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INVESTIGATING SPOT WELD GROWTH ON 304 AUSTENITIC STAINLESS STEEL (2 mm) SHEETS

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Abstract

Resistance spot welding (RSW) has revolutionized automotive industries since early 1970s for its mechanical assemblies. To date one mechanical assembly out five is welded using spot welding technology in various industries and stainless steel became very popular among common materials. As such this research paper analyses the spot weld growth on 304 austenitic stainless steels with 2mm sample sheets. The growth of a spot weld is primarily determined by its parameters such as current, weld time, electrode tip and force. However other factors such as electrode deformations, corrosions, dissimilar materials and material properties are also affect the weld growth. This paper is intended to analyze only the effects of nuggets growth due to the current and weld time increment with constant force and unchanged electrode tips. A JPC 75kVA spot welder was used to accomplish it and the welded samples were undergone tensile test, hardness test and metallurgical test to characterize the formation of weld nuggets.

Keywords: Spot welding, Nugget growth, Stainless steel spot welding.

1. Introduction

Spot welding process is a joining process in which two or more metal sheets are joined together through fusion at a certain point [1]. The spot welder uses two copper electrodes to press the work sheets together and force high current to pass through it. The growth of weld nugget is therefore determined by its controlling parameters such as the current, weld time, electrode tips and electrode force [2]. In this experiment the current and weld time were varied to see the weld growth while the electrode tips and force remained unchanged [3]. The investigation was carried out to characterize the spot weld growth for 2 mm base metals by varying the welding current and weld time, in other word.

2. Experimentation

The rectangular-shaped specimens were equally prepared with a size of 200mm (length) × 25 mm (width) × 2 mm (thickness) as shown in the Fig. 1 and its chemical composition is listed in Table 1. Initially some samples were welded to characterize the working regions without producing expulsion or poor weld. Hence it was found that the welding current of 7, 8, 9 kA and weld time of 10, 15, 20 cycles were simply giving reasonable working region and therefore a weld schedule was developed in accordance with these values (Table 2). Meanwhile the electrode force was set to be constant at 3 kN and truncated type electrode tips (diameter 5 mm) were also kept unchanged.

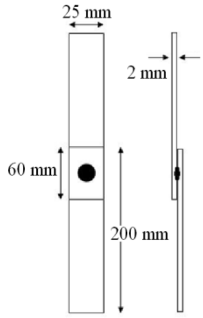

Fig. 1. Welding Sample with Dimension.

Table 1. Chemical Composition of 304 Austenitic Stainless Steel.

Element	C	Cr	Ni	Mn	Si	S	N	P
Weight %	0.046	18.14	8.13	1.205	0.506	0.004	0.051	0.030

Table 2. Weld Schedule.

Weld Schedule	Sample No	Material	Electrode Tip (mm)	Current (kA)	Time (cycle)	Force (kN)
1	1-5	SS	5	6	10	3
2	6-10	SS	5	7	10	3
3	11-15	SS	5	8	10	3
4	16-20	SS	5	6	15	3
5	21-25	SS	5	7	15	3
6	26-30	SS	5	8	15	3
7	31-35	SS	5	6	20	3
8	36-40	SS	5	7	20	3
9	41-45	SS	5	8	20	3

A pair of water cooled copper-alloy electrodes with truncated tips was used to join these base metals. The test samples were initially placed on the top of lower electrode (tip) of the spot welder (75 kVA) as overlaying 60 mm on each other and then the initiating pedal was pressed. The weld process was started right after with squeezing cycles and; once the squeezing force is reached the welding current is delivered in accordance with the given preset values. Thereafter the electrode pressing mechanism (pneumatic based) consumes some time for cold work and eventually return to the home position of electrode. The process controlling parameters (welding current and weld time) are set before the welding process starts. So the weldment happens in accordance with these parameters.

3. Results and Discussion

Hardness test was carried out by using Rockwell hardness (B Scale) machine with 20 kg of pressing forces on selected 9 samples from weld schedule (Fig. 2). The hardness of welded areas (≈ 96 HRB) seemed to be higher than unwelded areas (≈ 86 HRB) due to the solidification process. However the hardness distribution along the line of measurements was not giving any relationship as it fluctuates up and down at fusion zones [4]. Moreover the heat affected zones (≈ 90 HRB) was lower in hardness as compared to fusion zones; as it was partially melted but not fully.

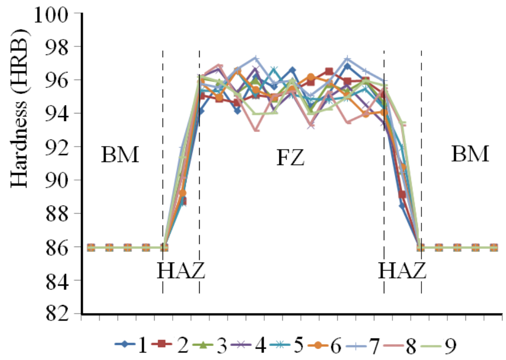

Fig. 2. Hardness Survey.

The ultimate tensile strength (UTS) at which the maximum breaks occur was taken into consideration using tensile machine for all the samples [5]. Five samples were developed for each weld schedule and the average values of five samples were taken as final tensile strength as shown in Fig. 3. The first five samples show the real tensile test values and consecutive sixth bar shows the average that obtained. As for the weld schedule from 1 to 2; there are increases in strength due to increase in current (7 kA to 8 kA) with time cycle 10. The same principle goes to weld schedule 2 to 3 as another increase in current (8 kA to 9 kA) was applied whilst the time cycle was same as before [6]. Similar results were notice for weld schedule 4, 5, 6 and 7, 8, 9. Besides the weld time increments from weld schedule 1 to 4 and from 4 to 7 with same current were also produced increase in strength. Further analysis of weld time increment of 2, 5, 8 and 3, 6, 9 also produced similar result [7]. In contrast, expulsion had caused inconsistent weld development and therefore extreme cases were not analyzed here. However some common types of tensile break were found through this experiment as shown in Table 3. Having considered the failure modes of tensile test, we have noticed some of the common failure while performing tensile test. Thus: (A) represents Interfacial Fracture regions of base metals. The failure mode (B) represents Tear from Edge of one side of base metals and (C) represents Tear from Edge of both sides of base metals (Fig. 4).

The standard metallurgical study was conducted for each weld schedule out of nine. It obviously shows how the nuggets growths were happened in 304 austenitic stainless steel with respect to current and weld time changes. It particularly shows the diameter of fusion zones (FZ), heat affected zones (HAZ), indentation of electrode (IE), and micro structural view of after the solidification (Fig. 5) [8]. The strengths were increased due to diameter increment but the hardness increments