical microscope. Weld nugget geometry is shown in Fig. 1. The effect of welding current on nugget size was investigated by putting obtained results in related diagrams.

3. Results and discussion

In low welding current application, small weld nugget widths and similarly tensile-peel strength values were obtained due to low amount of heat to the welding zone and low elemental diffusion between the base metals. As a result of welding current and nugget width increments, the tensile-peel strength of welded samples rises up to 7–8 mm of nugget widths as shown in Fig. 2a. Tensile peel-strength of welded samples starts to decrease at nugget width above 8 mm. When the nugget height diagram was investigated maximum tensile-peel strength of welded samples was obtained at of 0.8–1 mm as shown in Fig. 2b. The maximum tensile-peel strength value was obtained at nugget size ratio of 0.13–0.16 as shown in Fig. 2c.

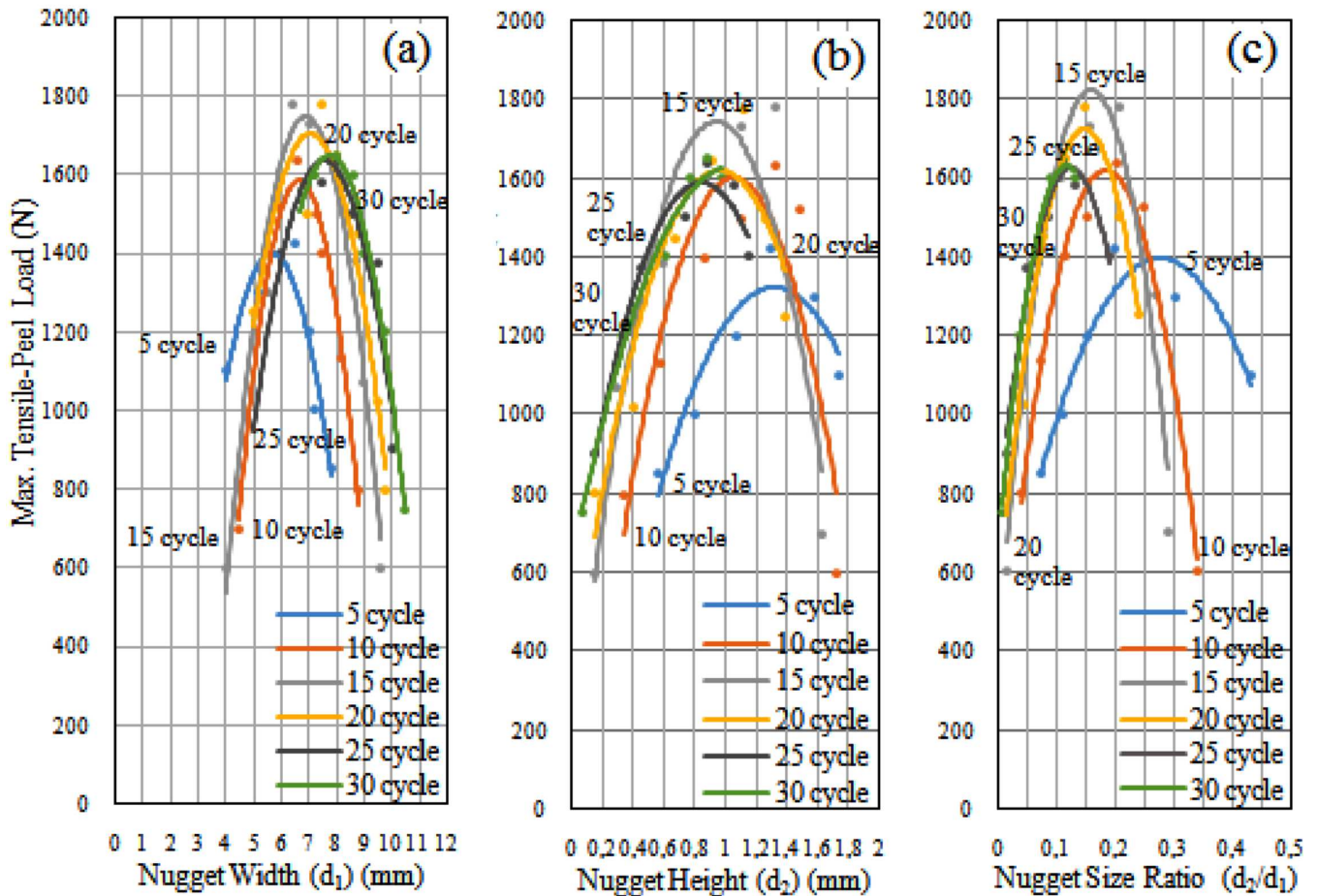


Fig. 2. The effect of nugget width (a), height (b) and size ratio (c) on tensile-peel load.

Microstructures and SEM image of interface sections are, respectively, shown in Fig. 3. DP base metal contains a combination of ferrite and martensite phase and TWIP base metal contains austenite phase. Application of electric current and pressure heats DP and TWIP steel sheets to the melting point (liquid state) of both. And a pool of molten metal that quickly cools and forms a nugget

zone alloy of the two materials with larger grain growth. In Figure 3a, microstructure of DP800 and nugget zone are shown together. In Figure 3b, microstructure of TWIP950 and nugget zone are shown together. Figure 3c shows the electron image SEM of DP800 and nugget zone microstructure. There is an interface layer between the base metal and nugget zone.

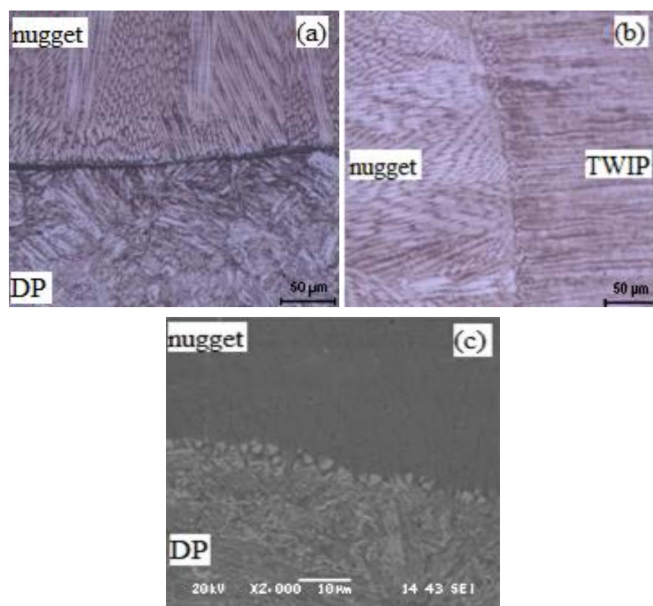


Fig. 3. Microstructure and SEM image of interface sections. (a) microstructure of DP800/nugget interface, (b) microstructure of nugget/TWIP950 interface, (c) SEM image of interface zone of DP800/nugget interface.

4. Conclusion

As a result of work performed at 4 kN electrode force, maximum tensile-peel strength is obtained at 8.17 kA welding current applied during 15 cycles. Since the depth of electrode indentation into material is not exceed the 30% of sheet thickness limit accepted for a good surface quality.

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