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(Full length research article)

Effects of Welding Parameters on the Characteristics of A95083 RSW Joint with Cover Plates

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Abstract

In this study aluminium alloy A95083 sheets were welded using the technique of resistance spot welding with cover plates. The effects of welding parameters on the characteristics of the joint were investigated. The joint with larger nugget and higher tensile shear load was obtained under relatively low welding current condition. Enhancing electrode force and extending down-sloping time are effective for inhibiting pores formation and increasing the tensile shear strength of the joint under corresponding welding conditions. The results reveal that the technique is feasible to weld A95083 alloy.

Keywords: *RSW, Aluminium alloy, Tensile strength*

1. Introduction

In automotive industries, weight reduction is strongly demanded for energy and natural resource savings. Owing to low density and significant mechanical properties, aluminium alloys have been adopted and are expected to be extensively used in the future, to partially replace steel that is primary construction material in automobile. On the other hand, resistance spot welding (RSW) is a widely used and important welding process in the fields of automotive manufacturing because of its low cost, easy automation and minimum skill requirements. Therefore, the investigation on the RSW of aluminium alloy is also indispensable. In recent literatures concerning the RSW of aluminium alloy,

Sun et al. reported the microstructures and mechanical properties of the joint, and Wang et al. studied the effect of welding time on the microstructure and tensile shear load of the joint. These experiments not only provided useful information to understand the performance of aluminium alloy joint, but also revealed that enormously high welding current was required in the RSW process of aluminium alloy due to high electrical and thermal conductivity of aluminium alloy. In the previous study, aluminum alloy sheets have been welded using the technique of RSW with cover plates and favorable joint has been attained under the welding condition of low welding current. In view of physical properties similarities between aluminium alloy and aluminum alloy, aluminium alloy was also welded employing this method in the present study. In order to provide some foundational information for improving mechanical properties of the aluminium alloy joint, the availability of this method for aluminium alloy welding and the effects of welding parameters on the characteristics of the joint were investigated. The results reveal that the technique is feasible to weld aluminium alloy, and that the enhancing electrode force and extending down-sloping time are effective for inhibiting pore formation and increasing the strength of the joint under corresponding welding conditions.

1.2 RSW with cover plate

RSW is a joining process based on the heat source obtained from Joule's effect of the resistance and electric current flow through the sheets held together by the electrode force, in which the coalescence occurs at the spot area in the faying surfaces. Therefore, in the process of RSW between aluminum alloy and SAE HSLA 945A, enormously high electric current is required because of low heat generation and high heat conduction of aluminum alloy. In this case, the utilization of enormously high welding current would reduce electrode tip life and require adopting larger capacity RSW machine. In order to enable the RSW between aluminum alloy and SAE HSLA 945A under relatively low welding current condition, a technique of RSW with cover plate

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has been proposed. Fig. 1 shows the schematic diagram of this welding process, in which a cover plate was placed on the aluminum alloy sheet. Here, it is required that the cover plate was a metal sheet with relatively lower electrical conductivity than aluminum alloy, so the higher heat generated in the cover plate as to be conducted from the cover plate to aluminum alloy sheet. 945A was selected as the cover plate material. In the present study, the similar material joints of aluminum alloy sheets were also prepared to compare the strength with dissimilar material joints between aluminum alloy and steels. In such a case, the aluminum alloy sheets were placed between both cover plates when they are welded.

2.1 Experimental materials and procedures

The material used is 2 mm thick aluminium alloy UNS A95083 sheet with the compositions given in table 2. Fig. 2 shows the configuration and dimension of specimen. The A95083 sheets were welded using a stationary RSW machine. Copper-chromium alloy electrodes with a tip diameter of 6 mm were used. Fig. 3 shows the spot welding cycle adopted in this study, in which down sloping time refers to the time of welding current reducing to zero. Welding conditions are given in table 1. In order to examine the mechanical properties of the joint, the tensile shear test was performed under a cross-head speed of 1.5×10^{-5} m/s at room temperature. The nugget diameter was measured from the fractured surface after tensile shear testing. The joint tensile shear load and nugget diameter were determined based on the average value over five measurements per-condition. Moreover, the aluminium alloy joint welded by conventional RSW without use of cover plate was also investigated to make a comparison between the two methods.

Table1 Composition of HSLA 945A

C	Mn	P	S	Si	Fe
0.15	1	0.04	0.05	0.9	Bal

Table 2 Composition of A95083

Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
0.4	0.4	0.1	0.4	4	0.5	0.15	0.05	Bal

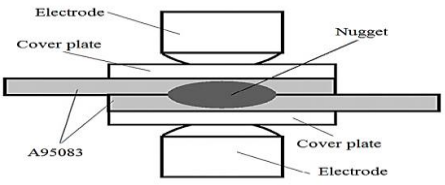

Fig.1 Schematic diagram of spot welding with cover plates

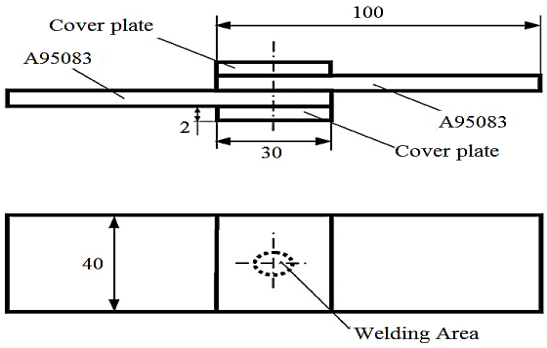

Fig. 2 Configuration and dimension of specimen

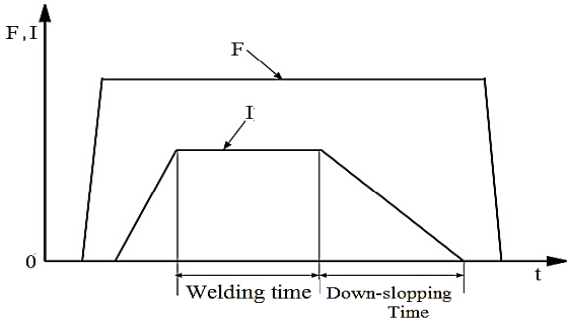

Fig. 3 Schematic diagram of spot welding cycle

Table 3 Welding conditions

Welding conditions				
	Set-1	Set-2	Set-3	Set-4
Welding current(KA)	5-10	9-15	6-15	6-15
Welding time(cycles)	10	10	10	10
Electrode force(KN)	2	2	2	1-5
Down-slop time(cycles)	0	0	0-40	0
Cover plates	Yes	Yes	Yes	Yes
Pre treatment	Cleaning with acetone			
Electrode tip material	Cu-Cr alloy, tip diameter = 6 mm			

4. Experimental results and discussion

4.1. Characteristics of the joint welded by RSW with cover plates. Generally, welding current has effects on the nugget diameter and tensile shear load of joint. Fig. 4 and 5 show the effects of welding current on the tensile shear load and nugget diameter of the joints welded under the welding conditions of sets 1 and 2. In the case of RSW with cover plates, the nugget diameter and tensile shear load of the joints increased with the increasing of the welding current. The maximum tensile shear load of 4 KN and the nugget of 11 mm in diameter were obtained

at the welding current of 12 KA. Moreover, the fracture type of the joints varied with the welding current. Shear and plug fracture were observed in the range of 5–8 KA and 9–12 KA of the welding current, respectively. As shown in fig. 4, when welding current is below 9 KA, the joint was unable to be attained by conventional RSW without use of cover plate. It should be noticed that the joints welded by conventional RSW exhibited lower strength and smaller nugget under the same welding conditions in comparison with the joints welded by the RSW with cover plates. This is attributed to the effect of the cover plates on the formation of nugget. Higher heat generated in cover plates with low electrical conductivity transferred to the welding region, which resulted in the formation of larger nugget. Therefore, the RSW with cover plates can improve performance of joint.

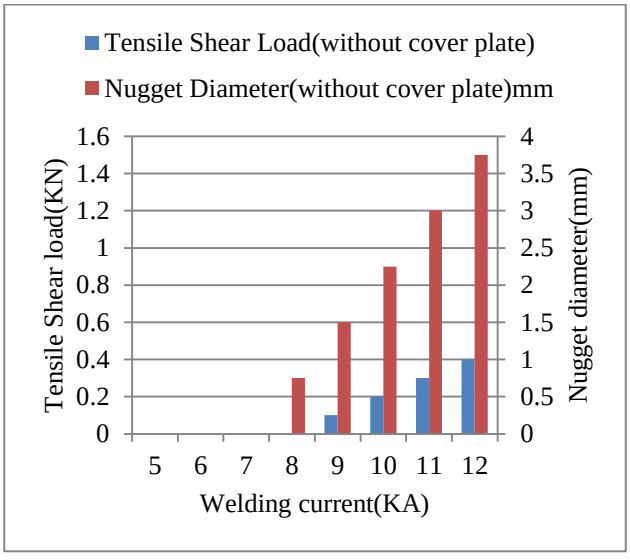

Fig.4 Effect of welding current (1st set of experiments)

In RSW, heat input increases with the increasing of welding current, which results in the increasing of nugget diameter. As shown in fig. 4 and 5, the tensile shear load of the joints increased with the increasing of the welding current. It is attributed to the increase of the nugget diameter, and nugget diameter is one of the influencing factors for joint strength in both cases of shear and plug fracture [5]. Sun et al. have welded 1.2 mm magnesium alloy AZ31 sheets using RSW, and obtained the maximum tensile shear load of 3 KN and nugget diameter of 6.5 mm from joints welded at the welding current of 23 KA [2]. Wang et al. have reported that the maximum tensile shear load of 1.98 KN and nugget diameter of 5.3 mm were obtained from joints welded under the condition of welding current of 17 KA, who welded 1.0 mm thickness aluminium alloy AZ31 sheets using RSW [3]. Compared with these results, the joints welded by RSW with cove plates exhibited higher tensile shear load and larger nugget. This is attributed to the effect of the cover plates on the formation of nugget as above mentioned.

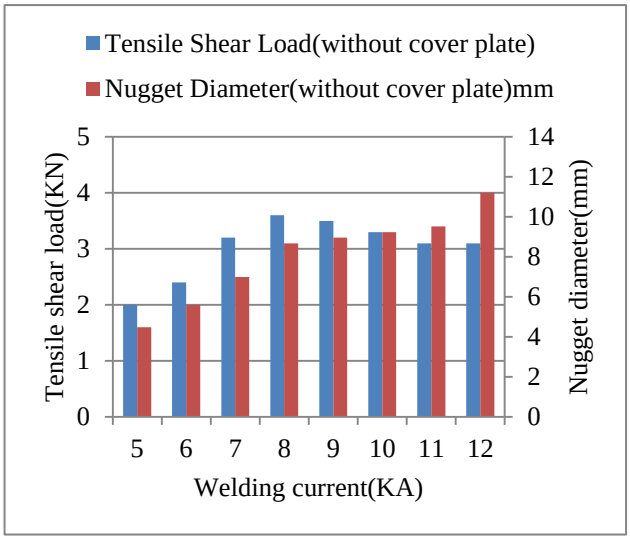

Fig.5 Effect of welding current (2nd set of experiments)

This suggests that the technique of RSW with cover plates is able to weld aluminium alloy A95083 sheets under the same degree welding current as that of the RSW of steel [6–8]. It is well known that the reliability of spot welding joint is also related with the shape feature of nugget

5. Conclusions

In the present study, aluminium alloy sheets were welded using the method of RSW with cover plates. The effects of welding parameters on the characteristics of the joint and suppressing pores formation were investigated. Main results obtained from this study are as follows:

1. The joint with larger nugget and higher tensile shear load were obtained under relatively low welding current condition. The RSW with cover plates is feasible to weld aluminium alloy.

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