Study of The Effect of The Electric Current Strength of The Weld on The Tensile Strength of The Welded Gas Cylinder Material Joint Capacity of 3 Kg

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Abstract. The effect of welding electric current strength on the tensile strength of the 3 kg capacity gas cylinder material welding joint has been studied. The welding carried out in this study is a damping arc welding with variations in electric current of 40A, 60A, 80 A, 100 A, and 120 A. The results show that: The maximum tensile stress is found in the welded specimen with an electric current of 40 A with a tensile strength of 13 kg/mm$^2$, 60 A with a tensile strength of 12 kg/mm$^2$, 80 A with a tensile strength of 28 kg/mm$^2$, 100 A with a tensile strength of 46 kg/mm$^2$. The maximum tensile stress is the test object which is welded with 120 A electric current with a tensile strength of 39 kg/mm$^2$. With the above results, it can be seen that the highest tensile strength of maximum is the sample that is welded with 100 A electric current. The highest maximum tensile strength reaches 46 kg/mm$^2$. The results of observations of micro structures in welded and HAZ matrix areas are Ferrite and Perlite.

Keywords: Welding, Electric Current, Material, 3 Kg Gas Cylinder, Tensile strength, microstructure.

1. Introduction
As it is known that the Government of Indonesia in 2014 has decided that kerosene fuel is replaced with gas because the availability of kerosene in Indonesia has been greatly reduced. As we know Indonesia has large natural gas reserve with total production reached until 7,764 MMSCFD. Thus, housewives in Indonesia, since then, cook no longer use kerosene stoves. But housewives cook a lot using a gas stove with a 3 kg LPG gas cylinder [1-6]. But the reality is that many people are complaining now that the LPG gas cylinders with a capacity of 3 kg are less secure and this can pose a high risk, such as the explosion of LPG gas cylinders and some supporting components whose quality is doubtful.

One way to overcome the dangers of 3 kg capacity LPG gas cylinders is to improve the quality of cylinders and find out how the industrial management process of making 3 kg capacity LPG gas cylinders, as well as research on welding testing methods that are in accordance with established procedures. One of the most important processes in the metal, machining and manufacturing industries is the metal joining process called welding process. The welding procedure looks very simply, but actually there are many problems that occur in the field when the welding process is carried out [1-7]. The 3 kg capacity gas cylinder is a pressure vessel which is a storage place for LPG (Liquid Petroleum Gas) with carbon steel plate material while SG 295 with 2.5 mm plate thickness. In addition, the 3 kg capacity gas cylinder has three general parts consisting of the handle of the tube, the tube body, and the tube leg with a tube height of ± 83 mm and the outer diameter of the tube body is...
260 mm. In this scientific work will be reported on, the study of the effect of the strength of the electric current welding on the tensile strength of the material connection of 3 kg LPG gas cylinders.

2. Experiments
The samples used in this study are material from 3 kg LPG gas cylinders (Figure 1). The first step is to open the bolt that binds to the 3 kg capacity LPG gas cylinder with the aim of removing the gas content until it runs out, to ensure the gas content contained in the 3 kg capacity LPG gas cylinder runs out, then the next process of the tube is immersed in a water bath with a time range ± 30 minutes, so that the smell of gas caused completely disappear, then the tube dried in the hot sun, and then the tube is cut with a grinding wheel. The material from the tube is cut into two parts, one part, the tube is cut into 10 samples that have been cut into rectangles according to the dimensions of length 100 mm, width 60 mm and 2.5 mm plate thickness (Figure 2). Tube plates that have been cut and then every two plates are welded with the SMAW (Shielded Metal Arc Welding) method with the variation of current strength used is 40 A, 60 A, 80 A, 100 A, and 120 A with a constant voltage of 24 V. Samples after welded into 5 samples and ready to be in the stress and strain test, And the micro structure is observed.

Below, this is the original form of a 3 kg capacity gas cylinder along with its construction part as shown in Figure 1.

![Figure 1. Construction of 3 kg capacity LPG gas cylinders](image1)

![Figure 2. LPG gas cylinders 3 kg capacity are cut into 10 samples](image2)

3. Results and discussion
3.1 Tensile Test Results
From the results of tensile testing data obtained the plate tensile strength and fracture time and variations in electric current of 40A, 60A, 80A, 100A, 120A, and 140A at the welding connection, Heat Input (19.2, 29, 38, 450, 58 and 67 kJ/cm ) to get the maximum tensile stress and changes in cross-sectional area. To find out the strength of each test object, the calculation is performed in accordance with the existing data and formula. The test results are then implemented to obtain the mechanical properties of tensile testing of each test object, such as tensile strength, and changes in cross-sectional area.
Table 1. Initial Tensile Strength.

| Test Specimens | Sample Code (A) | Tensile Strength (kg/mm²) [Mpa] |
|----------------|----------------|---------------------------------|
| 1              | 40             | 13 [127]                        |
| 2              | 60             | 12 [118]                        |
| 3              | 80             | 28 [274]                        |
| 4              | 100            | 46 [451]                        |
| 5              | 120            | 39 [382]                        |

Figure 3. Graphic comparison of electric current to tensile strength (Dark blue colour is electric current (Ampere), and light blue colour is Tensile Strength (kg/mm²) or [MPa]).

Analysis of the magnitude of the current strength and structure with a variation of the current strength of 40A, 60A, 80A, 100A, 120A, and tensile strength describe the comparison value of the tensile test of 13 kg/mm², 12 kg/mm², 28Kg/mm², 46 kg/mm², 39 kg/mm² from the result of tensile strength of 40A has decreased 60A. 12 kg/mm² and riding Ampere 80A increased 28 kg/mm² and increased 100A strength from 46 kg/mm² and added current to 120A decreased the tensile strength of 39 kg/mm² which is the best or the best tensile strength of 100A with a yield of 46 kg/mm².

Specific graph Structure comparison of electric current and tensile strength

Figure 4. Tensile Test Specimens.
3.1.1 Calculation of tensile testing results.

To get the values of the mechanical properties as above, the following formulas are used:

a. The maximum tensile stress contained is held by the test object:

\[ \sigma_u = \frac{F_u}{A_0} \text{(N/mm}^2) \]  \hspace{1cm} (1)

\( F_u \) is pull force (N) and \( A_0 \) is initial area, in the middle of the tensile test sample (figure 4).

b. Strain Calculation:

\[ \delta = \frac{A_1 - A_0}{A_0} \times 100\% \]  \hspace{1cm} (2)

\( A_1 \) is area after being pulled (figure 4).

A. For Test items with sample code 40A.

a. The maximum tensile stress contained is held by the test object:

\[ \sigma_u = \frac{N}{mm^2} = 3.93 \approx 4N \]  \hspace{1cm} (3)

b. Strain calculation from this sample:

\[ \delta = \frac{32.25 - 26}{26} \times 100\% = 24\% \]  \hspace{1cm} (4)

B. For Test objects with sample code 60 A

a. The maximum tensile stress contained is held by the test object:

\[ \sigma_u = \frac{N}{mm^2} = 4.03 \approx 4N \]  \hspace{1cm} (5)

b. Strain calculation from this sample:

\[ \delta = \frac{29.25 - 26}{26} \times 100\% = 12.5\% \]  \hspace{1cm} (6)

C. For Test objects with sample code 80 A

a. The maximum tensile stress contained is held by the test object:

\[ \sigma_u = \frac{N}{mm^2} = 9.16 \approx 9N \]  \hspace{1cm} (7)

b. Strain (\( \delta \))

\[ \delta = \frac{29.90 - 26}{26} \times 100\% = 15\% \]  \hspace{1cm} (8)

D. For the Test object with sample code 100 A.

a. The maximum tensile stress contained is held by the test object:

\[ \sigma_u = \frac{N}{mm^2} = 15.41 \approx 15N \]  \hspace{1cm} (9)

b. Strain (\( \delta \))

\[ \delta = \frac{29.25 - 26}{26} \times 100\% = 12.5\% \]  \hspace{1cm} (10)
E. For Test items with sample code 120 A

a. The maximum tensile stress contained is held by the test object:

\[ \sigma_u = \frac{382 \text{ N}}{29.37 \text{ mm}^2} = 13.01 \approx 13 \text{ N} \]  \hspace{1cm} (11)

b. Strain (\(\delta\))

\[ \delta = \frac{29.37 - 26}{26} \times 100\% = 4.34\% \]  \hspace{1cm} (12)

**Table 2.** Tensile test results.

| No | Ampere Sample code | Dimensions (mm) | \( A_0 \) Weldwidth (mm) | \( W_1 \) Wide Cross section Welded (mm) | \( L_0 \) Initial sample Length Test (mm) | Fu force Maximum Which in Hold on Test Objects (N / mm²) | \( A_1 \) Large Cross section End TEST objects (mm²) | \( W_0 \) Wide Final section Test Object (mm) |
|----|--------------------|-----------------|--------------------------|-----------------------------------------|----------------------------------------|-------------------------------------------------|--------------------------------------|---------------------------------------|
| 1  | 40                 | 13 x 2          | 26                       | 12.90                                   | 300                                    | 127                                             | 32.25                                               | 33                                    |
| 2  | 60                 | 13 x 2          | 26                       | 12.72                                   | 300                                    | 118                                             | 29.25                                               | 33                                    |
| 3  | 80                 | 13 x 2          | 26                       | 13.00                                   | 300                                    | 274                                             | 29.90                                               | 33                                    |
| 4  | 100                | 13 x 2          | 26                       | 13.00                                   | 300                                    | 451                                             | 29.25                                               | 33                                    |
| 5  | 120                | 13 x 2          | 26                       | 13.01                                   | 300                                    | 382                                             | 29.37                                               | 33                                    |

From the test results also obtained a graph between the tensile strength and the fracture time of the recording device on the testing machine (see Figure 4-5).

![Figure 5. Graph of the results of tensile testing of 40A.](image)

![Figure 6. Graph of 60A tensile test results.](image)
In specimen 1 sample code 40A with tensile strength reaches 127 N/mm$^2$, specimen 2 sample code 60A with tensile strength reaches 118 N/mm$^2$, specimen 3 sample code 80A with tensile strength reaches 274 N/mm$^2$, specimen 4 sample code 100A with tensile strength reaches 451 N/mm$^2$, specimen 5 sample code 120A with tensile strength reaches 382 N/mm$^2$, with an average tensile speed of five specimens of 30 mm/min.

| I(A) | Stress = $\sigma$ (N) | Strain = $\delta$(%) |
|------|------------------------|----------------------|
| 40   | 3.93                   | 24                   |
| 60   | 4.03                   | 12.5                 |
| 80   | 9.16                   | 15                   |
| 100  | 15.41                  | 12.5                 |
| 120  | 13                     | 4.34                 |
In specimens 1 to 5 with variations of 40A, 60A, 80 A, 100A, and 120A, plate fractures occur at the weld joint and this concludes that at the weld joints specimen I to 5 is not perfect even though the average tensile strength value obtained for testing plates obtained prices of 27.6 kg/mm$^2$ [270.4 MPa] because the plates have not passed the standard test with a tensile strength of more than 41.0 kg/mm$^2$ recommended by SNI (Indonesia National Standard). The results are far from the SNI standard values and not broken bolts occur in the welded joint. This could be due to the influence of the parent metal, the nature of the HAZ (Heat Affected Zone) area. Weld metal properties and dynamic properties of the joint.

3.2 Micro Structure Metallographic Testing Results
The following are shown photographs of microstructure observation results of metallographic testing results with inverted metallurgical microscope olympus BX41M-LED test machine with a magnification of 500x and 1000x. This observation is to see the structure of the 3 kg LPG cylinder. Following are the results of observational photographs in the form of the spread of microstructure of metal. From observing the microstructure, it can be seen that the observed matrix is ferrite and perlite

![Figure 10. Sample tensile test results](image)

![Figure 11. Photograph of microstructure observations of the material with heat input of 29 kJ/cm (60A), magnification of 500x](image)
Figure 12. Photograph of observations of microstructure of the material by providing heat input of 38.4 kJ/cm (80A), magnification 500 times.

Figure 13. Photograph of microstructure observations of the material with 50 kJ/cm (100A) heat input, magnification 500 times.

Figure 14. Photograph of microstructure observations of the material with heat input of 58 kJ/cm (120A), magnification of 500 times.

Figure 15. Photograph of microstructure observations of the material with heat input of 67 kJ/cm (40A), magnification of 500 times.
Figure 16. Photograph of observations of microstructure in the material by giving heat input of 29 kJ/cm (60A), magnification of 1000 times.

Figure 17. Photograph of microstructure observations on the material by providing heat input of 38.4 kJ/cm (80A), magnification of 1000 times.

Figure 18. Photograph of microstructure observations on the material by giving heat input of 50 kJ/cm (100A), 1000x magnification, is the ferrite matrix and pearlite matrix [1,2, and 9].

Figure 19. Photograph of observations of microstructure in the material by giving heat input of 58 kJ/cm (120A), 1000x magnification, is the ferrite matrix and pearlite matrix [1,2, and 9].
Based on observations of microstructure and from reference [1,2, and 9]. So, the matrix contained in the material after welding is the ferrite matrix and pearlite matrix [1,2, and 9].

4. Conclusion

After analyzing and calculating the test result data regarding the welded joints of material from a 3 kg capacity gas cylinder, it can be concluded as follows:

Material from 3 kg LPG gas cylinders, the best / greatest tensile strength is when welded at 100 A with time (t) = 10 minutes. For samples that were welded 100 A, for time (t) = 10 minutes there was a matrix: ferrite, and pearlite [1,2, and 9]. The ferrite matrix was more even and dominant.

5. References

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