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# ANALYSIS OF SAW WELDING PROCESS IN PRESSURE VESSEL TANK FOR AMMONIA FLUID WITH PRESSURE CAPACITY OF 13 Pa

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***Abstract***

Pressure vessels are widely used to accommodate pressurized fluids, one of which is to accommodate ammonia with a working pressure of 13 Pa. Pressure vessels use ASTM A516 Grade 70 as raw material. This material has the advantage of being resistant to changes in temperature and good weldability. To make this equipment, a lot of joining processes are used, because the welding process is unavoidable in the construction of joints and the manufacture of processing equipment made of stainless steel. Of the many metal materials, ASTM A516 Gr 70 because of its low carbon content thereby avoiding the possibility of sensitization of the welded components, has good weldability properties because it has high temperature resistance. There are many ways of connecting with welding techniques, one of which is using the Submerged Arc Welding (SAW) technique. (SAW) is a welding process using a submerged arc in flux. The function of the flux is to prevent oxidation, as an alloying element in the chemical composition of the weld metal, as a stabilizer, and as an oxidizer. The welding carried out in this study uses current variations, including 350 A. , 400 A, 410 A san 430 A . Next, a test is carried out from the results of the welding process such as a tensile test tap test. From the test results, it is obtained that the current strength value is suitable to be recommended for the welding process, namely at a current of 400 A seen from the value of the tensile test results and the hardness test.

Keywords : Pressure vessel, ASTM A516 Gr 70, SAW welding

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|---|---|---|

## Introduction

Pressure vessels are currently widely used to accommodate or store gas or liquid fluids with a high enough pressure. Pressure Vessel is a Steam Aircraft in which there is pressure and is used to accommodate gas, air, a mixture of gases, or a mixture of air, either compressed into liquid in a dissolved or frozen state. A storage tank is a vessel other than a pressure vessel that stores or stores hazardous liquids or other liquids, in which there is a compressive force caused by the weight of the stored or stockpiled liquid in a certain volume. Pressure vessels are made from sheet plates which are then rolled out and then connected by a welding process. The welding process used to connect plates that have been rolled include SAW welding, Submerged Arc Welding is a welding process using an arc immersed in flux, so that when the weld metal freezes it will be covered by flux which becomes slag. The function of the flux is to prevent oxidation, alloying elements in the chemical composition of the weld metal, as a stabilizer, and as an oxidizing agent. The SAW process is widely used on thick plates because the welding speed is very fast and can shorten the processing time. Pressure vessels are widely used for the process of storing pressurized fluids, in this study the fluid is ammonia which has a design pressure of 13 Pa. The research conducted here used ASTM A516 GR 70 steel material, this material is widely used to make pressure vessels, the problem taken in this research is the mechanical properties that occur in ASTM A516 Gr 70 material when the SAW welding process is carried out. Then the current strength and voltage are varied to produce an optimal

**JMM :**
**Journal of Mechanical and Manufacture** [Vol. 2, No. 1, Oktober, 2022, pp. 12-19]

welding process in the research to be carried out. This welding process is intended to determine the mechanical properties of the welded area and the HAZ (Heat Affected Zone).

## Research Methods

The material used in this research is Carbon Steel Plate A516. Grade 70 with chemical composition, namely.

Table 1. Chemical composition of base metal SA 516 Gr 70
(Guangzhou Kingmetal Steel Industry Co., Ltd )

| C | Cr | Mn | N | Ni | P | S |
|---|---|---|---|---|---|---|
| 0,10-0,22 | 0,3 | 1-1,7 | 0,3 | 0,3 | 0,03 | 0,03 |
| Si | Cu | Mo | Nb | Ti | V | |
| 0,6 | 0,3 | 0,08 | 0,01 | 0,03 | 0,02 | |

| Properties | Value |
|---|---|
| Tensile Strength ($N/mm^2$) | 510/ 650 |
| Yield stress/ min ($N/mm^2$) | 335 |

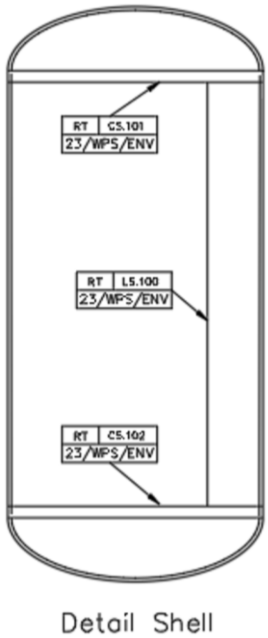


Figure 2. The analyzed part of the LS 100 Welding Process

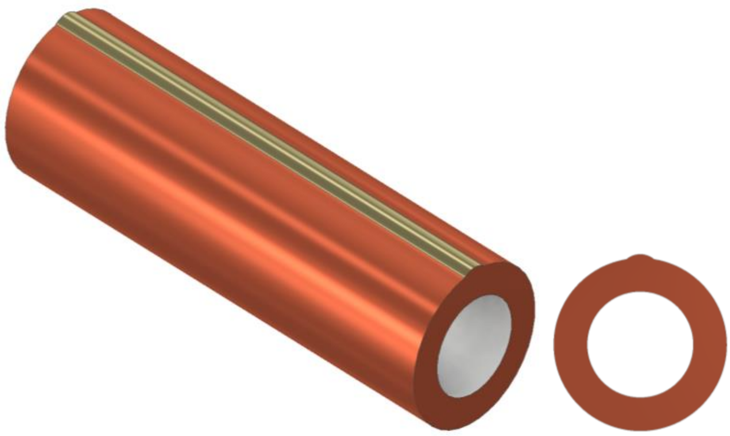

Figure 3 Figure 3D Shell

The part being analyzed is the longitudinal direction of the shell because that part experiences the greatest loading of 13 Pa. From this research and testing, it is hoped that the correct welding process parameters can be achieved so that they can extend the live time of the pressure vessel and can reduce the company's production costs.

**Material preparation**

Before the research process is carried out, the determination of materials and other preparations to support the welds to be used must be selected in advance, so that the results obtained are as desired.

**Dimensions of Research Materials**

The material used in this study was ASTM A516 Gr 70. The dimensions for this test specimen were 500 mm long, 150 mm wide and 15 mm thick. In this welding process, a gap or groove with a size of 3 mm is made. A complete test specimen is made with the following steps: • Test specimens are made with a size of 500 x 150 x 15 mm • The side to be welded is a single V – weld groove • The connection process is carried out by means of SAW welding • Cleaning of slag from welds The test material taking position can be as shown in the following figure

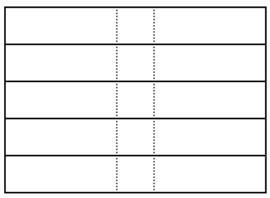

Figure 4. Position for taking the test material

Submerged Arc Welding.

The welding machine used is:

- Model : Automatic
- Type : Submerged Arc Welding
- Type : ESAB LAE 1000
- Power Source : A5 - PEF
- Production : ESAB
- Polarity : DCRP

JMM :
Journal of Mechanical and Manufacture [Vol. 2, No. 1, Oktober, 2022, pp. 12-19]

Figure 5. SAW Welding Machine

Electrode.
The electrodes used in this process are OK AUTROD 16.30 or AWS A5.9/ER 316L with a diameter of 3.2 mm. The chemical composition of the electrode is.
Table 2. Chemical composition of the AWS A5.9 electrode according to ESAB

| C | Si | Mn | Cr | Ni | Mo |
|---|---|---|---|---|---|
| 0,01 | 0,42 | 1,88 | 18,32 | 11,78 | 2,53 |

**Welding Process**
The welding was carried out using the SAW (submerged arc welding) process by varying the current, the welding parameters can be seen in table 3 Before welding the material is ceramic, in the SAW welding process a ceramic called ceramic baking material (CBM) is used, which is used as an additive to the welding process. CBM is a finely produced ceramic with a composition of naturally mixed inorganic substances (kaolin, talc, alumina, magnesia, etc.). This CBM is anti-acid, anti-chemical and anti-corrosion and also does not cause changes or reactions to the steel during the welding process.
Table 3 Parameters of the welding process Specimen.

| Parameter | Spesimen 1 | Spesimen 2 | Spesimen 3 | Spesimen 4 |
|---|---|---|---|---|
| Welding Current (Ampere ) | 350 | 400 | 410 | 430 |
| Welding voltage (V) | 30 | 30 | 30 | 30 |
| Welding Speed (cm/min) | 20 | 20 | 20 | 20 |

**Research Method (10pt)**

Calculation of Heat Input From the results of welding with different current parameters, the heat input value is obtained by taking the average heat input value, this is because the heat input for each layer is different, while each current has several layers to fill. weld groove. An example of the calculation results as shown below:

1. At a current of 350Ampere

- On pass 1

$t_1$ = 66 seconds = 1.1 minutes
$S_1$ = Length / time = 500 mm / 1.1 min
= 454.545mm/min

$$HI_1 = \frac{60 \text{ x } 30 \text{ volt x } 350 \text{ Ampere}}{454{,}545 \text{ mm/min}}$$

$$= \frac{63.10^4 \text{ Watt}}{454{,}545 \text{ mm/min}}$$

$$= \frac{63.10^4 \text{ J/s}}{454{,}545 \text{ mm/min}}$$

$$= 1386 \text{ J/s}$$

$$= 1{,}386 \text{ Kj/mm}$$

- On pass 2

$t_2$ = 65 detik = 1,083 menit
$S_2$= Panjang / waktu
= 500 mm / 1,083 menit
= 461,681 mm/min

$$HI_2 = \frac{60 \text{ x } 30 \text{ volt x } 350 \text{ Ampere}}{461{,}681 \text{ mm/min}}$$

$$= \frac{63.10^4 \text{ Watt}}{461{,}681 \text{mm/min}}$$

$$= \frac{63.10^4 \text{ J/s}}{461{,}681 \text{ mm/min}}$$

$$= 1{,}364 \text{ Kj/mm}$$

For further calculations, see the table below

Table 4 Parameters of the SAW welding process

| ARUS (Ampere) | PASS | Volt | Time (menit) | speed (mm / min) | TEMP (°C) | HEAT INPUT (Kj/mm) | HEAT INPUT AVERAGE (Kj/mm) |
|---|---|---|---|---|---|---|---|
| 350 | 1 | 30 | 1,083 | 461,68 | 160 | 1,386 | 1,423 |
| | 2 | 30 | 1,2 | 416,666 | 162 | 1,364 | |
| | 3 | 30 | 1,116 | 448,028 | 212 | 1,469 | |
| | 4 | 30 | 1,133 | 441,306 | 206 | 1,427 | |
| | 5 | 30 | 1,116 | 448,028 | 217 | 1,406 | |
| 400 | 1 | 30 | 1,21 | 413,223 | 208 | 1,742 | 1,678 |

**JMM :**
**Journal of Mechanical and Manufacture** [Vol. 2, No. 1, Oktober, 2022, pp. 12-19]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 30 | 1,2 | 416,666 | 214 | 1,728 | |
| | 3 | 30 | 1,1 | 454,545 | 238 | 1,584 | |
| | 4 | 30 | 1,15 | 434,783 | 284 | 1,656 | |
| | 5 | 30 | 1,10 | 414,783 | 264 | 1,556 | |
| 410 | 1 | 30 | 1,16 | 431,034 | 168 | 1,712 | 1,717 |
| | 2 | 30 | 1,13 | 442,478 | 284 | 1,667 | |
| | 3 | 30 | 1,183 | 422,654 | 312 | 1,746 | |
| | 4 | 30 | 1,183 | 422,654 | 313 | 1,746 | |
| | 5 | 30 | 1,183 | 422,654 | 313 | 1,746 | |
| 430 | 1 | 30 | 1,1 | 454,545 | 186 | 1,702 | 1,727 |
| | 2 | 30 | 1,083 | 461,681 | 254 | 1,676 | |
| | 3 | 30 | 1,166 | 428,816 | 257 | 1,804 | |
| | 4 | 30 | 1,166 | 428,816 | 257 | 1,804 | |
| | 5 | 30 | 1,166 | 428,816 | 257 | 1,804 | |

**Results and Discussion**

Visual Inspection Results

The results of this visual inspection are obtained after the welding process is complete for the entire test specimen to determine the final shape of the weld, as shown in the image below.

Figure 6 Welding Results with Ampere 350 A Volt 30

Figure 8 Welding Results with Ampere 410 A Volt 30

Figure 9 Welding Results with Ampere 430 A Volt 30

**Results of Hardness Testing**

The hardness of a metal is defined as the material's resistance to compression. The hardness test aims to determine the metal's resistance to plastic deformation, carried out in the welded area and the HAZ area. Each hardness range for each material is shown in the table

Table 5 Table of the relationship between the current and the average hardness

| Ampere | Kekerasan (HV) | | | |
|---|---|---|---|---|
| | weld metal | fusion Line | HAZ | base metal |
| 350 | 246 | 213,7 | 247.53 | 279,97 |
| 400 | 247.9 | 227.6 | 259.47 | 283.33 |
| 410 | 251,83 | 198.97 | 253.93 | 277,93 |
| 430 | 233.73 | 253.7 | 274.3 | 283,23 |

**Tensile Test Results.**

Tensile testing is carried out to determine the mechanical properties of the welded area against tensile loads by applying a force to the test sample. Tensile testing is affected by the properties of the base metal, as well as the properties of the heat affected area. The results of the tensile test can be seen in table 6.

Table 6. Table of Tensile Test Results

| spesimen | Area ($A_o$) $mm^2$ | Yield Load ( Kgf ) | yield strength ($Kgf/mm^2$) | Tensile Load (Kgf) | tensile strength ($Kgf/mm^2$) | fault location |
|---|---|---|---|---|---|---|
| 350 A | 316 | 13000 | 41,139 | 19500 | 61,71 | Patah di base metal |
| 400 A | 312,84 | 12500 | 39,96 | 19500 | 62,33 | Patah dilasan |
| 410 A | 314,42 | 13000 | 41,35 | 19700 | 61,71 | Patah di base metal |

**JMM :**
**Journal of Mechanical and Manufacture** [Vol. 2, No. 1, Oktober, 2022, pp. 12-19]

| | | | | | | |
|---|---|---|---|---|---|---|
| 430 A | 316 | 13000 | 41,139 | 19400 | 61,39 | Patah dilasan |

## Conclusion

In the research that has been done, the following conclusions can be drawn:

1) The results of the "Soak Arc" welding process are very dependent on the use of the type of electrode and flux, current, voltage, welding speed.
2) the use of low currents will result in low penetration compared to the use of high currents which will result in deep penetration with a small number of layers.
3) the higher the current given, the greater the heat input in the HAZ and weld area so as to allow the formation of carbide precipitates at the grain boundaries.
4) From the results of the tensile test, the highest strength is found at 400 Ampere current but in this condition the fracture occurs in the weld area, whereas at 350 and 410 Ampere currents the tensile strength is almost the same and the weld results are quite strong because the fracture occurs in the base metal while the lower strength the lowest at a current of 430 Amperes where the fracture also occurs in the weld area.
5) The magnitude of the welding current, which also means the amount of heat input, will determine the ability of the heat to change the microstructure of the metal being welded, which also means changing the mechanical properties of the material.
6) In general, the larger the grain size, the lower the strength of the metal.

## Reference

N. U. P. K. C. D.K. Pratiwi1*, "Pengelasan Smaw Baja Karbon Rendah Dengan Yang Di Quenching Dan Normalizing," *Fakultas Teknik Universitas Sriwijaya,* 2017.

I. B. Cahya Sutowo, "Analisa Pengaruh Pengelasan Tig dan Mig pada Sambungan Las dengan Material Tipe Ss316 dan Ss304," *Universitas Muhammadiyah Jakarta, Jurusan Teknik Mesin,* 2008.

S. M. Rudi Siswanto, Buku Ajar Teknologi Pengelasan, Banjarmasin: Program Studi Teknik Mesin Fakultas Teknik. Universitas Lambung Mangkurat, 2018.

M. T. Q. Amin Nur Akhmadi1, "ANALISA HASIL PENGELASAN 2G DAN 3G DENGAN BAHAN PLAT BESI ST 40 KETEBALAN 10MM DAN VOLTASE 20 - 35 MENGGUNAKAN MESIN LAS MIG," *Journal Mechanical Engineering, Politeknik Harapan Bersama, ,* Vols. 9, No 2, 2020.

S. M. I. S. M. Mulyadi, Teknologi Pengelasan, Sidoarjo: Universitas Muhammadiyah Sidoarjo, 2020.

B. H. K. A. S. Mohruni(1), "Pengaruh Variasi Kecepatan Dan Kuat Arus Terhadap Kekerasan, Tegangan Tarik, Struktur Mikro Baja Karbon Rendah Dengan Elektroda E6013," *Jurusan Teknik Mesin, Fakultas Teknik, Universitas Sriwijaya.*

Z. T. R. Saifuddin A.Jalil1, "ANALISA KEKUATAN IMPAK PADA PENYAMBUNGAN PENGELASAN SMAW MATERIAL ASSAB 705 DENGAN VARIASI ARUS PENGELASAN," *Jurnal Polimesin,* Vols. 2, Nomor 2, 2017.