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Study Of Spot Welding Of Austenitic Stainless Steel Type 304

[1]J.B. Shamsul and [2]M.M. Hisyam

[1]School of Materials Engineering, Universiti Malaysia Perlis
[2]Kompleks Pusat Pengajian 2, Taman Muhibbah, Jejawi, 02600 Arau, Perlis.

Abstract: In this study, austenitic stainless steel type 304 were welded by resistance spot welding. The relationship of nugget diameter and welding current was investigated. Hardness distribution along welding zone was also investigated. The results indicated that increasing welding current gave large nugget diameter. The welding current did not much affected the hardness distribution.

Keywords:

INTRODUCTION

Resistance spot welding is usually used in the fabrication of sheet metal assembly. It can be used to weld materials such as low carbon steel, nickel, aluminum, titanium, copper alloy, stainless steel and high-strength low alloy steel. Resistance Spot welding process is most applicable in the industrial fields of manufacture and maintenance (car industry, aerospace and nuclear sectors, electronic and electric industries). Murat *et al.,*[1] have studied on the resistance spot weldability of galvanized interstitial free steel sheets with austenitic stainless steel sheets. In microhardness measurements, the maximum hardness values were in the middle of the weld nugget. Emin Bayraktar et al. [2] have contributed their research on the selection of optimal welding conditions and developed new grade steels for automotive applications. The study based on impact tensile testing to spot welded sheets. The effect of nucleus size on mechanical properties in electrical resistance spot welding of chromide micro alloyed steel sheets was investigated by Aslanlar[3]. Bouyousfi *et al.,*[4] have studied the effect of process parameters (arc intensity, welding duration and applied load) on the mechanical characteristics of the weld joint of austenitic stainless steel 304L. The results showed that the applied load seems to be the control factor of the mechanical characteristics of weld joint compared to the welding duration and the current intensity. Nizamettin K.[5] has focused his study on the influence of welding parameters on the joint strength of resistance spot-welded titanium sheets. The results indicated that increasing current time and electrode force increased the tensile shear strength and the joint obtained under the argon atmosphere gave better strength. Hardness measurement results showed that welding nugget gave the highest hardness. The argon gas used during the welding process was seen to have no influence on the hardness values. This paper presents the effect of welding current on the physical properties of austenitic stainless steel type 304.

MATERIALS AND METHODS

Spot Weld Test Samples: The samples for this experimental procedure were produced based on dimension that was stated by American National Standards Institute (ANSI) and American Welding Society (AWS). This standard dimension for each plate to be spot welded is 76mm length and 19mm width, while the overlap for the lap joint is 19mm (Figure 1). A numbers of stainless steel 304 plates with the thickness of 3mm were cut into the standard dimension, placed as lap joint and then spot welded, producing 27 pieces welded samples. Before starting the welding process, it is important to make sure that the setting on the spot welding machine is as required. The spot welding machine has two important dials which is one for the welding current and another is for the welding duration. Another important step before starting the welding process is to turn on the water supply for the electrodes. This is for cooling the electrodes during the welding process. Two stainless steel plates were placed as a lap joint in between two water cooled electrodes. These plates were then clamped by the electrode where on the same time; current is flowing through the joint for a few seconds depends on the machine's setting. It is important to make sure that the electrodes clamp the joint at the centre of the overlap. The welding current that was used varies from 2.5kA, 3.75kA, 5kA and 6.25kA, as the cycle remains constant which is four cycle.

Corresponding Author: J.B. Shamsul, School of Materials Engineering, Universiti Malaysia Perlis.
E-mail address : sbaharin@unimap.edu.my

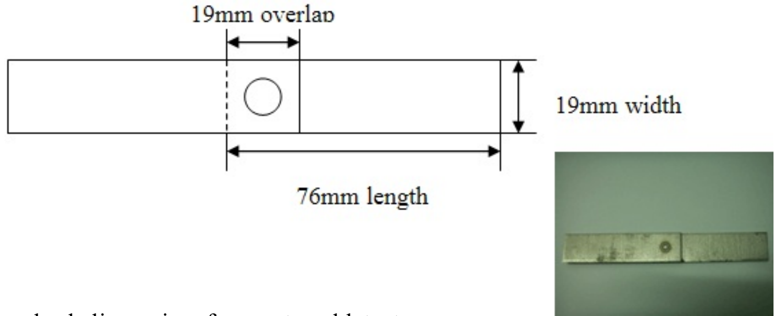
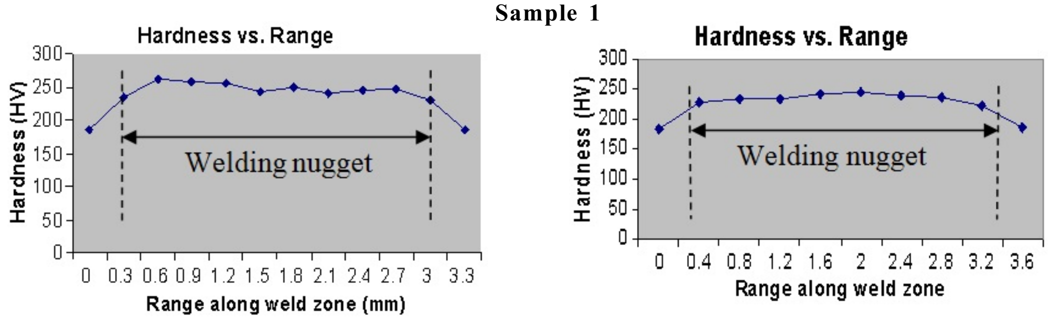


Fig.1: ANSI/AWS standard dimension for spot weld test.

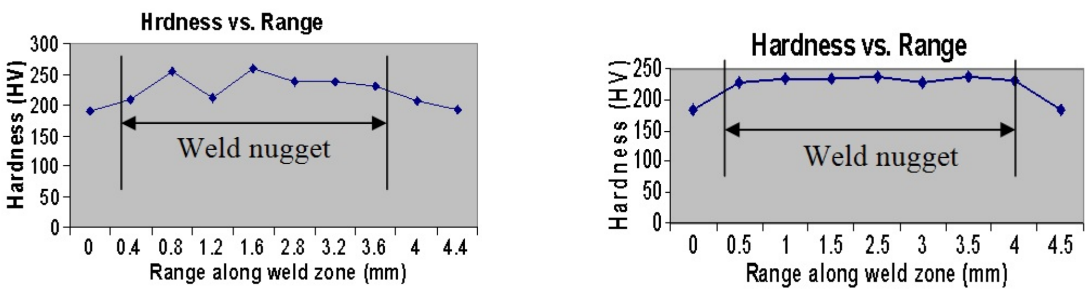
Sample 1



(a) **(b)**

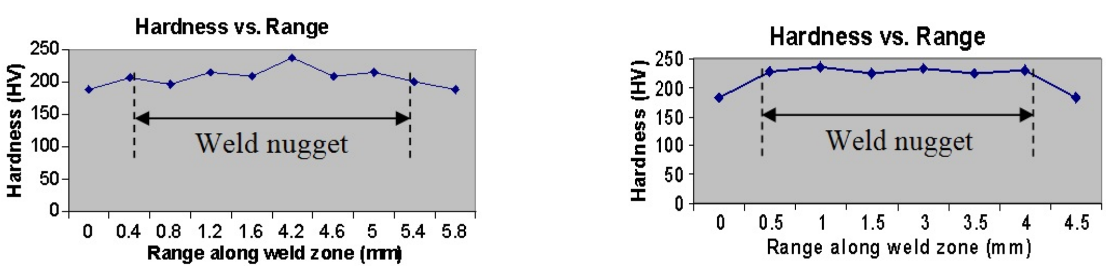
Fig. 1: Graphs of the microhardness distribution across weld nuggets.

Sample 2



(c) **(d)**

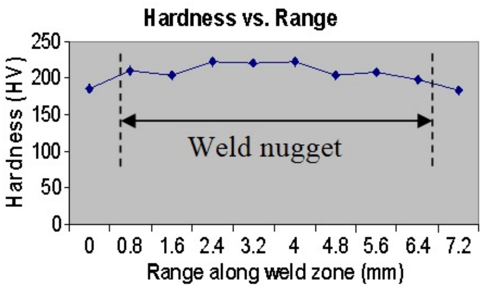
Sample 3



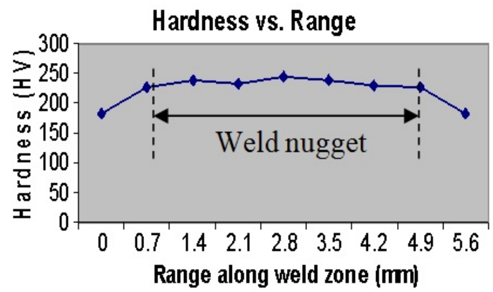
(e) **(f)**

Fig. 2: Graphs of the microhardness distribution across weld nuggets.

Sample 4



(g)



(h)

Fig. 3a: Graphs of the microhardness distribution across weld nuggets.

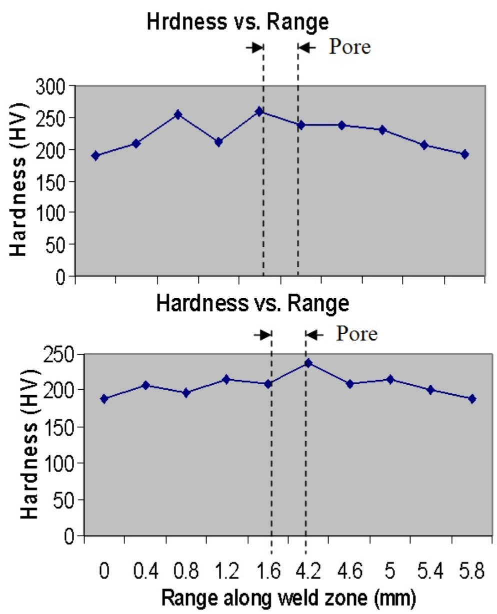
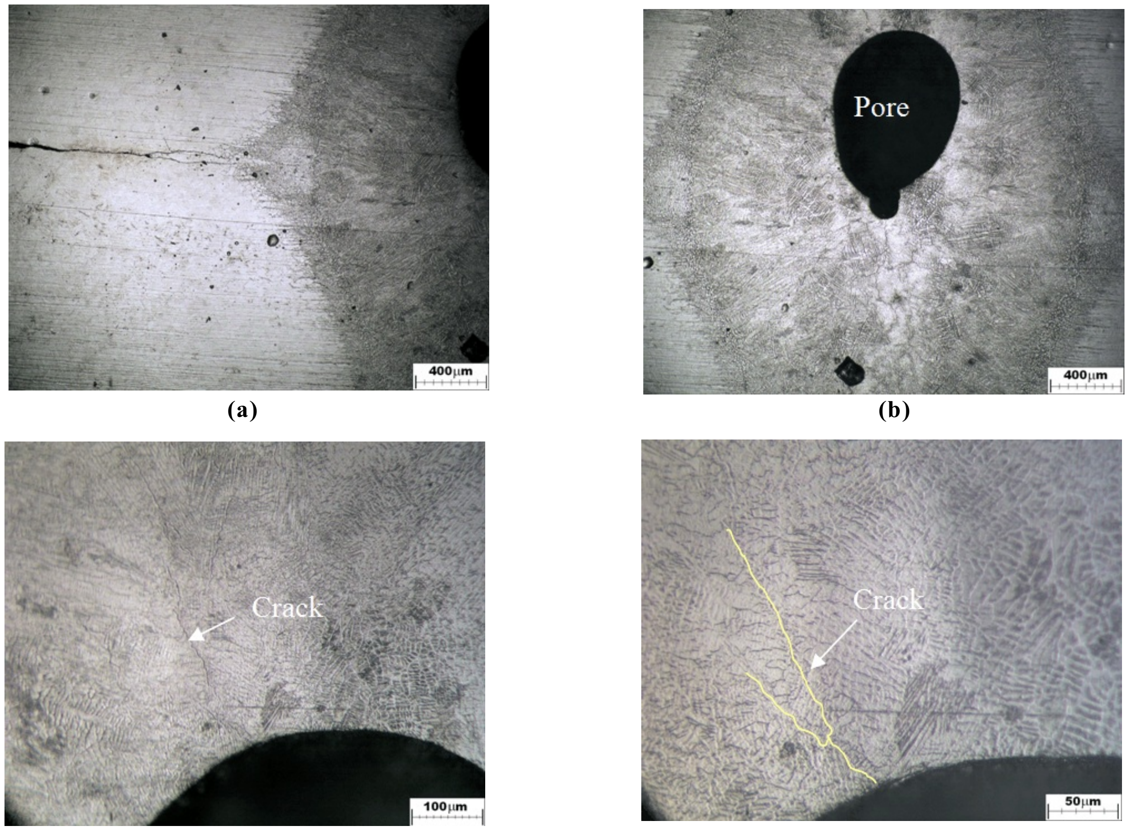


Fig. 3b: Hardness distribution for sample 2 and 3; showing pores.

After the current was cut off, the electrodes were let to remains clamping on the joint. This is to forge molten metal of the weld as it cooled. The materials studied are austenitic stainless steel type 304. The specimens were placed on each other and the welding current was changed from 2.50, 3.75, 5.00 and 6.25 kA during welding process.

Microhardness Test Samples: The weld joint was in the middle of the spot weld to obtain the cross section of the weld. Precision diamond cutter machine was used for this purpose. The cutting processes of these samples have taken a very long period as they have high strength property and the slow cutting speed of the precision diamond cutter machine. Cutting using this machine is a must as to obtain the unaffected weld surface of the spot welds. Cutting with using a normal high speed cutter such as Metacut abrasive cutting machine, will effect and damage the cross section surface of the weld. The heat generated by the normal cutter will affect the weld surface as they may experience heat treatment. These cross sectioned samples were then cut into small pieces with length about 10mm by using Metacut abrasive cutting machine. The reason for this step is to make the samples easier to be cold mounted. A few small pieces of PVC pipe have been cut as the moulds for cold counting. Then, a resin mixture with the composition of 98% resin and 2% catalyzer has been made. The PVC moulds were then placed on the flat tile and sealed with clay to avoid the resin mixture from leaking. The cold mounted samples were ground and polished. Grinding was carried out using abrasive sand papers that have grades such as 240, 360, 400,



(a) **(b)**

c **(b)**

Fig. 4: Microstructure of sample 3 (a) and (b) with magnification of 50X, and (c) with magnification of 200X and (d) with magnification of 400X.

600, and 800 and 1200, starting with the roughest till finest grade. Then these samples were polished with diamond solution followed by alumina. Mitutoyo Vickers Microhardness, Model HM-114 was used to measure hardness.

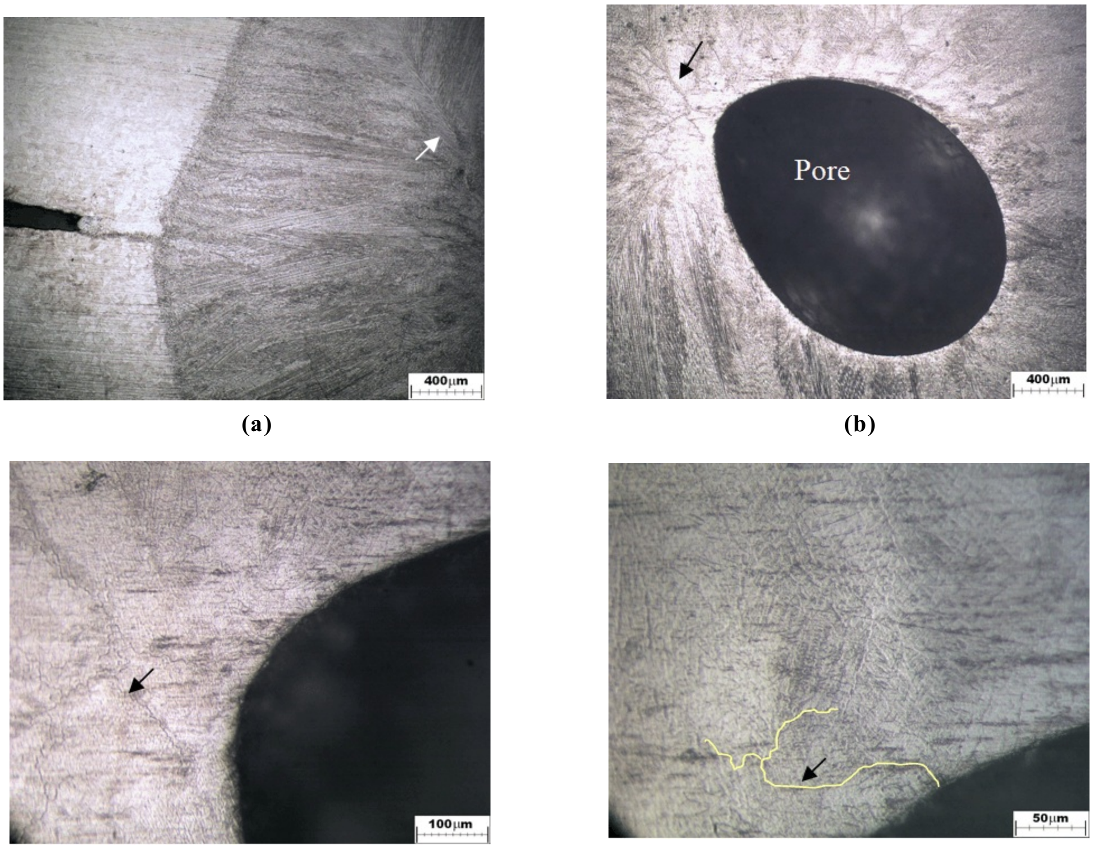
RESULTS AND DISCUSSIONS

The diameter of each nugget were measured and shown in Table 1. From this table, it is proven that the weld nugget increases with the increasing of welding current. Weld nugget for sample 4 with welding current of 6.25kA has the widest diameter of all samples. As noted in [5], the increasing nugget diameter has a limit. The continuing increased welding currents that surpass this limit will cause the nugget diameter to become shorter or decreased as the result of the excessive metal melting and splashing in the interlayer. As shown in the Table 1, the decreasing of nugget diameter cannot be observed as the diameter continues to increase till the final welding current used. This means that the welding current should be increased beyond 6.25kA to show the decreasing of nugget diameter for the constant welding duration.

Table 1: Nugget diameters produced by each applied welding current.

Samples	Welding Current (kA)	Nugget Diameter (mm)
Sample 1	2.50	3
Sample 2	3.75	3
Sample 3	5.00	5
Sample 4	6.25	6

Microhardness testing was carried out on the cross-section samples across the horizontal and vertical of the nuggets. Three hardness readings were taken for each area spotted along the nugget diameter. The averages of these reading were then calculated for precision. Graphs of hardness versus range were then made using the values obtained (Figure 2). The graphs were studied to show the effect of hardness distribution along the weld nuggets due to the varied welding current. Generally, from the graphs, the weld nugget has higher values of hardness compared to the heat affected zone and base metal. When the graphs were evaluated it was found that the hardness distribution across molten metal or weld nugget for all sample were almost the same. This shows that by varying the welding current, the hardness distribution across the weld nugget was not much effected.



(a) (b) (c) (d)

Fig. 5: Microstructure of sample 3 (a) and (b) with magnification of 50X, and (c) with magnification of 200X and (d) with magnification of 400X.

In the study carried out by Murat *et al.,*[1]. the hardness distributions were measured starting from the centre of the weld, while in this study the measuring was started from left to the right part and below to the upper part of the weld nugget of each sample. This is due to the defect in the form of pores that were existed at the centre of weld nuggets for sample 2 and 3 (Figure 4 and Figure 5). Thus, for these two samples, the hardness measurement at the centre of weld nuggets cannot be obtained (Figure 3a,b). Compared to the hardness values that were obtained by Murat *et al*[1], the hardness values across nugget diameter of the samples were much smaller. This is because of the great differences in the parameters used such as the electrode force and sample thickness. Nizamettin Kahraman[5] reported the hardness measurement increased to some extent when the electrode force was increased and all the other parameters were kept constant. The hardness of the weld nugget depends on the amount of deformation during the holding time and resting time of welding process where the pressure was applied continuously. It seems that the electrode force that was applied in this study which is 150kgf was enough to cause the deformation in the weld nugget that produces the maximum hardness.

Conclusion: Austenitic stainless steel AISI-304 is an extremely important commercial alloy due to its excellent corrosion resistance, high strength, good ductility and toughness. In this study, two plates of these steel were placed as a lap joint and spot welded using varied welding current. The results show that increasing welding current increased the nugget size. The nugget size does not influence the hardness distribution. In addition, increasing welding current does not increase the hardness distribution

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