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Effect of Welding Current on Tensile–Peel Loading of Welding Joints in TRIP 800 and Micro-Alloyed Steels in Resistance Spot Welding

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In this paper, an analysis of electric resistance spot welding between micro-alloyed steel sheets having 1 mm thickness and TRIP 800 (transformation induced plasticity) steel sheets having 1.5 mm thickness was made. Couples of steel sheets are used in automobile industry. Steel pairs were joined by using resistance spot welding as overlap joint. A timer and current controlled resistance spot welding machine had pneumatic application mechanism and 120 kVA capacity. Preparation of specimens by spot welding was performed using different cycles ranging from 5 to 30 cycle and welding currents ranging from 8.5 to 16.5 kA by rise of 0.5 kA. The electrode force was kept constant at 6 kN. The prepared welding specimens were exposed to tensile–peel tests and the obtained results were supported by diagrams. Finally, appropriate welding parameters were advised to the users.

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PACS/topics: resistance spot welding, welded joint, automotive steels, tensile–peel test

1. Introduction

Nowadays, automobile manufacturers use TRIP 800 steel sheets and micro-alloyed steel sheets in automobile body parts. Couple of these steel sheets ensures increase of safety and on crash performance of automobiles, therewith, decrease in the chassis and body parts weight of automobiles. The most important fact is obtained fuel economy because of these steel sheets for automobile companies. Welding process is the most important technique in automobile industry [1–7].

Resistance spot welding (RSW) is the most important technique joining automobile sheets. RSW is a widely used welding technique in automobile industry. At the present time, RSW is the most used joining method in new generation vehicles. In addition, RSW is suitable for automation and is a fabrication method in automobile manufacturing [8–10].

In this paper, the relationship between tensile–peel strength and welding current of welded TRIP 800 and micro-alloyed steels using RSW was investigated.

2. Experimental studies

A timer and current controlled RSW machine having 120 kVA capacity and pneumatic application mechanism with a single lever was used in the experiments. Welding was carried out by using water cooled Cu–Cr electrodes having a contact surface of the same diameter (6 mm). The specimens were overlapped with 30 mm spacing and welded. The welding periods applied in experiments are shown in Fig. 1. The chemical properties of TRIP 800 and micro-alloyed steel sheet are shown in Tables I and II, respectively.

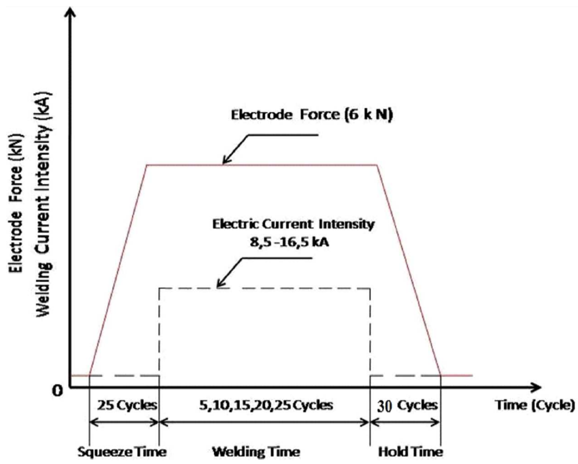

Fig. 1. Welding cycle for spot welding.

TABLE I

Chemical composition of TRIP 800 steels [wt%].

C	P	Mo	Co	Ti	Sn	Si	S	Ni
0.179	0.011	0.025	0.072	0.014	0.01	1.719	0.007	0.074
Cu	V	Mg	Mn	Cr	Al	Nb	W	Fe
0.1	0.013	0.001	1.691	0.065	0.027	0.053	0.04	95.902

TABLE II

Chemical composition of micro-alloyed steels [wt%]

C	Si	Mn	P	S	Ti	Fe
0.12	0.50	0.60	0.10	0.45	0.30	97.93

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The mechanical properties of TRIP 800 steel sheet is shown in Table III. Micro-alloyed steel sheet properties are shown in Table IV.

TABLE III

Mechanical properties of TRIP 800 steel sheet.

Yield strength [MPa]	Tensile strength [MPa]	Total elongation [%]
480.3	785.8	25.1

TABLE IV

Mechanical properties of micro-alloyed steel sheet.

Yield strength [MPa]	Tensile strength [MPa]	Total elongation [%]
184	357	39

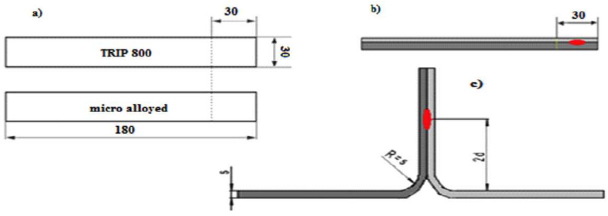

Fig. 2. The dimensions of the (a) materials of specimens (b) welding specimens for tensile–peel test, (c) the tensile–peel specimens.

At pre-welding, the specimens are cleaned ultrasonically and prepared as shown in Fig. 2. After that, these parts were overlapped with 30 mm spacing and welded.

Weld time was selected as 5, 10, 15, 20, 25, and 30 periods (1 period (per) = 0.02 s). The other welding parameters are electrode force 6 kN, clamping and hold times of electrode (25 per) were kept constant. The welding current was increased from 5 to 16.5 kA by 0.5 kA increments. Maximum tensile–peel loading value was obtained at 10 per at approximately 16 kA welding current.

3. Results

The welded specimens were put to tensile–peel tests in a testing machine in laboratory environment.

The tensile speed was kept 20 mm/min during test. The tensile–peel loading is the maximum values read from the scale of the machine.

Three types failure mode were obtained: (1) separation, (2) knotting, (3) tearing. Samples of them are shown in Fig. 3. Spurt out failure observed on welding nuggets due to increased welding current. In high welding currents obtained samples of them are shown in Fig. 4.

At 13.5 kA welding current, tensile–peel strengths of specimens increase up to 30 per where the maximum point is for this current. The maximum tensile–peel strength is obtained at 10 per or 16 kA welding current. The tensile peel strength increases to a certain point and then fall rapidly such as shown in Fig. 5.

High welding current application, cross-section area decreases, as a result, tensile-peel strength of joint decreases.

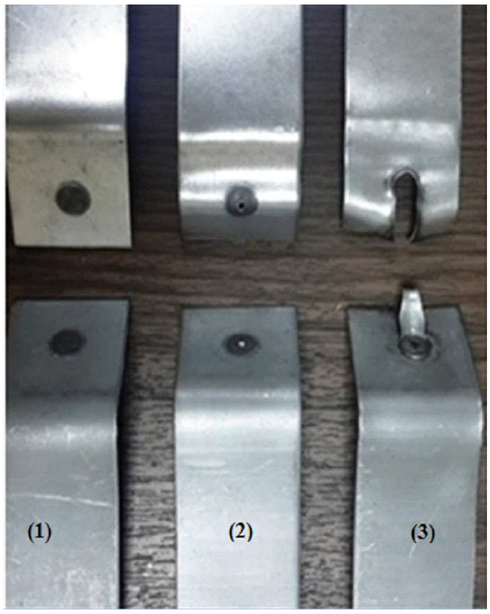

Fig. 3. Fracture surface of tensile–peel specimens.

Fig. 4. Spurt out failure observed in weld nuggets.

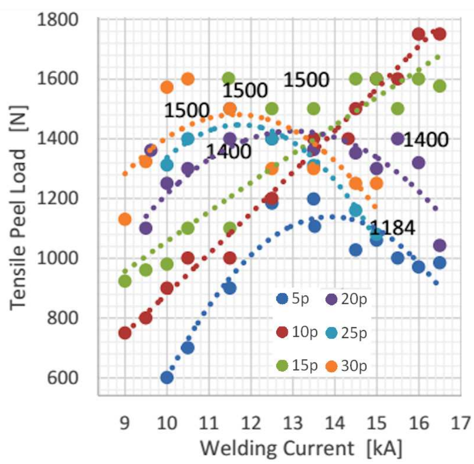

Fig. 5. Effect of welding current on tensile–peel load of weld joints.

In low welding current application, small weld nugget diameters were obtained and similarly lower tensile peel strength value than that of base-metal was measured due to low heat application to welding zone. As a result, break type was observed as separation.

4. Conclusion

As a result of the work performed at 4 kN electrode force, the obtained results and some suggestions are given below.

Three types of breaking failure modes were obtained: (1) separation, (2) knotting, (3) tearing.

In the joining couple of sheets, maximum tensile peel strength is obtained at 16.5 kA welding current, at 10 period.

High welding current application, cross-section area decreases, as a result, tensile–peel strength of joint decreases.

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