

Hardness Evaluation on SS 316L Joined with Gas Tungsten Arc Welding Under Constant Heat Treatment

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ABSTRACT

The purpose of this study is to show the hardness of the GTAW welding results on SS 316L metal with surface heating during the welding process. Observations in this study used SS 316L material with heat temperature regulation on the metal surface of the welding process using heating variations of 100 °C, 120 °C and 140 °C. The welding process of SS 316L material used a welding joint model uses single V-type welding joint with an angle of 60°, a spacing of 2 mm, a root surface of 1 mm and a thickness of 5 mm. Vickers hardness test was conducted to evaluate the hardness of samples. The results indicate that all specimens show a difference in the level of violence comparing with the values of the average level of hardness in each weld specimen. Specimens with the welding process heating temperature 100 °C have an average hardness value of 115.6 HVN. In contrast, samples with heating 120 °C have increased by having an average hardness value of 131.0 HVN. In comparison, heating specimens with heating surfaces of welding 140 °C have an increase in hardness values with an average of 171.5 HVN.

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Keywords: Gas Tungsten Arc Welding (GTAW), heat treatment, SS 316L steel

I. Introduction

SS 316L material is stainless steel which has been widely used in the world of oil, gas and manufacturing industries. In the welding process of SS316L material, the welding heat melts the end surface of the welded parent metal which blends with the fused metal fills in the weld area and its surroundings and gives the effect of changing the mechanical and geometrical properties of the weld metal [1]. Factors that affect the mechanical properties of welds are affected by the cooling rate that influenced by several factors, namely plate thickness, welding conditions, preheat, heat input and the environment [2]. Heat input is one parameter that contributes to distortion and residual stress [4][6].

In previous studies, the process of cooling treatment after welding to obtain the mechanical properties of metals [6]-[10]. The more welding layers increase, the higher the distortion. On thin plates, distortion often occurs, resulting in undesirable dimensions of dimension changes. But on thick plates with a broad cross-section, distortion is not visible, but the formed residual stress is considerable if a measurement is made. Changes in the geometry of the welds occur due to local heating with welding heat sources where the temperature distribution is uneven and changing, as well as changes in welding speed [3]. The heating process on the outside of the welding surface also increases welding strength [12].



Different heating processes use plasma for preheating in aluminium alloy welding [13], while other studies conduct the design heating using gas heaters for preheating in carbon steel welding [14][15]. The excessive heating temperature or less heating temperature affects the welding results, and this proof will be evaluated through the heating process during the welding process on SS 316 L metal. The purpose is to show the hardness of the metal after the welding process with Tungsten Gas Arc Welding under Constant Heat Treatment.

II. Material and Methods

This study used material of SS 316L, and heat temperature treatment on the metal surface of the welding process applied the heating variations of 100°C, 120°C, and 140°C. The welding process of SS 316 L material with a welding joint model used single V-type welding joint with an angle of 60° (Figure 1), root spacing 2 mm, root surface 1 mm at a thickness of 5 mm. The work of making specimens which include cutting material, making the seam is done by cold working. It was intended to change the mechanical properties of SS 316L material due to the influence of heat that arises when the working process occurs. Welding was carried out at the welding lab of Malang State University using ESAB Asia/Pacific low product hydrogen electrodes for small alloy steel types, namely basic OK 74.78. The electrodes used in welding high strength steels and also for low-temperature construction.

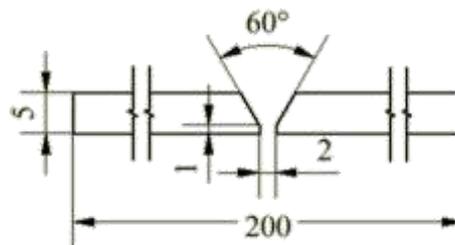


Fig 1. Size of the weld seam

The chemical composition of SS 316L material in this study is shown in Table 1.

Table 1. Chemical composition of 316 stainless steel.

Elements	Weight Percentage
Carbon	0.08
Manganese	2.00
Sulphur	0.030
Silicon	0.75
Nitrogen	0.10
Phosphorus	0.045
Chromium	16.0-18.0
Nitrogen	0.10
Nickel	10.0-14.0
Molybdenum	2.0-3.0

The material specifications were 316 Austenitic stainless steel with a thickness of 3 mm, length of 100mm and the number of samples were 27.

III. Results and Discussions

The welding area is observed as eleven as the welding process by giving a heating process to the metal surface during the welding process. The welding area is generally divided into three regions that experience differences between base metal, weld metal, Heat Affected Zone (HAZ) [16]. In detail, the discussion of the hardness of welds through the Vickers hardness test in the weld area will be discussed.

Heating Temperature 100 °C.

The final results of the welding process by heating the metal surface reaches a temperature of 100 °C, macrostructural of welding obtained, as shown in Figure 2.

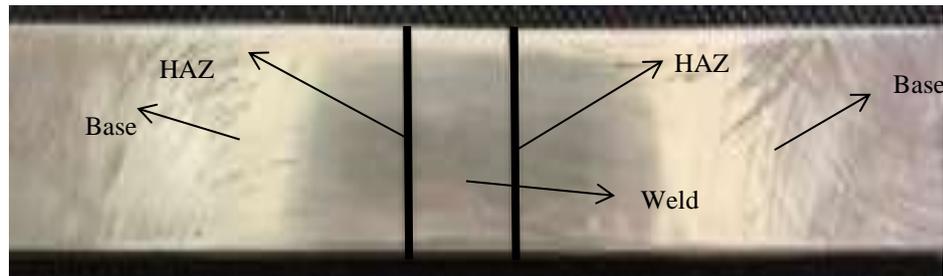


Fig 2. GTAW welding results with a constant temperature of 100 °C

The macrostructure shows the results of welding with surface heating has a hardness level with an average value of 115.6 VHN, as shown in Table 2.

Table 2. Vickers hardness test results on GTAW welding results with a constant the temperature of 100 °C.

Heating Temperature	Test Point	Hardness Test (VHN)
100°C	1	112.5
	2	118.6
	3	104.6
	4	116.8
	5	114.4
	6	122.3
	7	120.8
Average		115.6

Heating Temperature 120 °C.

Metal surface heating is carried out by the next GTAW welding process with a heating temperature of 120 °C in order to compare and see the maximum results from this test. From the results of surface heating in this treatment, we get a macrostructure image, as shown in Figure 3.

The results of surface heating with a temperature of 120°C shows different macrostructure. The Vickers hardness test indicates an average value of hardness level of 131.0 VHN (Table 3). The level of violence at each point experiences an insignificant difference.

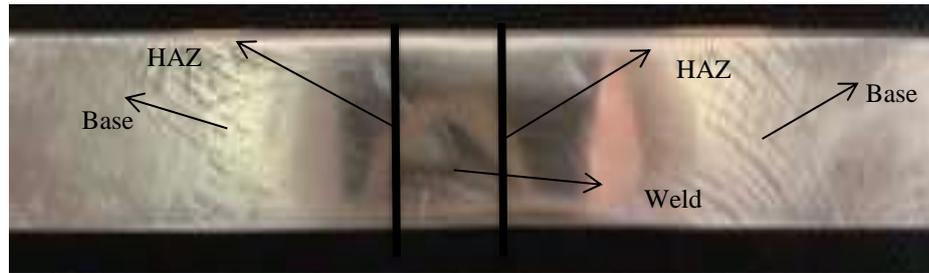


Fig 3. GTAW welding results with a constant temperature of 120 °C

Table 3. Vickers hardness test results on GTAW welding results with a constant temperature of 120 °C.

Heating temperature	Test point	Hardness test (VHN)
120°C	1	132.6
	2	137.9
	3	129.6
	4	131.7
	5	134.7
	6	130.3
	7	120.8
Average		131.0

Heating Temperature 140 °C.

Consider to the latter to produce the right level of hardness; heating was done by adding a temperature of 140 °C. The result of the macro welding structure is shown in Figure 4.

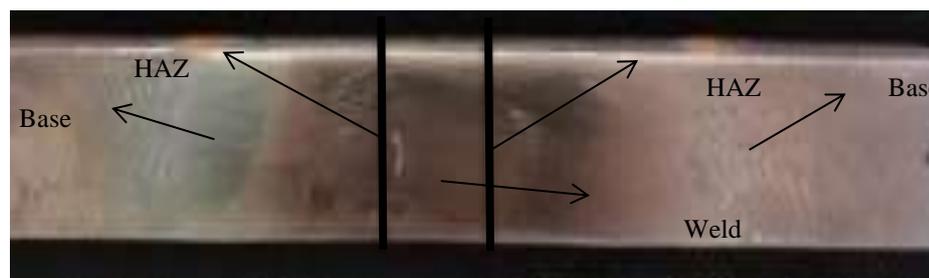


Fig 4. GTAW welding results with a constant temperature of 140°C

While comparing the final results to produce a more effective level of violence, the hardness test with a surface heating of 140 °C obtained an average value of 171.5 VHN. Table 4 shows the level of surface hardness also does not experience a significant difference. This case is due to the amount of the current (ampere), the type of electrode and the same speed

Table 4. Vickers hardness test results on GTAW welding results with a constant the temperature of 140 °C.

Heating Temperature	Test Point	Hardness Test (VHN)
140°C	1	165.8
	2	175.5
	3	170.3
	4	167.4
	5	174.6
	6	178.3
	7	168.8
Average		171.5

Hardness Test Data Analysis

From the results of the hardness test of the welding process to the three specimens, the ANOVA test will be conducted to see an efficient comparison of results. This step was taken to see the contribution of differences in heating on the SS 316L metal surface by welding GTAW. The results of the Vickers hardness test for each specimen described through the ANOVA analysis results are shown in Table 5.

Table 5. Homogeneity test of variances hardness test results

Levene Statistic	df1	df2	Sig.
.137	2	18	.873

Table 6. ANOVA analysis of hardness test results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11666.000	2	5833.000	201.690	.000
Within Groups	520.571	18	28.921		
Total	12186.571	20			

The Anova test (Table 6) is used to determine the parameters of how much heating effect on the metal surface by GTAW welding. The variations in the hardness level at each point show that the level of hardness of the metal is significant differences. The Anova analysis shows that hardness level will have a different peak temperature with different cooling acceleration due to heating of the given metal surface. A right procedure was obtained from the results of this study, which can be applied in the testing process.

IV. Conclusions

It can be concluded that the welding process of SS 316L material with heating temperature 100 °C, 120 °C, 140 °C results in an average hardness value of 115.6 HVN, 131.0 HVN, and 171.5 HVN, respectively. ANOVA analysis indicates that the variations in the hardness level at specimens are significant differences. By providing heat to the

metal surface during the welding process will affect the price of cooling on the metal surface.

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