

Resistance Spot Welding Parameters Optimal Selection for Automotive Steel Plate

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To cite this article:

Tang Ke, Liang Cui, Zhou Ping. Resistance Spot Welding Parameters Optimal Selection for Automotive Steel Plate. *International Journal of Systems Engineering*. Vol. 2, No. 1, 2018, pp. 36-41. doi: 10.11648/j.ijse.20180201.18

Received: June 26, 2018; **Accepted:** July 19, 2018; **Published:** August 18, 2018

Abstract: In welding workshop, multi plate lapping is used to resistance welding usually, but so many uncertainty factors are there in welding process. In order to use less test times to meet production requirements and solve the welding nugget problem of multilayered panel lap, the optimizing welding parameter for 3 layer of low carbon steel plate with thickness of 0.8 mm + 1.4 mm + 1.8 mm was found in this paper. Experimental results show that: the welding current 9.6/8.8/11.1 KA, welding time 5/19/5 CY, electrode pressure 3 kn is suitable for 3 layer of low carbon steel plate with thickness of 0.8 mm + 1.4 mm + 1.8 mm, multiple-pulse welding parameter is appropriate for multilayered panel lap, and diameter of nugget on each layer can achieve 6mm.

Keywords: Resistance Spot Welding, Welding Parameters, Nugget Size, Welding Quality

1. Introduction

Resistance spot welding is the most common connection method in the automobile manufacturing industry. [1]. There are more than 5,000 solder joints in the mini-car body such as the body floor, roof, front body, etc. [2-7], different areas bear the energy absorption in the event of a collision, connection, support and other functions. [8-9]. The actual application needs to connect different thickness, different material of steel plate for welding. [10-13]. Currently, two-layer or three-layer laps with different strengths and thicknesses have occurred in the same station while the resistance spot welding process parameters are difficult to apply to. [14-15].

This article takes the 1st station of the front body area in Wuling Hongguang S' production line (this station welds the left front beam welded part and the front plate welding assembly) as the research object, which provides new ideas and methods for different overlapping resistance spot welding parameters selection of Wuling Hongguang S.

shown in Figure 1.



2. Materials and Methods

Taking Obara integrated resistance spot welding machine (Model: ST21, rated power 180KVA), supporting X-type manual welding gun (Model: UXH-C9625) for welding, as



Figure 1. Test with resistance welding machine and hand gun.

The front left girder and dash panel parts are all Baosteel BLD low-carbon steel plates and table 1 shows the chemical composition of the test steel plate. A total of 11 welding spots are lapped between the front girder and the dash panel, among them, 10 lapping pads for two plates, 0.8 mm thick and 1.2 mm thick, and three welding lapping plates with a plate thickness of 0.8 mm+1.4 mm+1.8mm. As there are two-layer

plates and three-layer plates, test is processed as follows: Firstly, taking the same plate and thickness to simulate three-layer plate overlap, choosing different welding parameters to test on three-layer plates in order to obtain welding parameters with different thickness and further define the process parameters that meet the technical requirements. Then verify the left front girder and the dash panel connection area to obtain the final process parameters.

Table 1. The chemical composition of the test plate.

brand	Analysis of chemical composition (melting)% (mass fraction)					
	C	Mn	P	S	Alt	Ti
BLCa	≤0.10	≤0.05	≤0.035	≤0.025	≥0.015	-
BLDa	≤0.08	≤0.45	≤0.030	≤0.025	≥0.015	-
BUSD	≤0.0010	≤0.45	≤0.025	≤0.020	≥0.015	-
BUFD	≤0.008	≤0.40	≤0.020	≤0.020	≥0.015	-
BSUFD	≤0.006	≤0.30	≤0.020	≤0.020	≥0.015	-

A. Allows adding Nb or Ti

B. Allows Nb to replace part of Ti, with total content of Nb and Ti is not greater than 0.20%

According to the leading plate thickness of the overlapping parts, refer to the "Suggested Value of SAW-GM Wuling Resistance Spot Welding Parameters" to select the resistance spot welding process parameters for the test. Table 2 shows the initial process parameters for resistance spot welding.

Table 2. The initial process parameters of resistance spot welding.

Preloading time /ms	Warm up time /ms	Welding current /KA	pulse	Welding time /CY	Electrode pressure /KN	Hold time /ms
50	50	8.5	1	9	3	120

3. Experimental Results and Discussion

3.1. The Influence of the Initial Welding Process Parameters on Welding

Three test pieces (0.8mm + 1.4mm + 1.8mm) with the same plate, thickness, and process were used. According to the welding process parameters in Table 2, the welding process was tested by selecting the current 8.5KA, electrode pressure 3KN, and welding time 9CY. The heat affected zone size of the solder joint was measured with a vernier caliper to be

8.59mm, as shown in Figure 2 (a). After the welded test piece was torn, there was a welding nugget (size 4.86mm) at the overlap of the 0.8mm+1.4mm plate, as shown in Figure 2 (b); but the 1.4mm +1.8mm plate lap joints did not form a nugget, tearing the solder joints after the brittle fracture surface was in a particle state, as shown in Figure 2 (c);

The test results show that the initial welding process parameters are not applicable to the actual lap state of the site, and the welding process parameters need to be adjusted one by one so that the welding of the three-layer plate meets the requirements of the welding nugget.

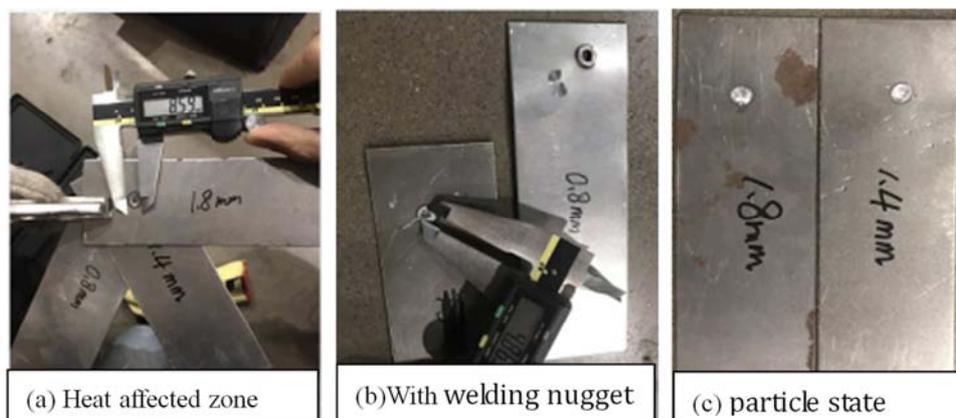


Figure 2. Nugget size of the solder joint using the initial welding process parameters.

3.2. Left Front Girder Welding Test and the Dash Panel Connection Area

The main factors influencing the nugget size of the solder joints of the test piece are welding current (KA), welding time (CY), electrode pressure (KN) and pulse, and other parameters remain unchanged. The electrode of this test adopts a spherical electrode cap and the dimension of the end face is $\phi 7\text{mm}$, and the process parameters are tested in a one-by-one comparison. The welding process parameters are shown in Table 3.

Table 3. Test with welding process parameters.

No.	Welding process parameters			
	Welding current /KA	Welding time /CY	Electrode pressure /KN	pulse
Original Data	8.5	9	3.0	1
Experiment 2	10.0	9	3.0	1
Experiment 3	10.0	14	3.0	1
Experiment 4	7.8/10.0	7/14	3.0	2
Experiment 5	7.8/10.0	7/14	3.8	2
Experiment 6	8.8/11.1/9.6	5/19/5	3.0	3

3.2.1. Experiment 2

While maintaining the welding time and electrode pressure constant, increase the welding current to 10.0 kA, Table 3. After tearing the welded test piece, there is a welding nugget at the lap joint of the 0.8mm+1.4mm plate. The size of the nugget is $\phi 5.69\text{mm}$, as shown in Figure 3 (a); but the 1.4mm+1.8mm plate joints did not form a nugget, tearing the solder joints after the brittle fracture surface was in a particle state, as shown in Figure 3 (b).

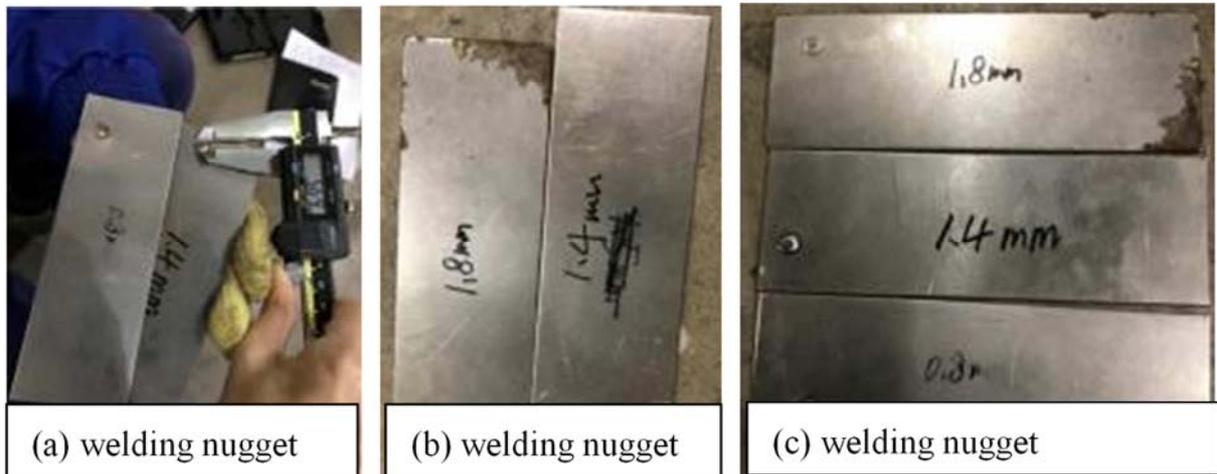


Figure 3. Nugget size of test 2.

3.2.2. Experiment 3

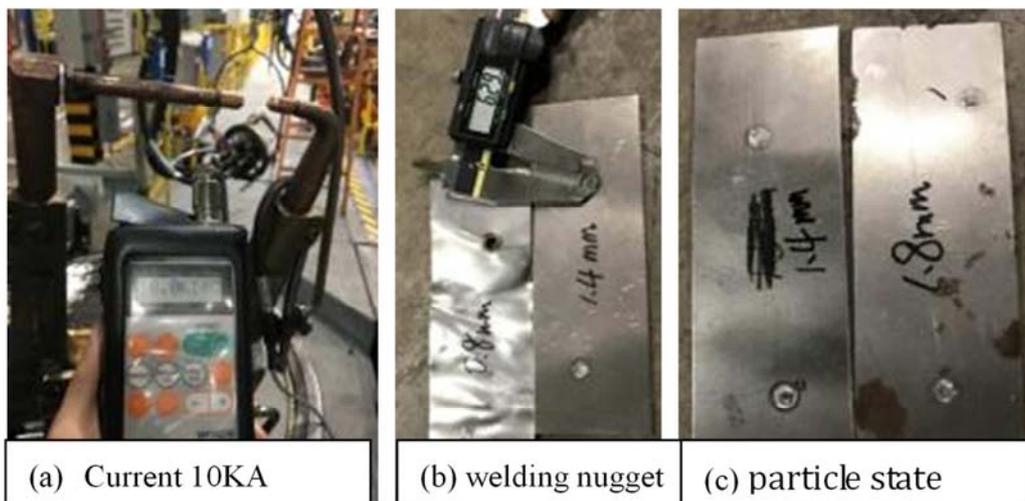


Figure 4. Nugget size of test 3.

The welding current was maintained at 10.0 kA, the welding time was increased to 14 cy, and the electrode pressure was maintained at 3.0 kN, Table 3. After the welding test piece was torn, there was a welding nugget at the overlap of the 0.8mm+1.4mm plate, but the nugget still did not form at the overlap of the 1.4mm+1.8mm plate, and the brittle fracture of the welding spot showed the particle state, as shown in the figure 4 (c) shows. Because the thickness of the three-layer plate is quite different, and the welding parameter nugget that meets the standard cannot be obtained by gradually increasing the single item of welding parameters, therefore, we have considered the selection of two welding pulses to increase the preheat welding before welding.

3.2.3. Experiment 4

Based on the results of the first three tests, we selected two pulses for testing. The first pulse: the welding current 7.8KA,

the welding time 7cy; the second pulse: the welding current 10.0KA, the welding time 14cy, the electrode pressure remains unchanged at 3.0KN, Table 3. After welding is completed, the heat affected zone of the solder joint becomes significantly larger, and the diameter is $\phi 9.6\text{mm}$, as shown in Figure 5 (a); after the welded test specimen is torn, there is a welding nugget at the overlap of the 0.8mm+1.4mm plate. The size of the nugget is $\phi 6.05\text{mm}$, as shown in Figure 5 (b); no nugget is formed at the overlap of the 1.4mm+1.8mm plate, and the brittle fracture of the solder joint indicates the particle state, but the shear stress is significantly greater than that of the single pulse. The parameters of the plate solder joints are large, as shown in Figure 5 (c). In general, this process parameter does not meet the specified nugget size requirements.

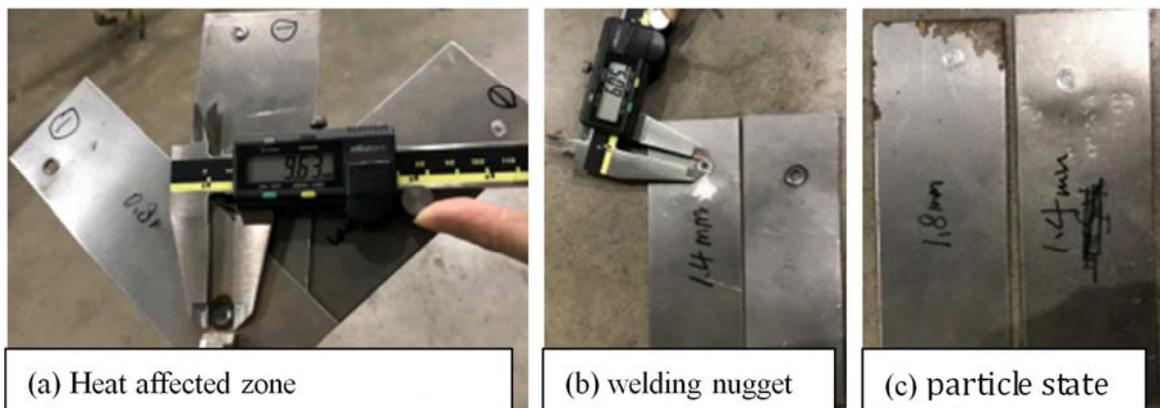


Figure 5. Nugget size of test 4.

3.2.4. Experiment 5

Based on the test 4, we used the parameters of the electrode pressure to 3.8 KN to verify the welding test piece under the condition that the welding current and welding time remain unchanged. The heat affected zone size of the solder joint is $\phi 10.75\text{mm}$ up to the standard upper limit, as shown in Figure 6 (a); after tearing the solder joint, there is a nugget at the

overlap of the 0.8mm+1.4mm plate and increases to $\phi 6.13\text{mm}$, as shown in Figure 5 (b); but there is still no obvious nugget formed at the overlap of the 1.4mm+1.8mm plate, as shown in Figure 5 (b); if the welding current, welding time or electrode pressure is separately increased, It is difficult to produce obvious results, and there is a risk of overheating in the heat-affected zone of the solder joint.



Figure 6. Nugget size and of test 5.

3.2.5. Experiment 6

On the basis of test 5, taking into account the number of welds in this station and the requirements for production tempo, we chose the soft specifications commonly used in welding parameters, increased it to 3-pulse welding parameters, and increased the preheating process and main The welding nugget holding process and welding parameters are shown in Table 3. The first pulse: the welding current 8.8KA, the welding time 5cy; the second pulse: the welding current 11.1KA, the welding time 19cy; the third pulse: the welding current 9.6KA, the welding time 5cy; the electrode pressure is maintained at 3.0KN. After tearing the solder joints,

welding nuggets existed on the 0.8mm+1.4mm plate, and the measured nugget size was $\phi 6.19\text{mm}$, as shown in Figure 7 (a); there was obvious welding at the overlap of the 1.4mm+1.8mm plate. The nugget, measured nugget size is $\phi 6.82\text{mm}$, as shown in Figure 7 (b); and there are obvious nuggets on both sides of the middle side plate (1.4mm thickness), both sides of the plate (0.8mm and 1.8mm Thickness) Holes with significant tearing of solder joints, as shown in Figure 7 (c). Using the welding parameters of test 6, the quality of the solder nuggets of the solder joints was acceptable.

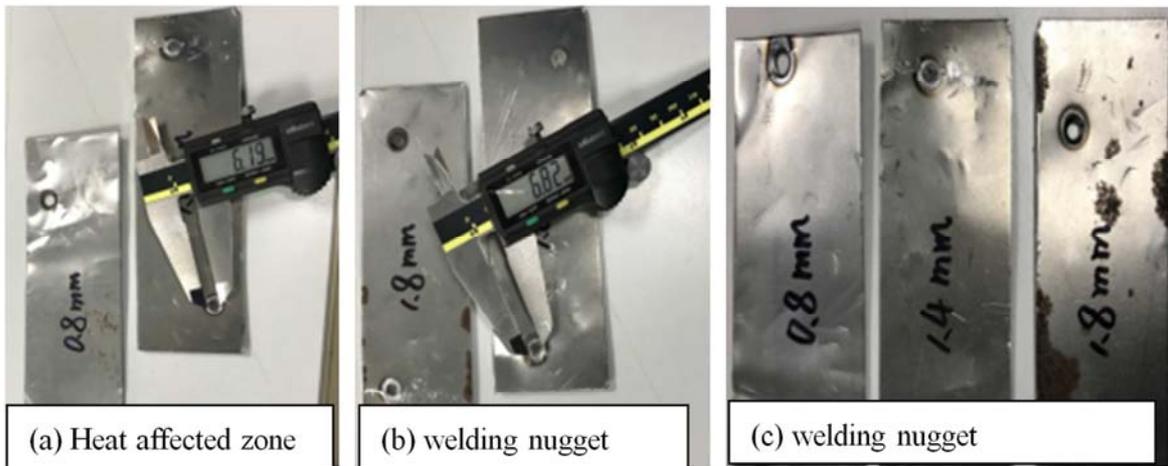


Figure 7. Nugget size and of test 6.

The actual working conditions of all parts overlap are more complex than that of the welding test piece. The data of the test 6 that passed the test is used to carry out the welding experiment on the manufacturing vehicle, and the hammer and chisel are used at the three-layer welding point (0.8mm+1.4mm+1.8mm) for the non-destructive test, lift the chisel 30° up and down, no welding is found in the solder joints, and the surface of the sheet metal was free from burrs and cracks. The quality of the non-defective solder joints of the manufacturing vehicle was acceptable, as shown in Figure 8.

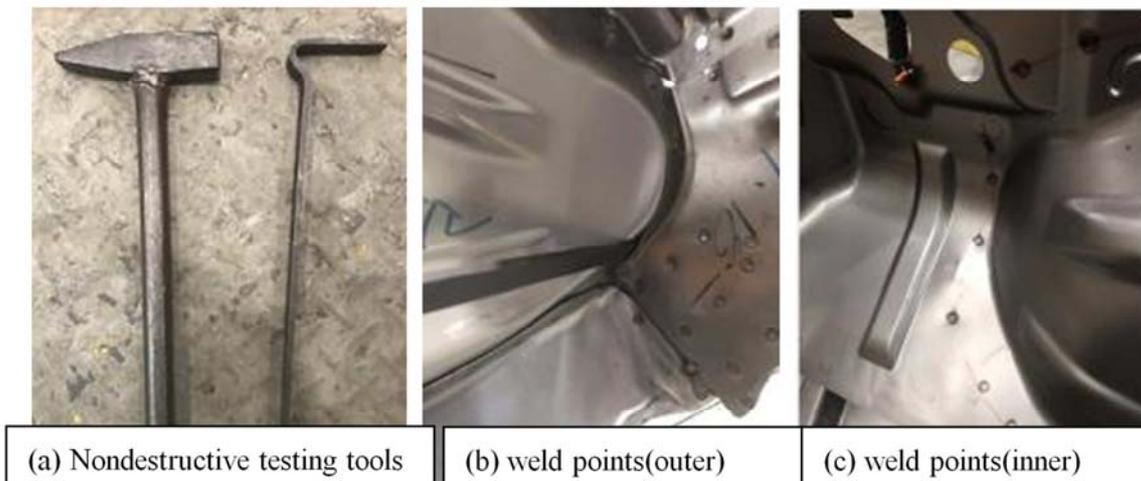


Figure 8. Actual non-destructive solder joint quality.

According to the quality requirements of resistance spot welding of SAIC-GM-Wuling, it is necessary to conduct full-destructive testing on the body joints on a regular basis. The joints in the front body area of this model were subjected

to a full-destructive test. There were solder nuggets on both sides of the welded joints, cracks appeared on both sides of the sheet, and the quality of the solder joints was acceptable, as shown in Figure 9.



Figure 9. Full-destructive testing.

4. Conclusion

Obtained the resistance spot weld nugget dimensions with pulses of 1, 2 and 3, taking into account comprehensively, 3 pulse welding parameters, welding current 8.8/11.1/9.6KA, welding time 5/19/5CY, electrode pressure 3KN, The diameter of the nugget between the overlapping plates of each layer was $\geq \phi 6$ mm. It is suitable for lap welding of plates with different thickness of 0.8mm+1.4mm+1.8mm.

In this paper, taking the left front beam and front panel lap joint as an example, it is expounded that when encountering the overlap between the two-layer board and the three-layer board, the welding process parameters for the three-layer board overlap should be selected preferentially which could solve the problem of welding nugget from the solder joints, hence provides a new idea and method for other automobile manufacturers.

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