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The Investigation of Microstructure and Mechanical Properties of Austenitic Stainless Steel Joints Obtained by Different Welding Methods and Different Welding Parameters

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***Abstract* –** In this study, two different welding methods as TIG and TIG Pulse are used for joining 304 series stainless steel sheets having 2 mm thickness. In preparation of welded specimens were used three different welding currents ranging from 70 A to 110 A by rise of 20 A.. The microstructure differences of the weld joints obtained by using two different welding methods and three different welding currents were investigated. Tensile specimens prepared according to standards were exposed to tensile testing at as speed of 20 mm/s. Fracture surfaces obtained from tensile test of welded specimens were examined and their mechanical properties were compared.

Keywords – TIG Welding, TIG Pulse Welding, Austenitic Stainless Steel

I. Introduction

Stainless steels are called iron-based alloys containing at least 10.5% Chromium surfaces of stainless steels have a chromium oxide layer. This layer is providing high corrosion resistance and prevents the oxide from entering and proceeding in the steel. There are five different types of stainless steel alloys according to the alloying elements contained. There are five different types of stainless steel alloys according to the alloying elements contained and these are given below.

1. Austenitic Stainless Steel
2. Martensitic Stainless Steel
3. Dual - phase Stainless Steel
4. Precipitation Hardening Strengthens Stainless Steel
5. Ferritic Stainless Steel [1,2].

Austenitic stainless steels have wonderful formability and high corrosion resistance, is also the most well-known type of stainless steel. These steels are the most commonly used types of steel and the most widely used because they show superior features in terms of cheapness, aesthetics, weldability and formability than the others steel types. Thanks to these properties are used in many different areas such as built-in kitchen, automotive, mine vehicles, railings, sheep industry etc. [3-4].

The most widely method used to joining the stainless steels is gas metal arc welding method. However, there are some problems caused by the heat effect during welding of stainless steels [5-11].

1) Sedimentation of chromium carbide (CrC) because of high heat input

2) Resulting of hot cracks on weld area because of rapid cooling

3) Formation of sigma phase because by increased heat time [7-12].

In this study, the effect of the welding method and the welding currents on the joining of two different welding methods and three different welding current densities were investigated.

II. Materials and Method

304 series austenitic stainless steel sheets have 2 mm thickness were used during all experiments and were welded by TIG and TIG Pulse welding methods in butt welding position. Three different welding current density were selected such as 70 A, 90 A and 110 A for both methods. The welded plates obtained are shown in FIG.1

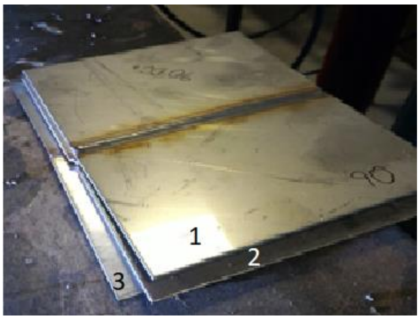

Figure 1. Welded plates

Tensile test specimens were cut using a water jet according to the standards such as 20x200x2. Measurements of tensile test specimens as schematic are shown FIG 2. The chemical composition and mechanical properties of the 304 L austenitic stainless steel was shown at Table 1 and Table 2 respectively

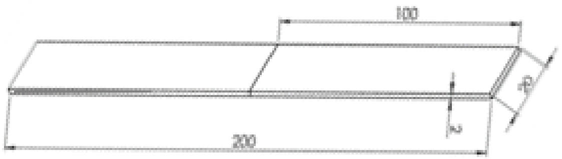

Fig. 2. Measurements of tensile test specimens

Table 1. The chemical composition of the 304 L austenitic stainless steel

%C	%Mn	%P	%S	%Si	%Cr	%Ni
0.08 max	%2.0 max	0.04 max	0.03 max	1 max	18-20	8-10

Table 2. The mechanical properties of the 304 L austenitic stainless steel

Tensile Strength (MPa)	515 - 720 MPa
Yield Strength,(%0,2)(MPa)	205 MPa (min)
Brinel (HB)	201(max)
Rockwell(HRB)	92 (max)
Elongation (%)	40

308 L welding wire was used as additional material for joining stainless steel during welding in all experiments. The chemical composition and mechanical properties of 308 L welding wire were shown at Table 4 and Table 5 respectively.

Table 3. Chemical composition of 308 L welding wire

%C	%Mn	%Si	%Cr	%Ni
< 0.03	1,0 -2,5	0,30- 0,65	19,50 -22,00	9-11

Table 4. Mechanical properties of 308 L welding wire

Yield Strength (N/mm^2)	380
Tensile Strength (MPa)	570
Impact strength (J)	100
Elongation (%)	40

Test specimens obtained as shown in FIG. 2 were exposed to test at as speed of 20 mm/s by a 30 tons capacity tensile test machine.

Three micro-structure and microhardness samples were prepared for each parameter by metallographic methods such as grinding, polishing, and etching processes. Microstructure images were obtained with a metal microscope and were analysed. Micro hardness measurements were made for each parameter from 3 different points at heat effected zones of welded joints.

III. Results and Discussion

1. Tensile Test Results

Tensile strength, yield strength and elongation values was measured at results of tensile test of three different welded specimens in butt welding position at two different welding methods. The arithmetic average of the obtained values was compared with the welding wire and the main material. The tensile strengths (Rm) and yield strengths (Re) of the welded joints obtained by the TIG method and TIG pulse method are given in table 5 and table 6, respectively. The graphs of the obtained values are shown in Figure 3 and Figure 4., respectively.

Table 5. The tensile strengths and yield strengths of the welded joints obtained three different welding currents in TIG method

Welding Current	Rm	Re
70	661	327
90	560	289
110	396	252

Table 6. The tensile strengths and yield strengths of the welded joints obtained three different welding currents in TIG Pulse method

Welding Current	Rm	Re
70	350	254
90	377	263
110	415	274

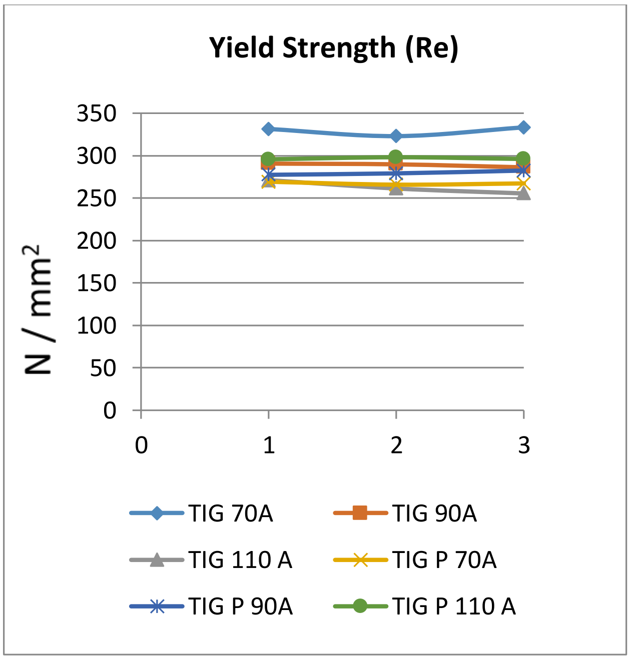

Figure 4. Yield Strengths of welded specimens

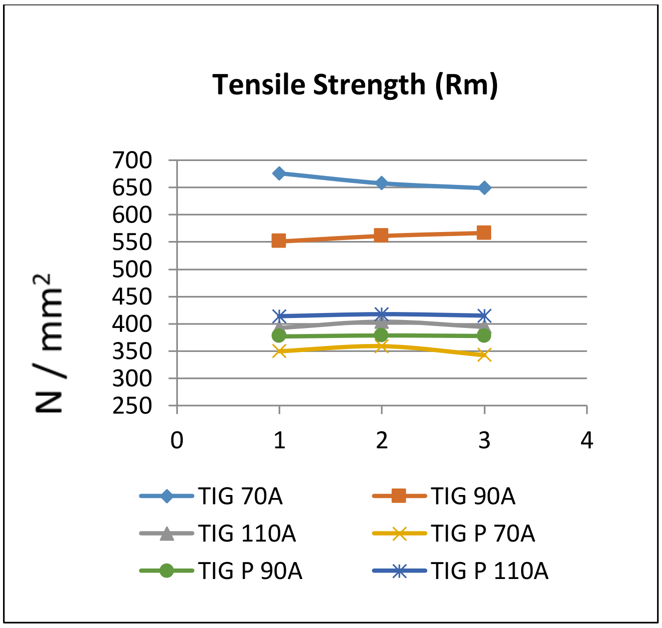

Figure. 4. Yield Strengths of welded specimens

2. Results of Microstructure

Metallographic processes have been applied to examine the microstructure properties of welded joints obtained with 3 different welding currents and two different welding methods. these operations are grinding (#180, #240, #320, #400, #600, #800, #1000, #1200), polishing (6µ and 3µ) and etching (%3 Nital- 15s).

In the selected welding currents (70A, 90A and 110A), while the welding current intensity increased, the dendritic grain size increased in microstructures. it was observed that the grains were directed from the transition zone towards the welding centre. The microstructure pictures (70 A, 90 A and 110 A) are shown in Fig 5, Fig 6 and Fig. 6, respectively.

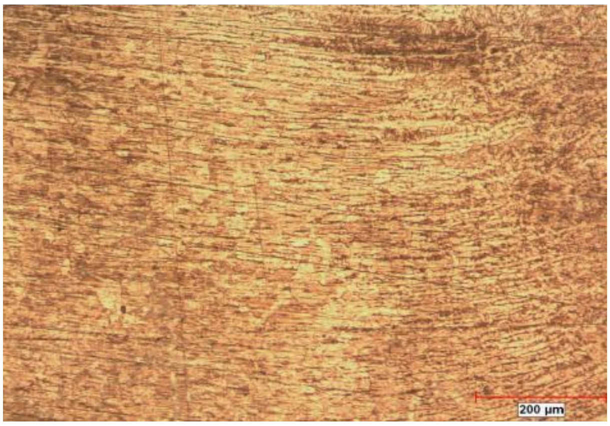

Figure 5. Microstructure image obtained in 70 A welding current

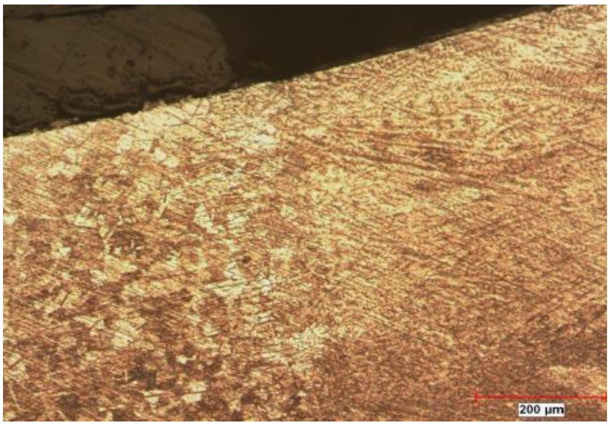

Figure 6. Microstructure image obtained in 90 A welding current

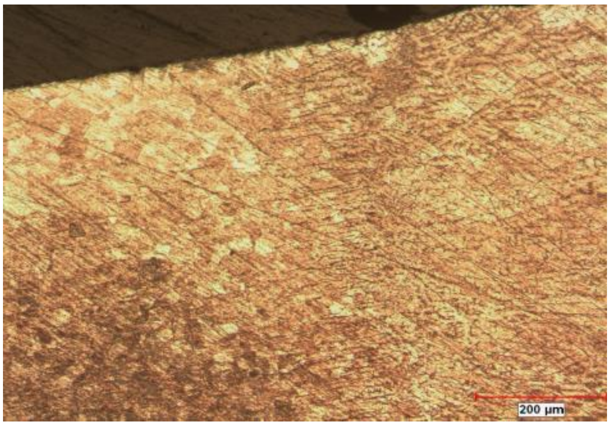

Figure 7. Microstructure image obtained in 90 A welding current

In the selected welding currents (70A, 90A and 110A) in TIG Pulse welding method, while the welding current intensity increased, the dendritic grain size increased in microstructures. this increase is not as high as in the TIG method. The growth of the dendritic structure is directly proportional to the increase in heat input. The microstructure pictures (70 A, 90 A and 110 A in TIG P method) are shown in Fig 8, Fig 9 and Fig. 10, respectively.

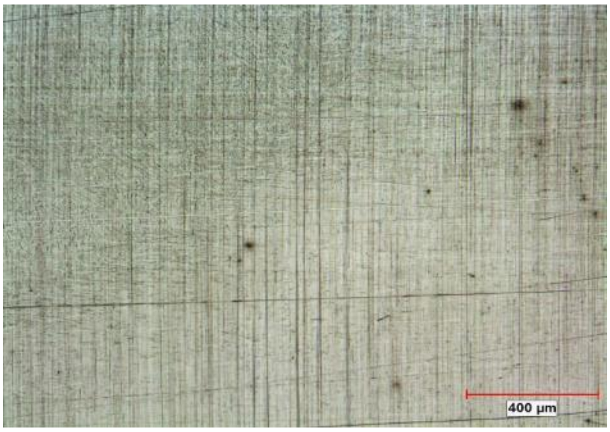

Figure 8. Microstructure image obtained in 70 A welding current in TIG P method

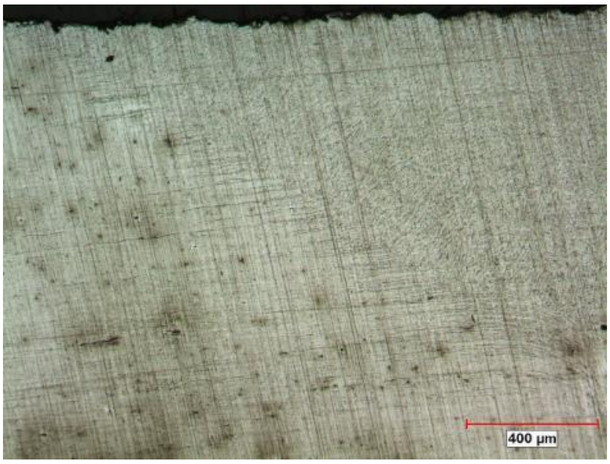

Figure 9. Microstructure image obtained in 90 A welding current in TIG P method

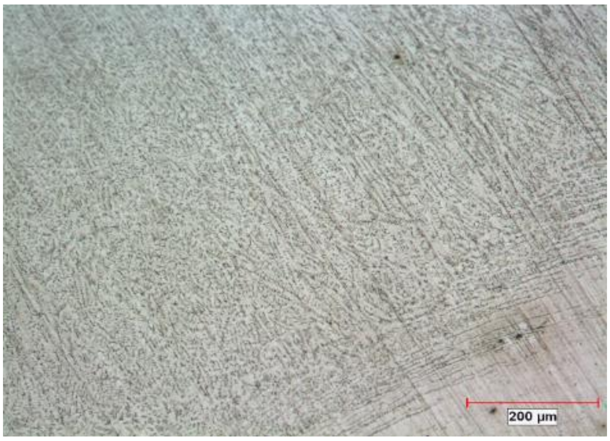

Figure 10. Microstructure image obtained in 110 A welding current in TIG P method

It has been observed that when the heat input increases, the tensile strength decreases in TIG welding method but when the heat input increases, the tensile strength increases in TIG P welding method.

IV. CONCLUSION

In this study, TIG and TIG Pulsed welding process were used as joining of 304 series stainless steels. Three different current intensity (70 A, 90 A and 110 A) were selected as the welding current intensity. Microstructural analysed and mechanical properties were determined.

As a result of this study,

1. Maximum tensile strength values as 661 MPa at 70 A, value as 560 MPa at 90 A, value as 396 MPa at 110 A were obtained in TIG welding method.

2. Maximum tensile strength values as 415 MPa at 70 A, value as 377 MPa at 90 A, value as 350 MPa at 110 A were obtained in TIG P welding method.

3. It has been observed that mechanical properties are increased with changing the welding parameters. It has been determined that decrease of heat input will have a positive effect on the mechanical properties.

4. It has been thought that CrC precipitation may be prevented with decreased of heat input.

5. It has been that CrC compound formed has a negative effect on the mechanical properties of welded joints in the welding of stainless steel according to literature.

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