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# Investigate of the influence for multiple resistance welding currents in austerities nickel-chromium alloys on welded joints mechanical characteristics

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## ABSTRACT

We have studied the shear strength, with regards to 302 "austenitic stainless steel spot welds". It is undeniable that the current for a welding within resistance spot welding development (RSW) shows a very important character. Nevertheless, these effects of this item are popular so it has been considered widely all through literature works. Our aim in this work is to show the effect of heat treatment on different joints welded at multiple currents. The experimental results demonstrate about a tensile shear strength that could be increased together along with the increasing in refer to current. Annealing treatment increases escorted by tensile shear strength as a size of grain reforms, in addition the remaining stresses removed. Refinement of grain serves to be an operative practice for a strength improvement. With that, the tensile; shear strength could be increased through having the annealed temperature of treatment reached; 750 C°. Regardless, at 850 C°, the tensile shear strength decreases.

**Keywords**: Resistance welding, Tensile Strength, Annealing, Austenitic Stainless Steel

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## 1. Introduction

Resistance spot welding as characterized: (RSW) is the procedure based on merging two or also three metallic sheets. Through the approach of fusion appearing in dis- joined spots, appearing in the sheets interface as administered in (Fig. 1). Fusion happens according to the generation of the heat result from current flow resistance via the metallic sheets. Hence, temperature escalates located on faying faces up until it gets near the metal plastic point, furthermore, at elevated temperature a metal starts toward fuse also this will yield that nugget. After switching off a current, the weld nugget be found let to cool until it becomes hardened under the given pressure. The heat generation taking place in any welding process increases the amount of molten metal connecting the pieces. It further highlights the fact that the current in RSW plays a significant role in this issue.

RSW process is reliant on the fusion between the sheets' metal using a combined work of pressure and heat. The amount of heat is generated due to the electricity that resists the current flow at the work pieces' interfaces. This is when the nugget between the faying surfaces is produced [1,2]. The resistance in respect to a circuit and the periodical duration in regard to flow current leaves an impact on the heat generation, but rate is lower [2,3,4].

RSW plays its part as an active technique to join metallic sheets in the production of various items [1,5,6,7,8,9,10]. It is typical for a car body to have thousands of spot welds to join the sheets of various metals and levels of thicknesses [11, 12]. Therefore, the process is used extensively to help bring together the: low carbon steel; stainless steels; also galvanized steel components, as their applications are multifarious [13,14,15].

Of late, aluminum alloys are also used in the automotive industry for bodies because the weight to strength ratio is deemed appropriate [8], [16]. The miscellaneous materials also are welded to get a best combination related to properties.

The cracking, insufficient weld depths, lack of penetration LOP, and cavitations of the nugget are named as the top reasons for the toughness reduction and failure, see Refs. [17]–[32]. The selection of suitable welding conditions would play a significant role to determine the toughness [20]–[22], [25].

Stainless steel is a common material in various medical devices due to the fact that the corrosion resistance is biocompatible, and there is an element of fracture toughness [33]. To keep the fracture toughness and other properties, post weld heat treatment would be a good idea.

This work takes a closer look into the effect of heat treatment on the joint toughness of 302 austenitic stainless steel. In comparison, the welding current was altered. Thus, this work ascertains the reason of crack in the spot weld of stainless steel 302.

## 2. Experimental work material

The AISI 302 austenitic stainless sheets of steel have been employed. Following their resistance to corrosion, high ductility, and the good weldability, it has many applications.

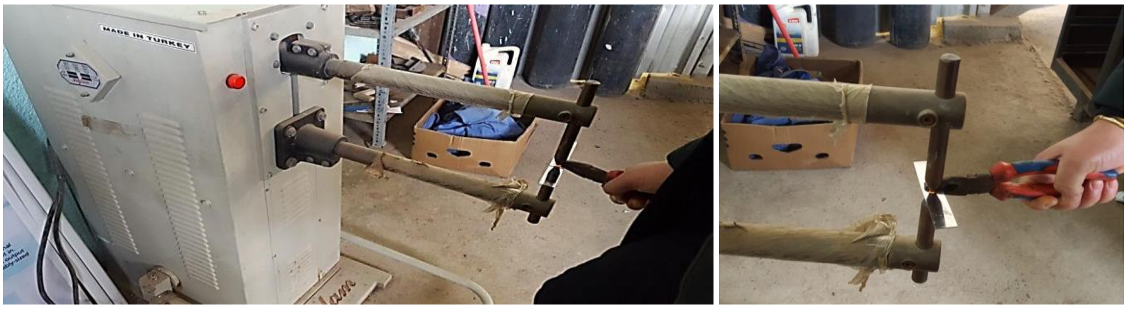

Figure 1. Welding process by RSW machine

302 austenitic stainless steels offer a useful resistance to corrosion on of the extensive range of moderately oxidizing to moderately reducing environments.

The 302 austenitic stainless alloy compared to the 305 austenitic stainless is greatly used in equipment and utensils to process and handle food, beverages and dairy products. Heat exchangers, piping, tanks and other process equipment that have contact with fresh water also use these alloys. The initiative of constructing facades and other architectural and structural applications open to non-marine atmospheres also means that 18-8 alloys are heavily utilized. This is additional to a wide array of applications involving household and industrial chemicals according to mechanical properties [34]. The specimens have been prepared following the American Welding Society Standard (ASTM)'s guideline [20] [22][25][35].

The plate thickness is measured at 1 mm. The chemical composition and mechanical properties based on the ASTM specifications A 240 and ASME specification SA-240 are shown in (fig. 2 and 3), respectively, see Ref. [36].

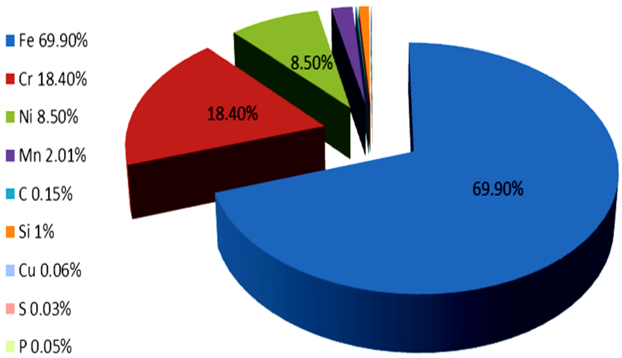


Figure 2. Chemical composition for Stainless Steel 302

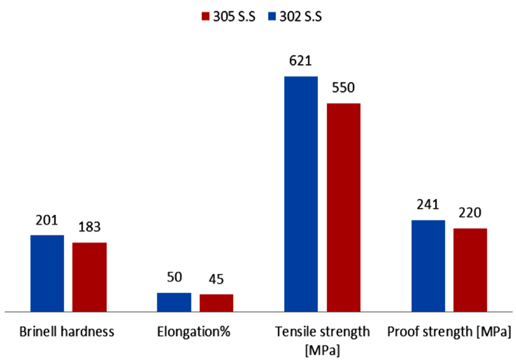


Figure 3. Mechanical properties of S.S 302 [36,37]

### 2.1. Specimen preparation

The geometry testing and the dimensions of the specimens are guided by a standard set by American National Standard Institute (ANSI) and the American Welding Society (AWS) - this can be referred to in figure 4. They are welded based on ANSI and AWS [38, 39].

The specimens were cleaned prior to the welding to get rid of the contaminations; hence, the resistance variation of the surfaces will be reduced [41].

The lap shear specimens according to AWS/ANSI standards are extensively used to test the weldment joint, welding defects and failure mode [11, 41, and 42] in a systematic manner.

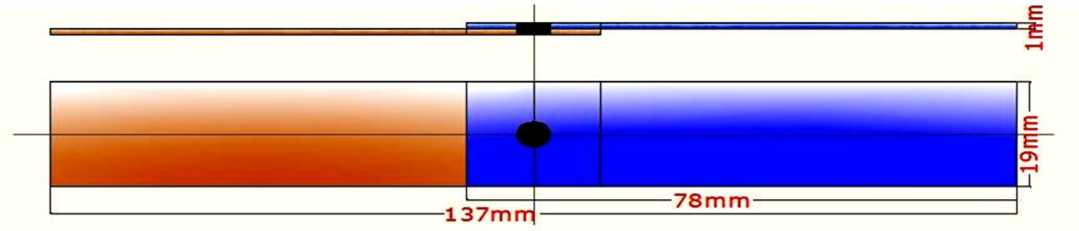


Figure 4. The spot welds specimen's dimensions, according to ANSI/ AWS standard

### 2.2. Process and machine

Welding process was performed with the help of a pneumatically operated machine. The welding current is directly controlled. The electrodes in this machine were 5 mm end diameter. The specimens were welded by means of setting the welding time at 0.25 seconds, and 4 bar electrode pressure, and diversifying the current from 1 kA to 5 kA, see (Fig5). Five joints have been prepared for each current value. Four of them have been subjected to heat treatment under different temperatures, hence, the tensile shear strength is to be analyzed, see Table 1.

### 2.3. Improve the tensile shear strength of resistance spot weldment by annealing treatment

Heat treatments give a significant effect on the mechanical properties. Heat treatment is given to austenitic stainless steels so that the precipitated chromium carbides can be dissolved. In this work annealing treatment has been applied at varying temperatures. The specimens have been cooled inside the furnace slowly.

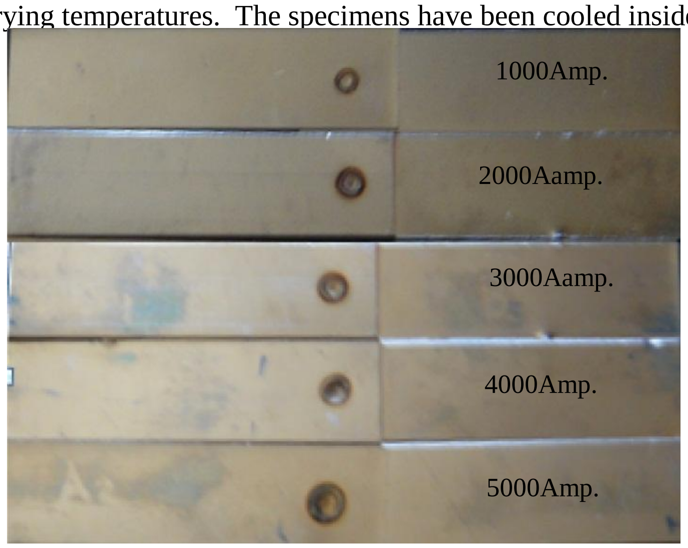


Figure 5. Photograph of spot welding specimens at varying values of welding current

## 3. Results and discussion

### 3.1. Tensile-shear strength test

Using the conventional tensile shear lap specimens, the tensile strength was measured based on the AWS standard practice, see Fig. 3. The results are provided in Table 1.

### 3.2. Effect of welding current

The current has a great effect on the tensile shear strength as shown in the experimental work, see Refs. [20,22,25]. The higher welding current from 1000 to 5000 Amp, causes higher shear force of joint.
The higher heat generation at the faying interface is resulted from the increase in the welding current and this further leads to the formation of larger weld zone (nugget zone) and in the increase of the overall bonding area. These results have been in line with many studies [23],[33],[77],[79] and [80]. These results come about, following the greater size of weld size and weld penetration studied by [79].
The increase in the welding current causes an increase in size of the weld nugget at such a rapid pace, and this is illustrated in (fig. 5).
The increasing welding current increases the melting zone, and this further increases the weld area and strength. The results are seen to be in line with different studies, see Refs. [3,43,44], see Fig. 6.

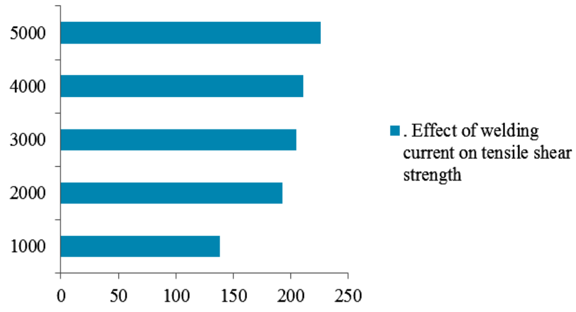


Figure 6. Effect of welding current on tensile shear strength

Table 1. Authenticity relevant to annealing upon the tensile force strength

| "Annealing" Temp. [°C] | Welding current ( Amp ) | Shear strength [MPa] |
|---|---|---|
| 500°C | 1000 | 145 |
| | 2000 | 205 |
| | 3000 | 209 |
| | 4000 | 213 |
| | 5000 | 232 |
| 600°C | 1000 | 150 |
| | 2000 | 210 |
| | 3000 | 215 |
| | 4000 | 225 |
| | 5000 | 235 |
| 700°C | 1000 | 153 |
| | 2000 | 218 |
| | 3000 | 220 |
| | 4000 | 227 |
| | 5000 | 237 |
| 800°C | 1000 | 130 |
| | 2000 | 189 |
| | 3000 | 200 |
| | 4000 | 205 |
| | 5000 | 218 |
| as welded | 1000 | 138 |
| | 2000 | 193 |

| "Annealing" Temp. [°C] | Welding current ( Amp ) | Shear strength [MPa] |
|---|---|---|
| | 3000 | 205 |
| | 4000 | 211 |
| | 5000 | 226 |

### 3.3. Effect of annealing treatment

The annealing works wonders in improving the mechanical properties. By warming up the specimen to a certain temperature and slow cooling in the furnace later, this enhances of grain proportions further then subsequently release the left stresses, see Refs. [20,22,25,28,29]. Thus, grain refinement is still effective towards improving the strength [46], see Fig. 7.

The shear strength increases with the higher annealing temperature up and around to: 750 °C, At: 850°C, the tensile value of shear strength will decrease and goes further down- the weld nugget stays in an ideal condition (i.e. at 5000 A), however. (See Fig. 5).

This phenomenon has been determined for the first time in the spot weld nugget of austenitic stainless steel, see Refs. [21,30]. The cracks will have started at the temperature higher than 750 °C. These cracks will definitely damage the structural integrity of the joints and failure will be imminent, see Fig. 5.

The Pearlite, and Austenite have been converted into Cementite At 800 °C. Therefore, this varying solidification rate will lead to the onset of cracks. That also appears if we reduce the elongation, see (Fig. 8) which draws a comparison between the tensile shear strength values at 800C̊ annealing temperature and without annealing at different welding currents.

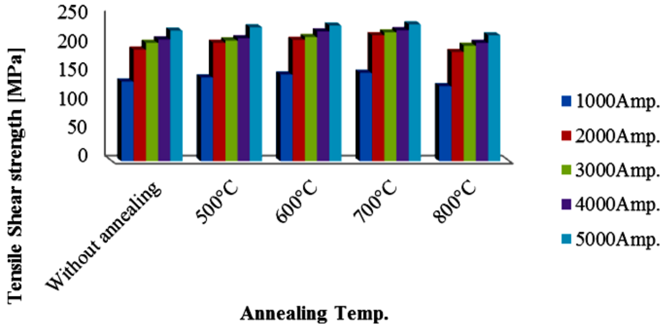


Figure 7. Effect of annealing temperatures on tensile shear strength

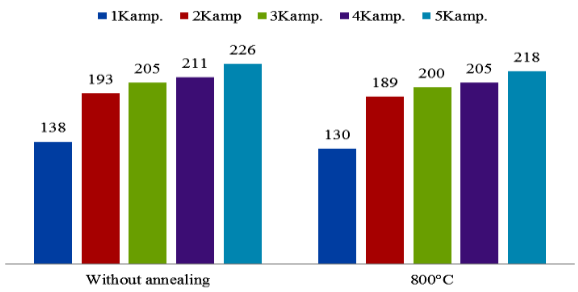


Figure 8. Tensile shear strength Comparison; (at annealing temperature of 800C̊; and with hout annealing) at varying welding current

## 4. Conclusions

Mechanical interactions and feature with regards to spot welding enhanced when a welding relevant to current is increased. Remaining stresses are tempted in the spot weld range because a great quantity appertaining to heating is induced within a metallic sheet very briefly. Post welds related to heat treatment temperatures have been adapted and the finding reveals that the strengthening treatment could perfects the grain bulk size so for eliminates best of the remaining stresses. Therefore, the strength force will be enriched up toward the annealing temperature touching on 750C°. The annealing temperature exceeding 850 C° will lower the tensile force within shear strength. This is with respect to the validity that: a transformation around the austenite grains increasingly to a Cementite provides further hardness and slight elongation. Next, the differences inside the range of solidification rates between compounds have led to the formation of cracks.

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