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The Effect of GTAW Welding Current on the Strength of AISI Steel 1045

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ABSTRACT

Welding is a process of joining materials by melting metal at high temperatures. Gas Tungsten Arc Welding (GTAW) is one of welding method to join metals. This welding process will affect the mechanical properties of a material. So, it is necessary to conduct a study on changes in mechanical properties that occur. This study aims to determine the mechanical properties of AISI 1045 medium carbon steel using the GTAW welding process with a current variation of 80 A and 100 A. The welding was used the AWS EWTh-1 tungsten electrode and ER70S-G filler wire. The type of connection was used a butt weld joint and a single V groove seam with an angle of 60^o. The standard of ASTM E8 was used for the manufacture of tensile test specimens. The results of tensile testing with welding current of 80 A was obtained an average stress of 518.463021 N/mm^2 and the strain of 19.55%. For welding with a current of 100 A, the average stress was 548.814727 N/mm^2 and the strain of 26.44%. Based on the fracture that occurred in the specimen, the critical area for fracture was the Heat Affecting Zone (HAZ), which the area has undergone a phase change during the cooling process. The weld area of connection part in the welding process has higher strength than the HAZ area.

KEYWORDS: *GTAW, Mechanical properties, Welding, Steel.*

1.0 INTRODUCTION

The AISI 1045 is a steel belonging to the carbon alloy steel, which is widely used as a construction material and as a component of machinery. The AISI 1045 steel has a carbon content of about 0.43% - 0.50% and belongs to the medium carbon steel group [1]. As the main material applied in machining, mechanical properties with certain specifications are needed such as in AISI 1045 steel using heat treatment methods with varying parameters.

The joining of two metallic materials with a heating technique called the welding process, which result in a change in the metal phase. Then, it undergoes a cooling process after the welding process is complete. The connection part has different mechanical properties from the parent metal according to the variations in the welding parameters that are carried out. That can affect the quality of connection of the material connection part.

Sugihrahma (2020) [2] conducted a study to investigate the effect of welding current on the mechanical properties of welding joints on low carbon steel with current variations of 100 A, 125 A and 150 A using SMAW welding and E7018 electrodes. Changes in mechanical properties can be seen in the tensile test results on the specimen. This indicates the welding current can influence on the strength of the welding joint [3],[4]. In addition, Yakin et al (2020) [5] also conducted research on changes in the mechanical properties of the welding joint. Research on changes in the mechanical properties of the welded joint was also conducted by Naufal et al (2016) [6] who in their publication stated that changes in the joint angle can affect the tensile strength of the joint.

To determine the quality of welding joints, it is necessary to analyze the strength of the joints [7],[8] and consider the application of welding parameters to the test results on welding samples [9][10]. According [11] conducted an analysis on the weld joint to determine the strength and critical parts of the welding joint. The results showed that changes in current still affect the strength of the connection. From the test sample, it can be seen that the fractured part is in the heat affected area of the welding area.

Differences in the pattern of heat treatment on cooling of the weld area can affect material properties as well as heat treatment and cooling in the formation of other steel materials [12][13]. Hardness is a mechanical property of the material, the heat treatment and cooling given to the steel material will produce different hardness values [14]. In this case, the optimal treatment must be obtained by performing various methods in order to produce the desired mechanical properties. Therefore, this paper aims to determine the mechanical properties of AISI 1045 medium carbon steel using the GTAW welding process with a current variation of 80 A and 100 A.

2.0 RESEARCH METHOD

In this research was used an experimental method with material specifications of AISI 1045 steel with a thickness of 12 mm. The welding process used the GTAW welding with EWTh-1 electrode type, which has a diameter of 1.6 mm. The argon gas was used in this research. The current strength was consists of 80 A and 100 A. Then, the type of connection was used a single V seam. The results of this welding were continued with the formation of specimens for tensile tests in accordance with ASTM E8 [15]. The bevel angle used 60°. The plate was welded in a 1G welding position using the GTAW (Gas Tungsten Arc Welding) welding type.

In Figure 1 is showed the dimension of the seam used in the preparation of the welding process referring to the AWS NUMBER 3 standard with a flat welding position (1G) Butt Joint Single V-Groove. This type of welding was chosen as a material to determine a good welding for a material when selecting a welding method.

The GTAW welding process on tensile test specimens in accordance with ASTM E8 (American Society for Testing and Materials) [15] in detail can be seen in Figure 3. It can be seen in Figure 3, the finishing specimen that has been joined by the GTAW welding method. In this tensile test, the number of samples was used 3 samples. The tests were carried out at various welding speeds and gas flow rate and voltage/current. All parameters or process variables of gas tungsten arc welding and possible connection types and their impact on tensile strength were analyzed.

The machine used for tensile testing on specimens was the Universal Testing Machine (UTM) as shown in Figure 4. In this study, tensile testing was used to measure the resistance of a material to slow static forces. One way to determine the magnitude of the mechanical properties of metals was by tensile test.

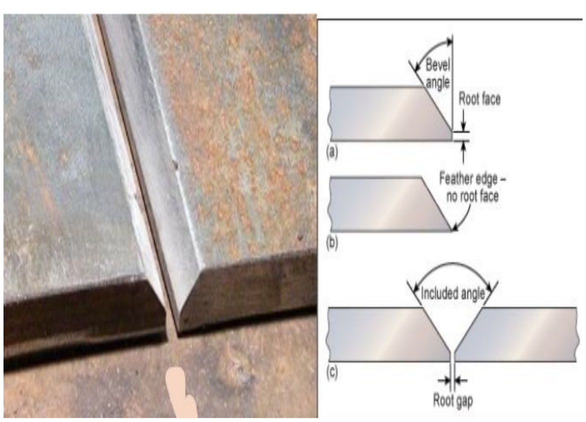

Figure 1: Specimen joint

Figure 2: Specimen welding

Figure 3: Specimens for tensile tests that have been welded

Figure 4: Tensile testing machine

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3.0 RESULT AND DISCUSSION

Based on the tensile test results was obtained specimen data as listed in Table 1. The average heat input for welding current 80A was 387.76 J/mm. The results for welding current of 100A, the average heat input was around 440.56 J/mm. The experimental results showed that increasing the welding current from 80A to 100A. That was revealed the increasing of the tensile test load linearly. The same thing happened to elongation, the 100A group in the specimen showed an increase in elongation value. In the study of Sugihrahma (2020) [2], which used SMAW welding with variations in welding currents of 100 A, 125 A and 150 A, it resulted the fluctuations in the tensile strength value based on the tensile test carried out. Therefore, it can be stated that different types of welding can produce different mechanical properties.

Table 1: Tensile test results data on AISI 1045 steel specimens

Current	Max load (N)	Yield point (N)	Yield strength (N/mm^2)	Tensile strength (N/mm^2)
80 A	41023.69	24131.35	288.06	512.80
	35256.76	19031.42	226.66	440.71
	35316.87	18981.33	228.86	441.46
Average	37199.10	20714.70	247.86	464.99
100 A	44279.68	28308.40	318.21	553.50
	34979.69	19453.27	219.75	437.25
	45661.26	30072.82	353.01	570.77
Average	41640.21	25944.83	296.99	520.50

Tabel 2: Load and elongation data

Current	Max load (N)	Lo (mm)	ΔL (mm)
80 A	41023.69	150	12.1
	35256.76	150	11.0
	35316.87	150	12.1
Average	37199.10	150	11.73
100 A	44279.68	150	15.8
	34979.69	150	15.8
	45661.26	150	16.0
Average	41640.21	150	15.83


a. 100A


b. 80 A

Figure 5: Fracture of tensile test results on the specimen

In the Table 2, it can be seen that the welding current of 100 A has a higher elongation value when compared to the welding current of 80 A. This shows that along with the increase in the load on the tensile test that occurs.

In the figure 5, it can be seen the results of the tensile test on the specimen where the ductile tensile fracture in most of the materials has a stringy appearance for all 80A and 100A groups. The white line on the specimen was a marking of the weld joint. The fracture was occurred around the HAZ area or known as the Heat Affecting Zone. This indicated that the weld joint has high strength from the HAZ region where phase changes have occurred during the cooling process.

5.0 CONCLUSION

The GTAW welding is a metal joining process by melting the parts that are connected using an electric arc generated by a tungsten electrode or a non-feeding electrode. The mechanical properties of AISI 1045 medium carbon steel using the GTAW welding process with a current variation of 80 A and 100 A was investigated in this paper. Based the results test, it can be concluded the GTAW welding of AISI 1045 steel with a current of 80 A and 100 A with air cooling media, has an influence on the mechanical properties of AISI 1045 steel. The tensile test results were revealed the increasing in the strength of the welded joint. In addition, experimental results prove that the fracture that occurs in the specimen was in the Heat Affecting Zone (HAZ) area. The HAZ region was a critical region of axial loading on the specimen.

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