

Experimental Study of Spot Weld Parameters in Resistance Spot Welding Process

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Resistance spot welding is a comparatively clean and efficient welding process that is widely used in sheet metal joining. This process involves electrical, thermal and mechanical interactions. Resistance spot welding primarily takes place by localized melting at the interface of the sheets followed by its quick solidification under sequential control of water cooled electrode pressure and flow of required electric current for certain duration. In this experimental work the tensile tests and the spot weld diameter were studied. The objectives of this analysis is to understand the physics of the process and to show the influence of the electrical current, weld time and the type material in resistance spot welding process.

Keywords: resistance spot welding, tensile tests, spot weld diameter, peak load.

1. Introduction

Resistance welding is the most commonly used method for joining steel sheets. An electro-conductive contact surface is created between the work pieces by pressing them together. Watercooled electrodes made of alloyed copper are used in resistance welding. Electrodes convey a pressing force to the joint and direct the welding current to the joint in an appropriate manner. After welding, the electrodes rapidly cool down the welded joint. Resistance spot welding is a complex process in which

coupled interactions exist between electrical, thermal, mechanical, metallurgical phenomena and even surface behaviors. Austenitic stainless steel constitutes the largest stainless family in terms of alloy type and usage [1]. The standard austenitic stainless steel weld metals contain two phases (austenite + ferrite) similar to an “as cast” microstructure [2]. The austenitic stainless steels are used for a very broad range of applications when an excellent combination of strength and corrosion resistance in aqueous solutions at ambient temperature is required [3]. The austenitic stainless steels are easily weldable [4]. The type 304L is used where extensive welding is to occur; it has lower levels of carbon (0.03% max. versus 0.08% for Type 304) to reduce the tendency toward carbide precipitation at the grain boundaries during welding [5]. However, when an austenitic stainless steel is welded, its heat affected zone (HAZ) is often sensitized by formation of intergranular Cr-rich carbides, which deteriorates the corrosion properties of the welded joint [6]. Delta ferrite has a beneficial effect in reducing or preventing microfissuring in austenitic stainless steel weldments [7]. Resistance spot welding is an inexpensive and effective way to join metal sheets. This process is ideally suited to production methods. Resistance spot welding (RSW) is used for the fabrication of sheet metal assemblies. The process is used extensively for joining low carbon steel components. High strength low-alloy steel, stainless steel, nickel, aluminum, titanium and copper alloys are also spot welded commercially [8]. After spot welding, important changes occur in mechanical and metallurgical properties of the spot welded areas and heat affected zones [9]. The investigation of these changes is very important for the safety strength of the welded joints. This work studies the tensile tests and the weld nugget diameter with two kinds of stainless steel (AISI 304 and AISI 430) to show the influence of sheet thickness, type material, electrical current and the weld time in resistance spot welding process.

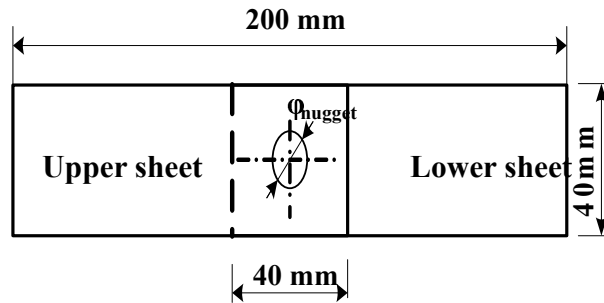


Figure 1 Dimensions of resistance spot-weld specimen (mm)

2. Experimental methods and materials

Resistance spot welding is a process of joining two or more metal parts by fusion at discrete spots at the interface of a workpiece. Resistance to current flow through the metal workpieces generates heat. Temperature rises at interface of the workpiece; when the melting point of the metal is reached, the metal will begin to fuse and

a nugget begins to form. The current is then switched off and the nugget is cooled down slowly to solidify under pressure. In this work, commercial AISI 304 and AISI 430 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 THI 50 Digit. The initial microstructures of the base metals are shown in Figures 2 and 3. 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.

Table 1 The chemical composition of AISI 304 and AISI430

Chemical compositions	AISI 304	AISI 430
C	0.07	0.08
Mn	1.75	1
Si	0.034	1
Ni	8.23	0.5
Cr	17.71	17
P	0.021	25
S	0.009	0.03

In the tensile tests the Instron 5582 machine was used. The Microstructure of different zone in resistance spot weld is shown in Figure 4. Figure 5 shows the failure mode in tensile test of AISI 430 resistance spot welding.

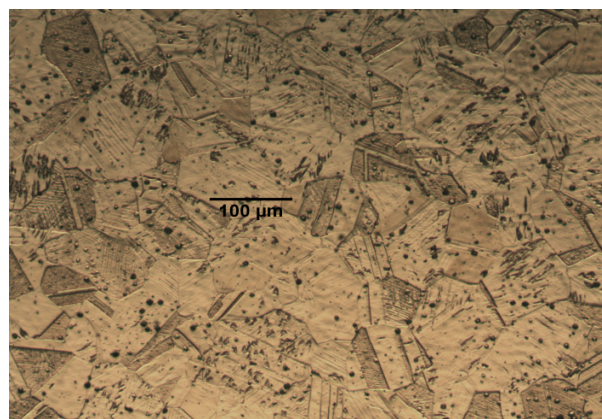


Figure 2 Initial microstructure of AISI 304

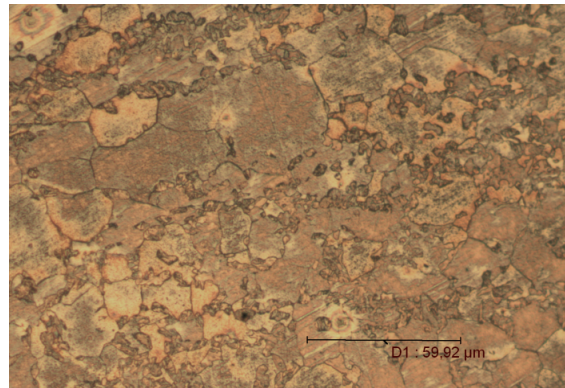


Figure 3 Initial microstructure of AISI 430

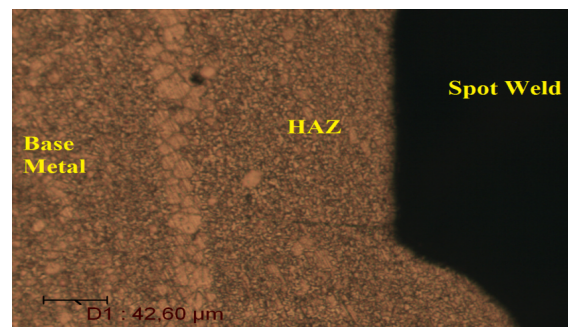


Figure 4 Microstructure of different zone in resistance spot welding



Figure 5 Failure mode in tensile test of AISI 304 resistance spot weld

3. Results and discussion

3.1. The tensile tests

In order to determine the influence of the thickness sheet on resistance of the pot weld, the Figure 6 indicates the influence of the sheet thickness on tensile test of welded joint using AISI 304 stainless steel, the graph shows clearly the difference of the peak load in the two thicknesses ($e = 1.5$ mm has the highest peak load).

The tensile test of spot welded joints is shown in Figure 7 for different weld time. It can be seen that the weld time has an influence on resistance spot welding.

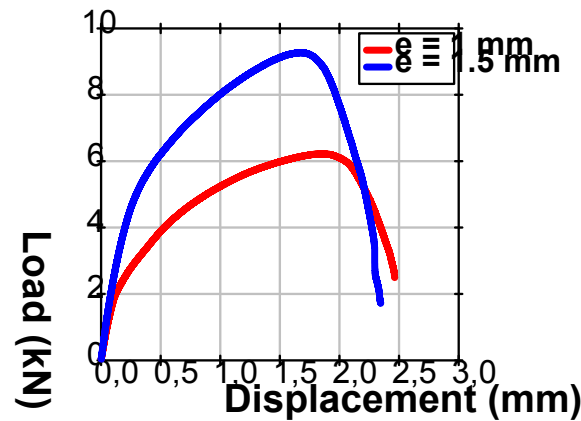


Figure 6 Influence of the sheet thickness on tensile test of welded joint: AISI 304, $I = 6$ kA, $t = 0.6$ s

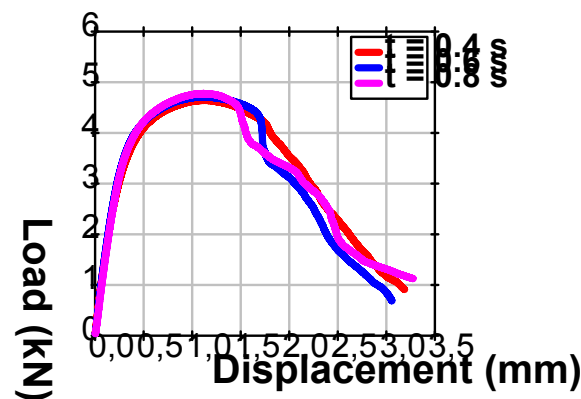


Figure 7 Influence of the weld time on tensile test of welded joint: AISI 430, $I = 8$ kA, $e = 0.8$ mm

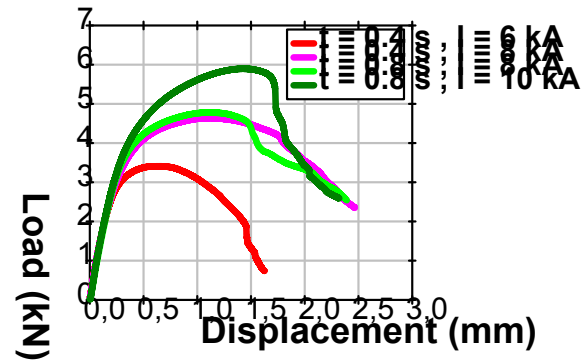


Figure 8 Influence of the electrical current on tensile test of welded joint: AISI 430, $e = 0.8$ mm

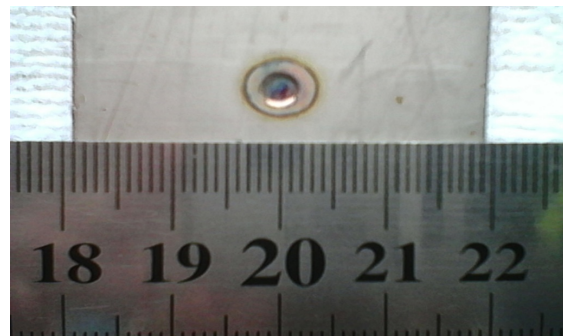


Figure 9 Measure of spot weld diameter

Table 2 Spot weld diameter with different electrical current

AISI 430			
Current intensity (kA)	5.5	6.5	7.5
Φ spot weld diameter (mm)	5	5.5	6
AISI 304			
Current intensity (kA)	5	6	6.5
Φ spot weld diameter (mm)	4	4.75	5.5

3.2. Spot weld diameter

To show the influence of the electrical current on spot weld diameter, we measured the spot weld diameter with different electrical current as it is indicated in Figure 9.

Table 3 Spot weld diameter with different weld time, $I = 6 \text{ kA}$

AISI 430			
Weld time (s)	0.4	0.6	0.8
Φ spot weld diameter (mm)	4.5	5	6
AISI 304			
Weld time (s)	0.4	0.6	0.8
Φ spot weld diameter (mm)	4.75	5.25	5.5

The Table 2 bellow explains that the electrical current has an effect on the spot weld formation.

In the Table 3, the spot weld diameter was measured with different weld time using AISI 304 and AISI 430 stainless steel. It is clear that the spot weld diameter increase with the welding time.

4. Conclusions

Resistance spot welding is widely used joining process for fabricating sheet metal assemblies in automobile industry. In comparison with other welding processes, RSW is fast and easy for automation. This process involves electrical, thermal and mechanical interactions. In these experimental studies the tensile tests and the spot welding diameters were carried out to show the influence of thickness sheet, type material, and electrical current and welding time in resistance spot welding process. From the results obtained, these parameters have an influence in resistance spot welding process.

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