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ARRANGEMENTS OF RSW POINTS AND WELDING CURRENT EFFECTS ON MECHANICAL BEHAVIOR OF 304 L STEEL

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ABSTRACT

The joining of thin sheets by resistance spot welding requires knowledge of the material to be assembled and the optimal welding parameters. This study is oriented to investigate the effect of welding current and the arrangement of weld points on breaking strength of the stainless steel 304L sheets experimentally. Welding current vary from 10 kA to 15 kA. Welding time and electrode force used in this study are respectively 11 cycles and 6 bars and keep constants. Tensile shear tests were conducted on resistance spot over lap joints. Results show that the distribution of weld points in the vertical direction under tensile applied stress has a strong effect on the strength and deformation of weld sheets in increasing of the welding current. Unneeded, the increase in the welding current makes it possible to increase the plastic deformation zone. The increase in the welding current causes a large fusion in welding point where the geometrical aspect is strongly affected.

Keywords: RSW, welding current, stainless steel, breaking force, arrangement of RSW points

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1. INTRODUCTION

The spot welding is the most well-known resistance welding process in various industries: automotive, welded mechanics, metal assemblies. It has the advantage of being fast, efficient, low pollutant, does not require filler material and suitable for welding steels, the main materials used in metal assemblies. The right material for this type of welding is 304L stainless steels with an interesting compromise between strength and density, a reasonable manufacturing cost and good spot welding ability. In this context, it is conceivable to reduce the thickness of the sheets used if they have higher mechanical properties, in order to guarantee the mechanical behavior of the structure. Nevertheless, the mechanical strength of the final assembly depends not only on the intrinsic mechanical properties of the sheets, but also on those of the welded connections, through which the forces pass. It is therefore necessary to have tools for predicting the mechanical strength of the welded points by resistance. The weldability of austenitic steels (304 L) by points and the mechanical behavior of the welded points present a field of investigation to this day, despite having been widely studied for several decades. Mechanical resistance of spot welding sheet depends essentially on welding current, welding time and welding force. The welding current is the most effective and common parameter to influence welding result of a given material configuration. The effects of welding parameters on the tensile shear strength of the joints were investigated by Qui et al. [1]. The effects of welding current on the mechanical properties of welded joint were investigated by Shawon et al. [2]. An increase in tensile strength of the weld coupon was shown in increasing of welding current. In Hasanbasoglu and Kacar investigation [3], it was found that the tensile shear load bearing capacity of welded material increased with an increase in peak welding current due to enlargement of the nugget size in resistance spot welding of dissimilar materials steels. Research conducted by Charde and Rajkumar shown that [4] tensile forces of RSW thin plate have proportional relationship with current welding until the expulsion limit occurs. Failure of martensitic stainless steel of overlap joint by RSW shows that breaking load increases with increasing of welding current and nugget diameter for each weld cycle [5].

In recent investigation conducted by Jagadeesha and Jothi [6], and at fixed welding time, the tensile shear load increases in increasing of welding current. It is recognized that the assembly of sheets requires multiple spot welding points. Additionally, to the effect of welding parameters on formation nugget and shear bearing spot weld arrangement in the multi-spot welded joints presents a very important and meaningful factor for determining the strength of the joints. The majority of tasks done related to the strengths of the spot welded joints relate to joints with one spot weld [7, 8]. Gean et al. [9] have studied the effect of one ant two resistance spot welding points on static and fatigue resistance in aluminium alloy joints. The authors have found that the fatigue strength of 16 spot weld specimens was 40% lower that for single spot welded specimens. Mohitel et al. [10] have optimised geometrical parameters

of resistance spot welding in overlap sheet with four welded resistance spot weld. The geometry parameter distance between two welds is most significant factor affecting tensile strength followed by overlapping length and distance of weld from edge. The effects of spot weld arrangements in multi-spot welded joints on the fatigue behavior of the joints are studied by Hassanifard et al [11]. The results have shown that the different arrangement of the spot welds in the joints would produce completely different stress gradients which affect the fatigue strength and fracture mechanics. The aim of this work is to provide elements of understanding on the behavior of spot-welded joints under the effect of the evolution of welding current and the arrangement of resistance spot welding points.

2. EXPERIMENTAL INVESTIGATION

The stainless steel 304L sheet with thickness of 2.0 mm was used in this study. The determined mechanical properties are shown on Table 1 and compared to those given by the supplier of this material. Fig. 1 shows the shape of the welded specimens used in the present investigation. Mechanical properties are given in Table 1 for receive material. The length of the overlapping is 50 mm. The tensile shear tests were conducted on tensile static machine tests "Controlab 600 KN" (Fig. 2). Welding conditions used in this investigation recommended for 304 L stainless steel are given in Table 2 with electrode diameter is equal to 7 mm. For each welding current and each weld spot configuration, only one sample is tested.

Table 1. Mechanical properties of stainless steel 304 L

	E (GPa)	**σe**	**UTS**	**A%**	**HRB**
Supplier	200	310	310	310	80 Max
Tensile tests	190	336	336	336	60

From Table 2, the external diameter in resistance spot welding and the depth are affected by the wending current. The increase of the welding current increases simultaneously the diameter of the nugget and depth at resistance spot welding for the same welding time and welding load. Also the variation of diameter of RSW from 10.5 mm at welding current equal to 10 kA to 14 mm at welding current equal to 15 kA contributes to increase the maximum tensile shear force for all welded samples.

Table 2. Welding current effect on geometric dimension of RSW points

Welding current (kA)	Welding time (cycle)	Welding force (bar)	Diameter in RSW point (mm)	Depth in RSW point (mm)
10	11	6	10.5	0.3
12	11	6	12	0.8
15	11	6	14	1.4



(A) (B)



(C) (D)

Fig.1. Overlap sheets with different arrangement of resistance spot welding points

2. RESULTS AND DISCUSSION

Under tensile applied load and for different arrangements of RSW points, the curves of load/displacement have the same evolution but with different maximum loads indicated in Fig.2. The mechanism of fracture in RSW type D (see Fig. 1) involves partial unbuttoning of the molten core. Figure 3 shows the effect of welding current on the evolution of the load/displacement curve for RSW joint type A. The plastic zone is affected by the increasing in the welding current (increased in plastic deformation). Figure 4 shows the same fracture mechanisms under the variation in the welding current. For the RSW type B, the fracture zone is localised in HAZ near the base metal. The fracture is oriented in the same direction of the RSW point positions (Fig. 5). Evolutions of load/displacement curve of RSW joints are shown in Fig. 6. The maximum loads for different welding current present random values. For I=10 kA, the maximum load is about 62 KN, but for I=12 kA and 15 kA, the values are respectively 67 and 65 KN. For arrangement type C, the increasing in welding current presents an inverse effect on maximum load (decreased in maximum load) (Fig. 7).

The same fracture mechanics is generated in this type (C arrangement) compared to the B arrangement. Figure 7 shows clearly the localisation of the crack path.

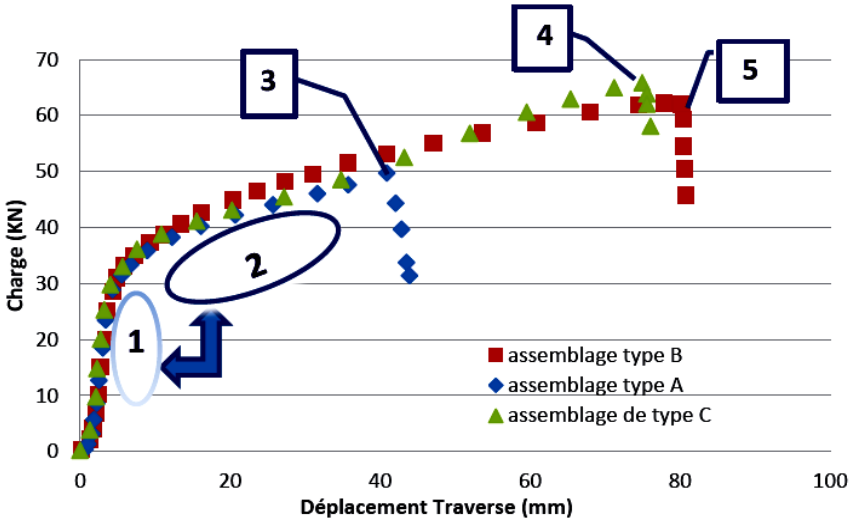

Fig. 2. Evolution of damage of RSW joints (1) Elastic zone (2) Plastic deformation (3, 4, and 5) maximum load point for different arrangements of RSW

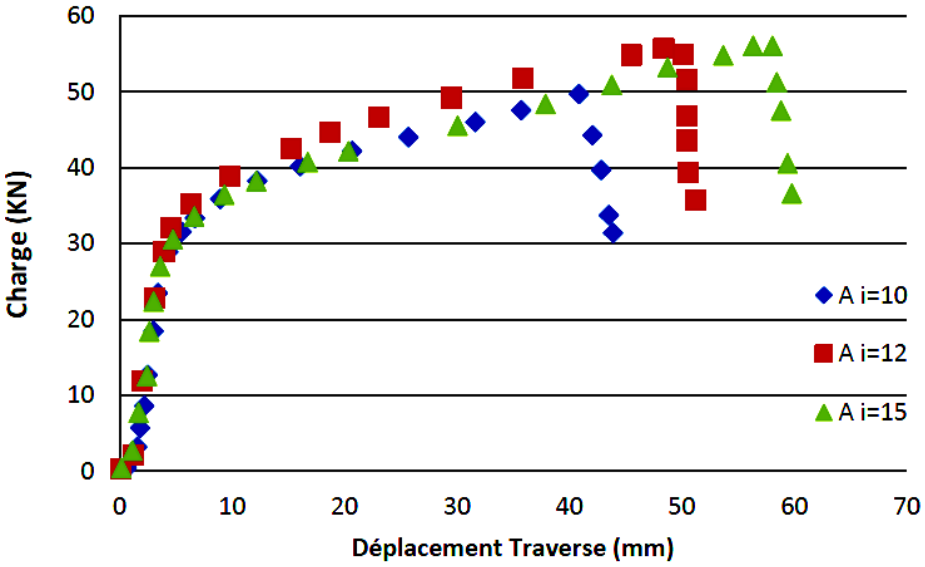

Fig.3. Effect of welding current on RSW joints (arrangement type A) on maximum load

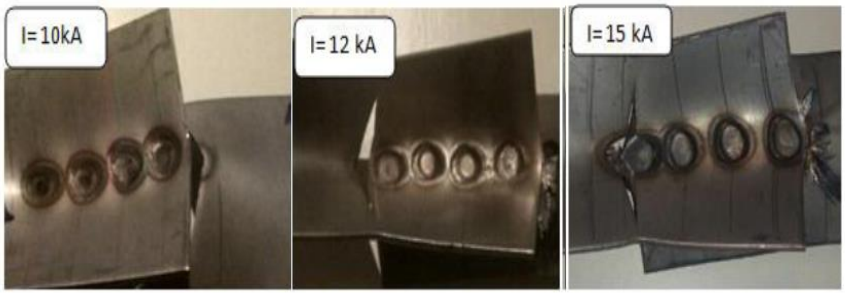

Fig.4. Fractured RSW joints of type A under welding current effect



Fig.5. Fractured RSW joints of type B under welding current effect

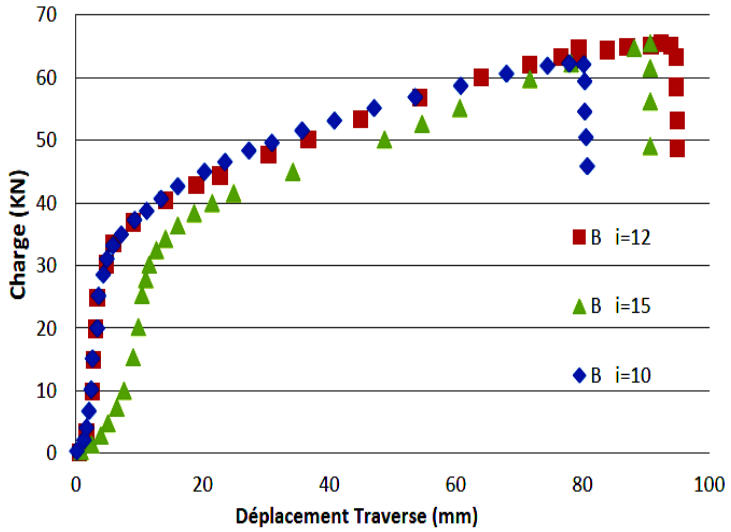

Fig.6. Effect of welding current on RSW joints (arrangement type B) on maximum load

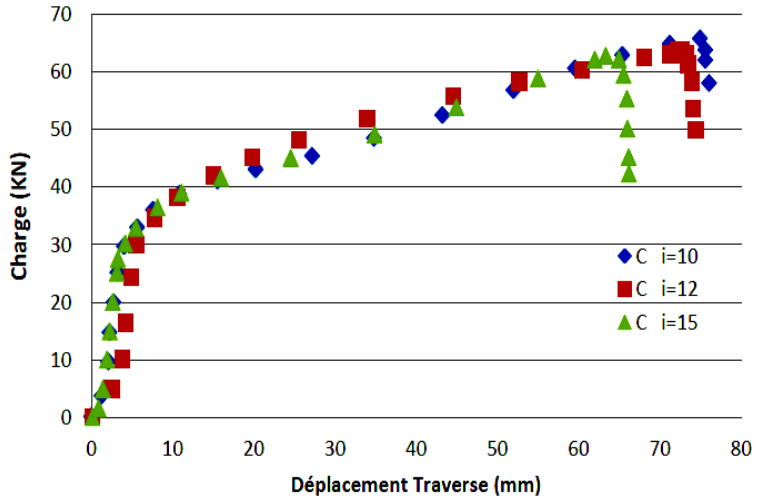

Fig.7. Effect of welding current on RSW joints - arrangement type C - on breaking load



Fig.8. Localization of damage under welding current Effect for RSW joints type C

The combined effects of welding current and arrangement of RSW are shown on Fig. 9. The presented results show that welding currents have affected breaking load in arrangement A, B and C. Also, the breaking load is affected strongly by arrangement configuration. Based on all configurations tests, the best configurations are “B” and “C” arrangements. It is noticed that for arrangements “B” and “C” the maximum tensile shear forces are respectively equal to 66 kN and 64 kN. For configuration "B", the rates of increasing of the maximum tensile shear force compared to configuration "A" are approximately 24%, 19% and 15% respectively for welding currents of 10 kA, 12 kA and 15 kA. Also for configuration “C”, the rate of increasing in the maximum tensile shear force compared to configuration “A” are approximately 32%, 14.3% and 11.5%. (See Fig. 9.)

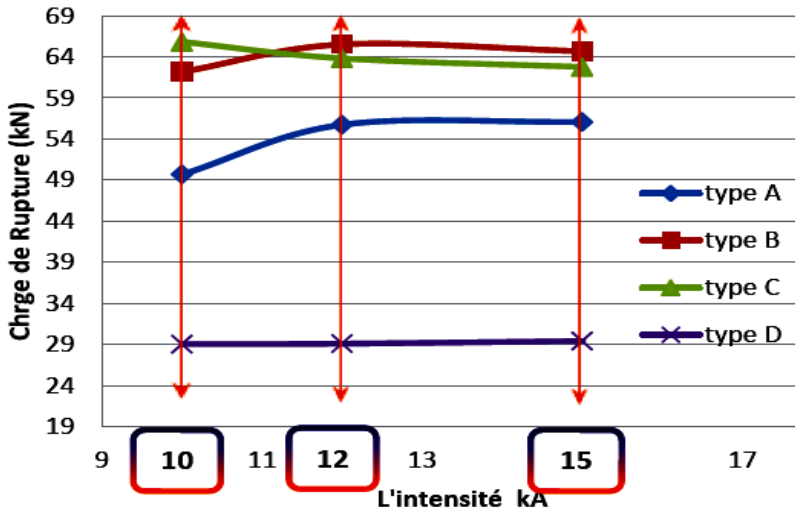

Fig.9. Effect of welding current and arrangement of RSW points on breaking load

4. CONCLUSION

In this investigation, stainless steel 304 L sheets were welded using RSW. The effects of welding parameters and the arrangements of RSW points on the mechanical behavior were studied. The concluding remarks are summarized as follows:

* The increasing of welding current allows increasing the diameter of RSW points.
* Welding current is dominant parameter on the evolution of the load/displacement curves.

* Increasing in welding intensity increases the plastic deformation zone and maximal load.
* Mechanical behavior is affected by the numbers of RSW points and arrangements and results show that configurations B and C presents good applied arrangement.
* Fracture Mechanics of RSW sheets depends on type of arrangements and orientation of generated stress.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] Ranfeng Qiu, Zhanling Zhang, Keke Zhang, Hongxin Shi, and Gaojian Ding, JMEPEG, Vol. 20, (2011) 355–358. https://doi.org/10.1007/s11665-010-9703-4

[2] Shawon M.R.A., Gulshan F., Kurny A.S.W., J. Inst. Eng. India Ser. D, Vol. 96(1), (2015) 29–36. https://doi.org/10.1007/s40033-014-0060-6

[3] Hasanbasoglu A., Kacar R., Materials and Design., Vol 28, (2007) 1794–1800. https://doi.org/10.1016/j.matdes.2006.05.013

[4] Charde N., Rajkumar R., Investigating spot weld growth on 304 austenitic stainless steel (2 mm) sheets". Journal of Engineering Science and Technology, Vol. 8, N° 1, (2013) 69–76.

[5] Kianersi D, Mostafaei A., Amadeh A.A., Materials and Design, Vol. 61, (2014) 251-263. https://doi.org/10.1016/j.matdes.2014.04.075

[6] Jagadeesha T., Sarvoththama Jothi T.J., Int. J. Adv. Manuf. Technol. DOI 10.1007/s00170-015-7693-y.

[7] Ali I., Khan M.I., Mooed K.M., Investigation of the effect of spot welding process parameters on mechanical properties of spot welds made on ASS 304 and ASS 2020 Steels - A Comparative study. International Journal of Advanced Multidisciplinary Research, vol. 2(6), (2015) 60–64.

[8] Lebbal H., Ziadi A., Berrekia H., Boukhoulda F.B., Latin American Journal of Solids and Structures, Vol. 13, pp. 1228-1235, 2016. https://doi.org/10.1590/1679-78252271

[9] Gean A., Westgate S.A., Kucza J.C., Ehrstrom J.C., Static and fatigue behavior of spot welded 5182-O aluminum alloy sheet, Welding Journal, vol. 78, (1999) pp. 80-86.

[10] Mohite1 N.T., Bagi. J.S., Optimization of geometrical parameters of resistance spot welding process for strength of welded joints. International journal of emerging engineering research and technology, Vol. 2(5), (2014) 60-66.

[11] Hassanifard S., Zehsaz M., Esmaeili F., Journal of Mechanical Science and Technology, Vol. 25(3), (2011) 647-653. https://doi.org/10.1016/j.matdes.2012.06.055