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Experimental Study of Tensile Test in Resistance Spot Welding Process

Abstract

Resistance spot welding (RSW) is a widely used joining process for fabricating sheet metal assemblies in automobile industry .In comparison with other welding processes the RSW is faster and easier for automation. This process involves electrical, thermal and mechanical interactions. Resistance spot welding primarily takes place by localized melting spot at the interface of the sheets followed by its quick solidification under sequential control of pressure water-cooled electrode and flow of required electric current for certain duration. In this work the tensile tests were studied, the results obtained show that the type material, the overlap length, the angle of the rolling direction and the thickness of the sheet have an influence in resistance spot welding process.

Keywords

Resistance spot welding(RSW) ; tensile tests; stress ;strain; DP450;TRIP700; HSLA350.

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1 INTRODUCTION

Spot welding or resistance spot welding (RSW) involves the joining of two or more pieces of sheet metal in localized areas or spots where melting and coalescence of a small volume of material occurs from heating caused by resistance to the flow of an electric current. This process is typically used to obtain a lap joint of sheet metal parts having a thickness of 3 mm or less. When the current is turned off this volume of molten metal cools down and solidifies beginning at its outer edges. The volume of metal from the work-pieces that have undergone heating, melting, fusion, and re-solidification is called the weld nugget.

The demand for lightweight bodies and high safety requirements has promoted the widespread use of advanced high-strength steels (AHSSs) in car body assembly. Owing to its combination of high strength and ductility, the dual-phase (DP) steel has become one of the most common used AHSSs in car body assembly. However, the major challenge of using AHSSs in the automotive industry is that they are prone to exhibit weld interfacial fracture when resistance spot welding (RSW) is used Marya and Gayden (2005). Moreover, the development of epoxy adhesive has contributed to an increasingly important role of adhesive bonding in mechanical fastening due to its high static and fatigue strength, weight reduction, etc. However, the adhesive-bonded specimens are often easily damaged in certain environmental conditions such as high humidity as Kinloch et al. (2007) and low temperature accordingly Miyoshi (1991). Therefore, the weld-bonded DP steel using epoxy adhesive which is a combination of RSW and adhesive bonding has been the subject of particular attention by Miyoshi (1995) and Darwish (2003).

Resistance spot welding is usually used in the fabrication of sheet metal assemblies. It can be used to weld materials such as low carbon steel, nickel, aluminum, titanium, copper alloy, stainless steel and High-strength low alloy steel. The resistance Spot welding process is most applied in the manufacturing industrial fields and maintenance (car industry, aerospace and nuclear sectors, electronic and electric industries). Many published results on the mechanical behavior of spot welds have been focused on the correlation of RSW process parameters, Murat and Ahmet (2004). Have studied on the resistance spot weldability of galvanized interstitial free steel sheets with austenitic stainless steel sheets. In micro hardness measurements, the maximum hardness values were found in the middle of the weld nugget. Emin et al. (2004) had based their research on the selection of optimal welding conditions and developed new grade steels for automotive applications. The study based on impact tensile testing to spot welded sheets, the effect of nucleus size on mechanical properties in electrical resistance spot welding of chromide micro alloyed steel sheets was investigated by Aslanlar (2006).

Bouyousfi et al. (2007) have studied the effect of process parameters (arc intensity, welding duration and applied load) on the mechanical characteristics of the weld joint of austenitic 304L stainless steel. The results showed that the applied load seems to be the control factor of the mechanical characteristics of weld joint compared to the welding duration and the current intensity. Nizamettin (2007) has focused his study on the influence of welding parameters on the joint strength of resistance spot-welded titanium sheets. The reported results of strength tests carried out on single spot welds by Yuh J (2003) and Radaj and Zhang (1995). Are insufficient to predict the behavior of the thin-walled beams under axial compression. In this work the tensile tests were studied with different kinds of stainless steels: the dual-phase (DP450), the tri-phase (TRIP700) and the High-Strength Low-Alloy

steel (HSLA350). This aims to show an influence of angle of the rolling direction, the overlap length, type material and thickness of the sheet in resistance spot welding process.

2 EXPERIMENTAL METHOD AND PROCEDURE

Spot welding involves the joining of two or more pieces of sheet metal in localized areas where melting and coalescence of a small volume of material occurs from heating caused by resistance to the passage of an electric current. This process is typically used obtain a lap joint of sheet metal parts. In this work, commercial DP450, TRIP700 and HSLA350 stainless steels were used. The sheet materials were cut into 140 mm X 40 mm. The dimensions and the specimens were joined as lap joints for the three materials according to the configuration shown in figure 1, using spot welding machine, type DALEX. The initial microstructures of the base metals are shown in figures 2, 3 and 4. Their chemical compositions are grouped in table 1. Before starting the welding process, it is important to make sure that the setting on spot welding machine has two important dials: the first for the welding current and the second is for the welding duration. Another important step before starting the welding process is to run on the water supply for the electrodes; this is to cool the electrodes during the welding process.

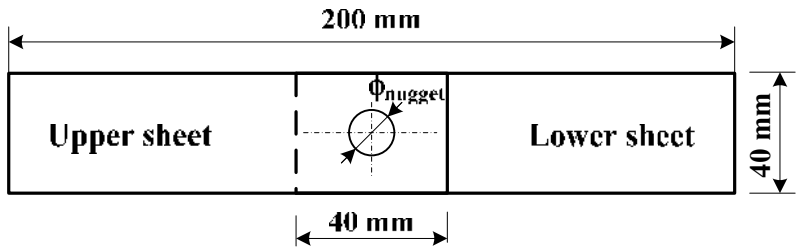


Figure 1: Dimensions of resistance spot-weld specimen (mm).

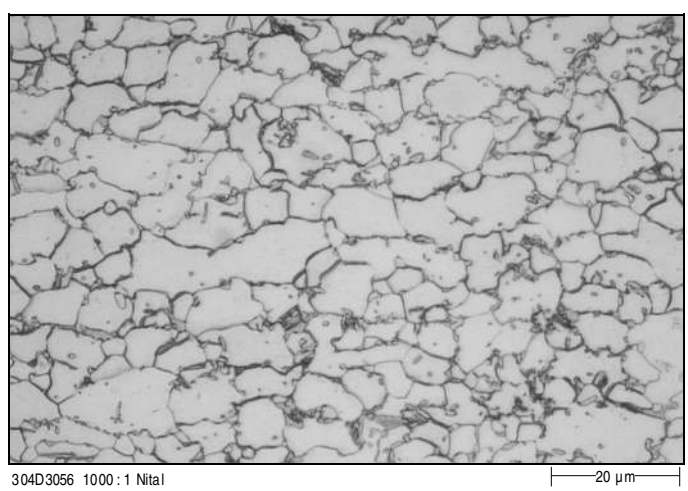


Figure 2: Initial microstructure of DP450-1,4mm.

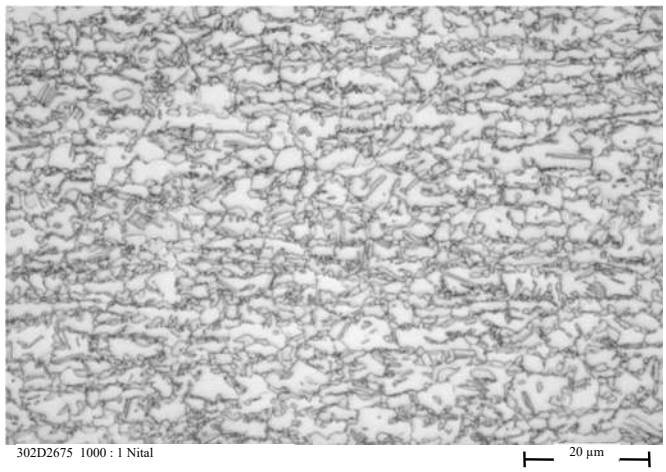


Figure 3: Initial microstructure of TRIP700-1,4mm.

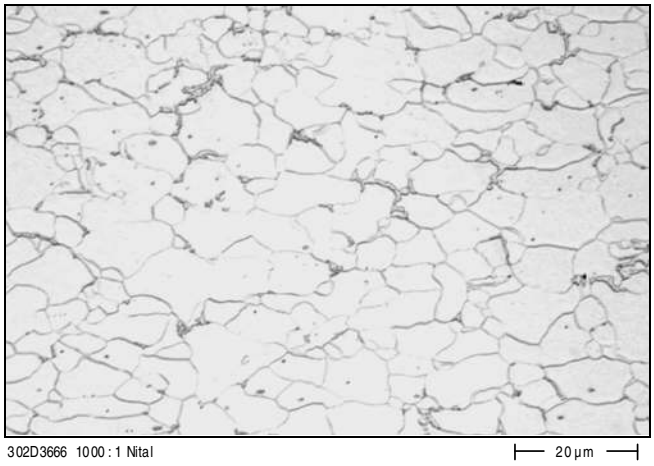


Figure 4: Initial microstructure of HSLA350-1,4mm.

Their chemical compositions are given in Table 1.

Chemical compositions [10-3%]														
	C	Mn	Si	P	S	Al	N	Cu	Cr	Ni	Mo	Ti	Nb	V
HSLA350-1.5mm	77	515	5	8	7	44	3.5	7	12	20	2	1	23	2
DP450-1.4mm	56	1270	140	9	2.5	25	7	19	495	21	4	<2	<2	6
TRIP700-1.4mm	220	1640	46	12	1	1510	2.8	20	30	24	2.6	6	<0.5	-

Table 1: The chemical composition of the three stainless steels with different thicknesses.

In the tensile tests the **Instron 8800** machine was used. Figure 5 shows the failure mode in tensile test of TRIP700 resistance spot welds.

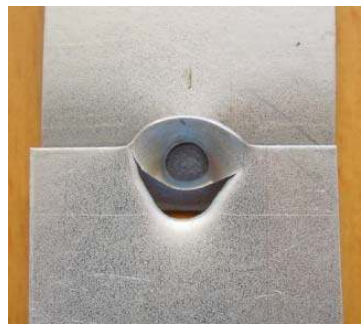


Figure 5: Failure mode in tensile test of TRIP700 resistance spot weld.

3 RESULTS AND DISCUSSION

Figures 6 shows the stress-strain curves at 0 ° and 90 ° of all plates of the high strength steels used in this work. The comparison between the two graphs shows that the behavior of the steel sheets does not vary significantly with the orientation of extraction of tensile specimens.

Furthermore, the graphs show clearly the difference in the tensile strength of the three grades of steel: the TRIP steel sheets have the highest yield, strength and tensile elongation, compared to the HSLA steel which has lower values for these properties.

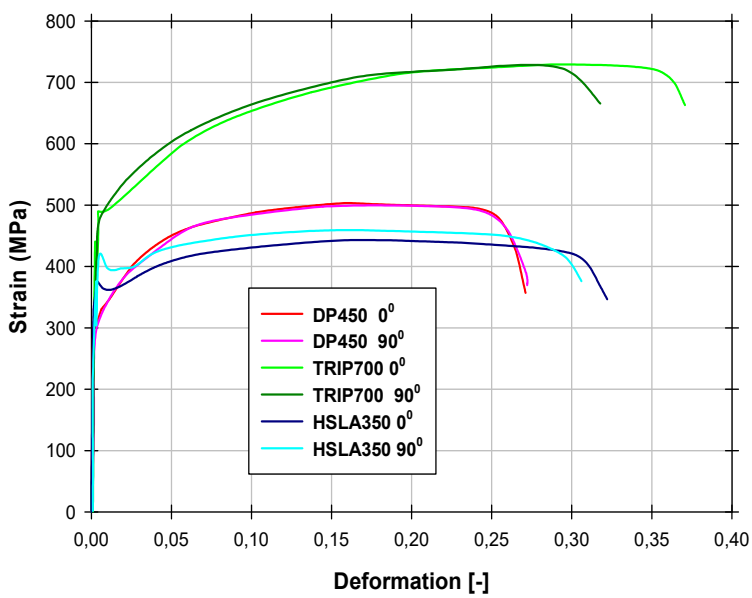


Figure 6: Stress – strain curve at 0 ° and at 90^0 with respect to the rolling direction.

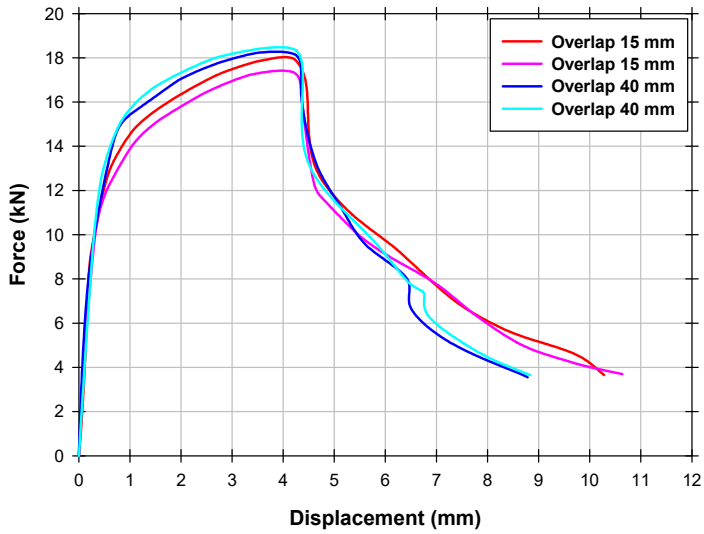


Figure 7: Influence of the length of overlap shear behavior of welded joints for steel points DP450-1,4mm.

Figure 7 shows the influence of the length of overlap on the shear behavior of welded joints for DP450-1,4mm steel, it is clear that the length of overlap has a weak effect on the shear behavior in the spot-weld as is mentioned in the following Table 2.

DP450	Peak load [kN]	Maximum equivalent load [kN] (width 50 mm, thickness 1 mm)
overlap 15 mm	17,77±0,23	12,70±0,17
overlap 40 mm	18,44±0,11	13,17±0,08

Table 2: Results means shear resistance spot welded joints DP450-1,4mm steel with different overlap length.

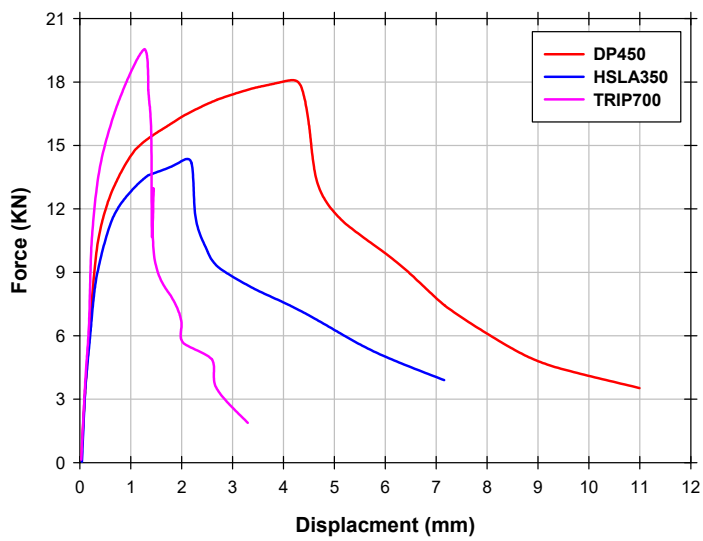


Figure 8: Influence of type material shear behavior of welded joints.

The shear behavior of spot welded joints is shown in figure 8 for different material types. The TRIP700 has the highest peak load of 19.32 kN with the maximum equivalent load equal to 13.80 kN. The following Table 3 shows the results for all materials.

Peak load[kN]		Maximum equivalent load [kN](width 50 mm, thickness 1 mm)	
HSLA-1,5mm	14,30±0,09	HSLA-1,5mm	9,53±0,06
DP450-1,4mm	17,77±0,23	DP450-1,4mm	12,70±0,17
TRIP700-1,4mm	19,32±0,18	TRIP700-1,4mm	13,80±0,13

Table 3: Shear behavior of spot-welded joints.

In figure 9 the Stress – strain curve of TRIP700 welding with deferent thickness sheet was carried out so it can be seen that the thickness has an influence in resistance spot welding.

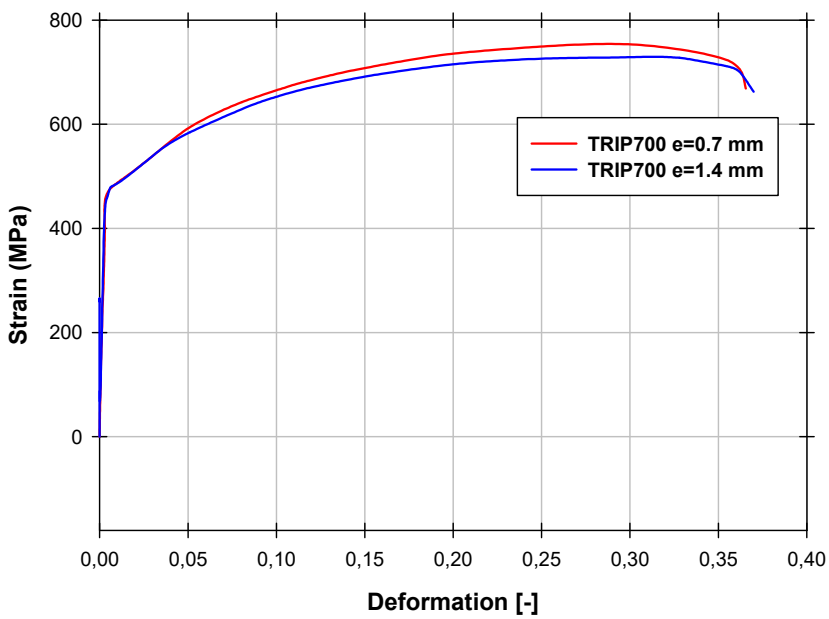


Figure 9: Stress – strain curve of TRIP700 welding with deferent thickness sheet.

4 CONCLUSION

The mechanical features are important aspects of resistance spot welding process since they have great influences on the properties of the welded joint and the quality of welded structure such as the tensile test. In this paper, an experimental study of tensile test in resistance spot welding process was conducted to show the influence of angle of the rolling direction, the overlap length, type material and thickness of the sheet in resistance spot welding process. From the results obtained, it can be said that the stainless steel trip700 has a high resistance than DP450 and HSLA350 in spot welding.

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