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Effect of current and welding time on tensile-peel strength of resistance spot welded TWIP 1000 and martensitic steels

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Recently, to reduce car weight for saving fuel, reducing gas emissions, and to raise car safety by selecting the optimum material that meets desired mechanical properties, Advanced High Strength Steels (AHSS) have been continuously in development. TWinning Induced Plasticity (TWIP) steels, that have high tensile strength with high elongation, and Martensitic steels, which tensile strengths can be raised up to 1700 Mpa, are among the most significant members of AHSS. However, strength of joints as important as the material itself. In an automotive body, the most practiced joining method is resistance spot welding. Tensile-peel test in resistance spot welding is of high importance, because its behavior akin to the breaking action of the sheet metal at the time of the accidents. In this study, tensile-peel strengths are investigated in terms of current and weld time using resistance spot welding. The weld time range is selected between 5-30 periods (a period 0,02 sec) with 5 period increments.

Keywords: Resistance spot welding, Tensile-peel strength, AHSS, TWIP, Martensitic steels

Nowadays, reducing greenhouse gases and reducing car weight have been the main motivation of automotive industries[1]. Martensitic Steels (MS) have high tensile strength and low elongation ratio. It can be a solution both for automotive crash component and for reducing car weight. TWIP steels is another important material which has high elongation ratio and high tensile strength at the same material. And, thanks to this combination of mechanical properties, TWIP steels have been attractive for automotive companies and can be used on car bodies[2].

Among welding methods, Resistance Spot Welding (RSW) is the most utilized method for vehicle manufacturers to assemble sheet parts[3]. Also, RSW has a lot of advantages over other welding methods. For example, it is too cheap, does not require an additional weld metal, has low welding time and easy-to-adapt robotic/serial applications[4]. In a modern automotive, there are between 2000-5000 spot welds[5]. This quantity illustrates the importance of mechanical properties of RSW joints. All materials on vehicles selected by design conditions. However, mechanical performance of joints also should be taken into account, because, mechanical properties of RSW joints highly affect joined material failure and joining quality.

In this study, tensile-peel strengths of TWIP/MS couples have been investigated in terms of different weld times and different weld currents. Also, separation modes have been evaluated.

Experimental Section

TWIP and MS sheets were welded by RSW method under constant cooling water flow rate and constant electrode force. Tensile-peel test executed to RSW applied specimens.

Materials

The Martensitic Steels (MS) having 1 mm thickness supplied from SSAB Turkey. TWIP steel having 1.4 mm thickness supplied from local dealer. Then, specimens sliced to 30×100 mm with Ermaksan hydraulic guillotine and ultrasonically cleaned. Chemical composition and mechanical properties of TWIP and MS have been presented in Table 1 and Table 2 respectively. The detailed dimensions of tensile-peel test specimen is presented in Fig. 1.

Welding process and executing tensile-peel test

A RSW machine having single lever pneumatic application mechanism with 120 kVA capacity were used in experiment. Current and timer values were adjusted with machine interface and continuously

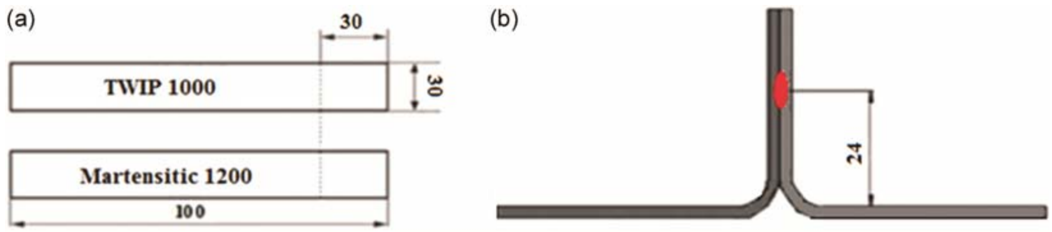

Fig. 1 — Dimensions of tensile-peel test specimens

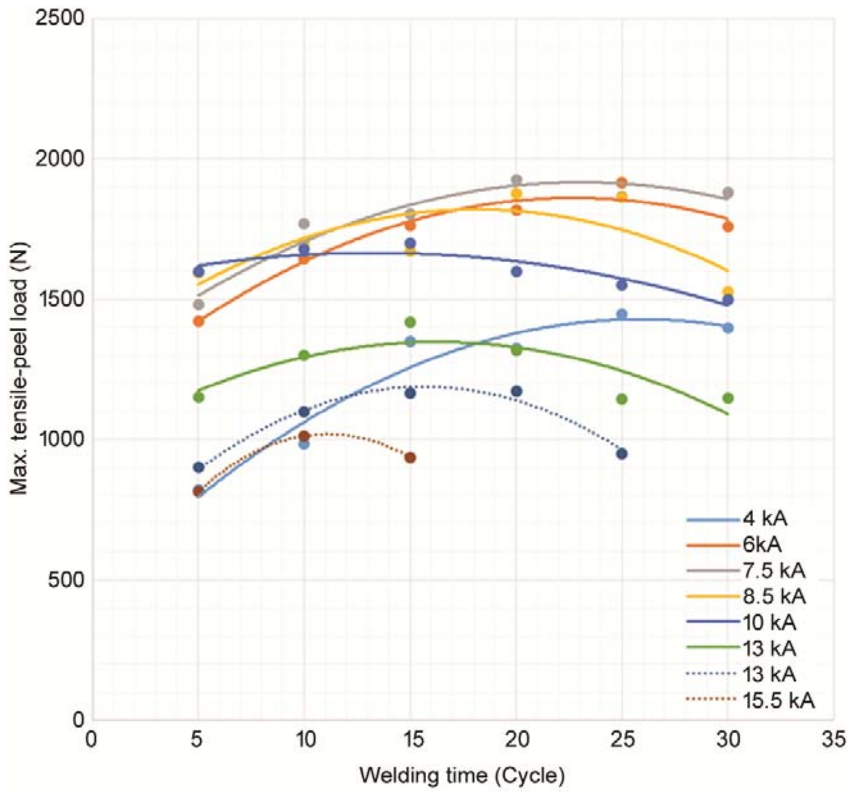

Fig. 2 — İnfluence of welding period on max. tensile-peel load

Table 1 — Chemical composition of TWIP and 1200M sheet steels [wt.%]

	C	Si	Mn	P	S	Cr	Mo	Al	Co	V
1200M	0,0791	0.201	1.6	0.00037	0.00022	0.0175	0.0373	0.0363	0.0133	-
TWIP	0.52	0.14	22.34	-	-	0.145	0.7	-	-	0.22

observed by ampere-meter. Cu-Cr electrodes with 6 mm tip diameter employed during experiments according to EN ISO5182 standard. The weld time ranges are selected between 5-30 period with 5 period increments and the current ranges are observed between 4-16.5 kA with 1.5 kA increments. All experiment repeated 3 times. Tensile-peel test were performed with SHIMADZU universal testing device having 50 kN maximum capacity. Tensile-peel test executed with 20 mm/min tensile speed. Tensile-Peel value determined by average of the 3 repeated specimens. Then, failure modes and were noted.

Table 2 — Mechanical properties of TWIP sheet steel with 1000 and 1200M

	Yield Strength [N/mm^2]	Tensile strength [N/mm^2]	Total elongation [%]
1200M	950	1282	3
TWIP1000	533	985	44

Results and Discussion

Effect of welding time

Effect of welding times on maximum tensile-peel load have been presented in Fig. 2. In 5 period, all maximum tensile-peel load results obtained relatively low compared to other periods. The maximum tensile-peel load achieved as 1970N in 20 period and 7.5 kA welding currents. Increasing in welding times causes a contraction in applicable welding currents.

Effect of welding currents

Influence of welding currents on tensile-peel loads have been presented in Fig. 3. As welding current

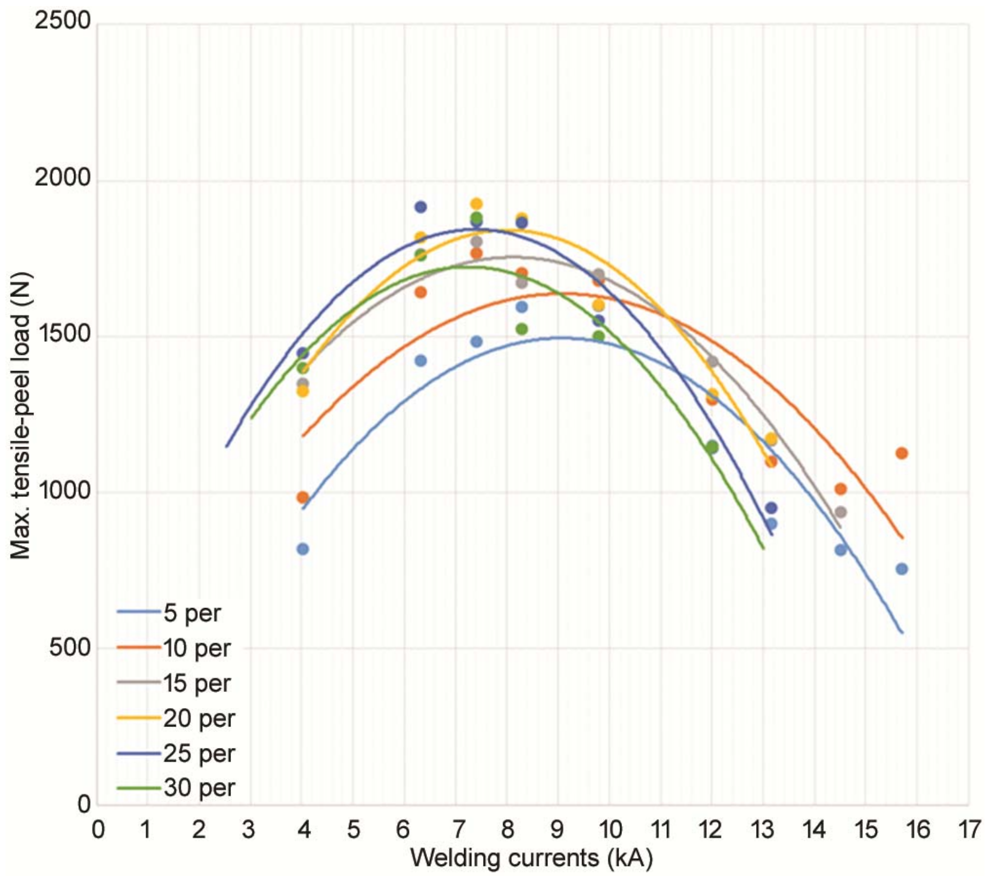

Fig. 3 — Effect of welding current on max. tensile-peel load

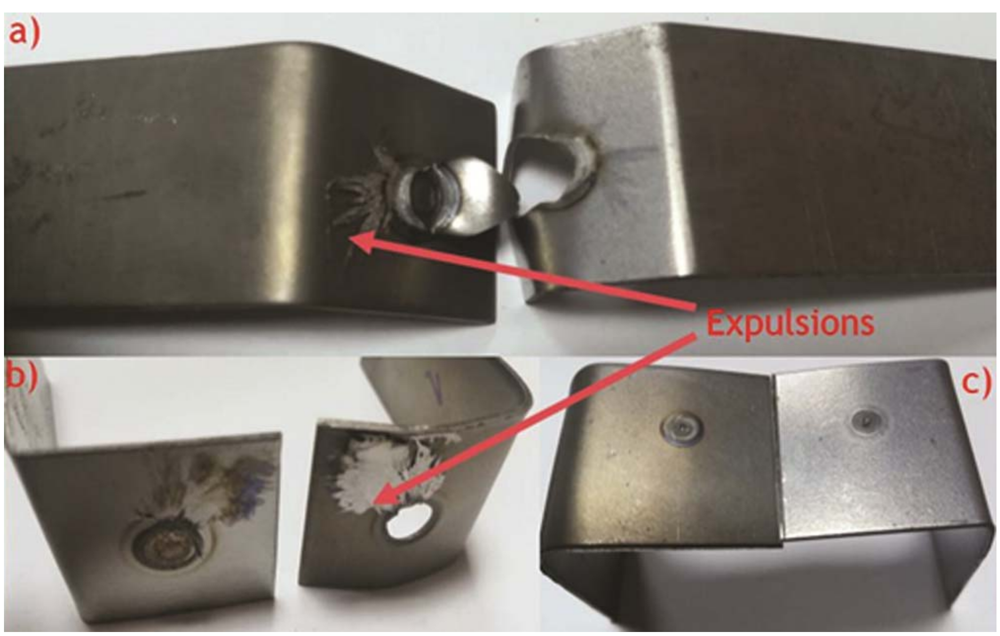

Fig. 4 — Separation modes of RSW applied TWIP/MS joints; a) Tearing, b) Knotting, c) Interfacial type separation

Table 3 — Welding parameter ranges of separation modes

Welding periods (1P=0.02 sec)	Ranges of interfacial separation (kA)	Ranges of tearing separation (kA)	Ranges of knotting separation (kA)
5P	4-6	-	7-16.5
10P	4	-	6-16.5
15P	4	6	4, 7-16.5
20P	4	8	6-7, 10-16.5
25P	-	6-8	4, 10-16.5
30P	-	6-8	4, 10-16.5

increased, maximum tensile-peel loads have been raised up to a maximum point. Then, the maximum tensile-peel load have been decreased. This situation is attributed to high current input in nugget zone which causes expulsions and decreases weld nugget dimensions.

Influence of welding on separation modes

In experiments,as shown in Fig. 4, three type of separation modes were formed. These are a) tearing type separation, b) knotting type separation and c) interfacial separation. Interfacial separation formed in low current and welding times. Also, in these currents and welding times as seen from Fig. 4-c, insufficient weld nugget formed which clarifies the reason of interfacial separation. In tearing type and knotting type separation modes, expulsions can easily be seen from Fig. 4.

Table 3 indicates welding parameter ranges of separation modes. As seen from the Table 3, interfacial separation mode formed up to 20 periods. Tearing type separation mode wasn't formed in low welding periods. Tearing was formed between only initial and medial current values. In the rest of currents and welding time parameters, knotting separation modes were formed.

Conclusion

In this work, effect of welding parameters on tensile-peel strength and failure modes have been investigated. Based on obtained results, following conclusions can be drawn;

1. As welding current increases, applicable welding period ranges decreased.
2. The maximum tensile peel load have been obtained as 1975 N in 7,5 kA welding current and 20 period welding time.
3. All separation modes have been observed in experiments.
4. Interfacial separation mode formed only in low currents and welding times
5. As welding currents increases, maximum tensile-peel loads have been raised.

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