Journal Of Metallurgical Engineering And Processing Technology, Vol. 4, No. 1, August 2023, pp. 41-48
P-ISSN: 2723-6854, E-ISSN: 2798-1037

Analysis of Penetrant Test Results of S355J2 Steel Welding Connections for Qualification Welding

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Abstract

NDT (Non Destructive Test) is a form of testing perfomed on materials or objects without causing permanent damage to the material or objects. NDT can be used for testing materials such as concrete, steel, iron, and other. This journal aims to determine the Penetrant Test testing process on S355J2 steel welding results to determine the qualifications of GMAW Welders. Welding testing by a certified welder using GMAW welding. NDT testing was conducted in the form of a visual test and a Penetrant test when testing the weld results. The obtained data showed the welder PT. INKA is qualified with the terms and standards that have been set by the company, namely AWS D1.1 and ASTME E 165. Therefore, the Welder can be involved in the current project.
Keywords: S355J2, WPQR, AWS D1.1, ASTM E 165, GMAW Welding, Physical Metallurgy

Introduction

Welding according to Deutsche Industrie Norman (DIN) is the metallurgical bonding of metal or metal alloy joint perfomed in a liquid state. Connection between these metals is done by heating which requires to melt the metal parts that will be connected to the electrode as an additive or filler (Suwahyo, 2011).

In current era there are many projects that use welding techniques, such as projects that will be carried out like the G20, therefore it requires the skills and qualifications of each welder so that the project can run smoothly. Each welding result will have quality based on several factors (Al Khotasa, 2016 (Abadi, 2019)

Determine the quality of the weld depending on the quality of the material to be welded, the suitability of the process being perfomed, and the expertise of a welder.(Thoriq, 2015)

NDT is a form of testing perfomed on materials or objects without causing permanent damage to The materials. NDT can be used for testing materials according to (Patil & Patil, 2008).

Liquid Penetrant Test or commonly called Dye penetrant test is one of the NDT methods. The trick is to apply a light-colored liquid to the surface of the inspected material, usually red which has high penetration properties according to (G. Kedarnath, 2017)

PT. INKA (Persero) uses standards to maintain quality and product quality. By way of applying standards to the fabrication process is GMAW welding. Before being able to be involved in a project, the welder who will take part must be qualified according to specified standards so that quality is maintained (Rahmatika et al., 2021).

The main goal of this research is to determine the welder qualifications

and achieving always high quality welds and a standard with certain parameters is needed. (Alip, 1989).One of the parameters used to evaluate the quality of the welds is the Welding Procedure Specification (WPS) (Amalia & Rahmatillah, 2022).

Methodology

The used method is to collect the literature and the standards such as WPS and WPQR data and standards from the Penetrant Test, then the data is obtained, namely primary data and secondary data.

Primary data obtained from conducting Penetrant tests during practical work at PT. INKA and secondary data provided by the company in the form of WPQR and WPS used during testing. This test uses S355J2 steel material which has been welded by a welder using the GMAW welding method with different welding positions, namely positions 1G, 2G, and 3G and each is done by two welders. (Endramawan et al., 2017)After that, NDT testing was perfomed in the form of a Penetrant Test as the basis for GMAW welder qualification. Material S355J2 (Mujiyanto, 2008).

The method I used in the analysis this time is a qualitative research method because analyzing data can be done by analyzing documents and observations, so as to get in-depth and good results.(Khotasa, 2016; Prasetya et al., 2017)

This research was conducted at PT INKA Madiun, which aims to analyze the ability of the welder working at PT INKA, whether it is in accordance with applicable standards or not, and can be included in the project to be worked on next.(Abi Sodik et al., 2019)

It is a low carbon manganese steel with medium tension that is easy to weld and has good impact resistance(Mvola & Kah, 2017). In this test, a discussion was perfomed regarding the results of the Penetrant Test on S355J2 steel welded joints as a basis for determining GMAW welder qualifications. The standards used are AWS D1.1 and ASTM E 165 (Sri, 2013).

1. AWS D1.1

American Welding Society (AWS) D1.1 is the most commonly used standard for welder qualification. committees and subcommittees consist of volunteer workers interested in advancing quality and work efficiency of the welding industry with develop this code. Differences between and AWS D1.1 are naming fabrication, inspections, and welding procedures and welder qualifications. (A. Ibrahim, 2012) some of the provisions that must be considered in AWS D1.1 for welding S355J2 steel are:

a) Type of Welding Process and Thickness
b) Type of Filler and Electrodes
c) Position at the time of Welding
d) Testing of welded joints
e) Identification of Welded Joints on Specimens
f) Parameters of Welded Connections on Specimens Proses

(Alfian Wahyu Prasetya, 2017)

2. Welding of test material

Welding uses the GMAW technique in accordance with the WPS standard used in each welding position. Welding

is perfomed in three positions, namely 1G, 2G, and 3G(Karadeniz et al., 2007).

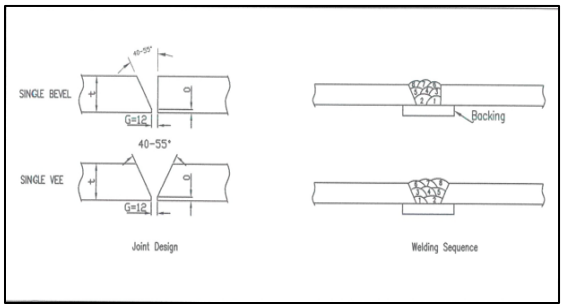

Figure 1. Schematic of the Welding Connection for the 1G position
(Source: Ahmad Abi, et al. 2019)

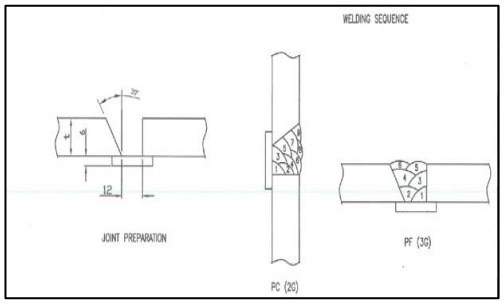

Figure 2. Welding Connection Scheme for 2G and 3G positions
(Source: Ahmad Abi, et al. 2019)

Information:

a. Shape : Single V Groove
b. Specimen length : 250 mm
c. Material Thickness :12 mm

Welding Parameters

a. Type of Current : AC
b. Electric Current : 158-206 A
c. Volts : 17-19 V
d. Gas Flow : 15-17 L/min
e. Gas Cup Size : 10 mm
f. Filler : AWS ER 70S-6
g. Welding Position : 1G, 2G, and 3G

1. Penetrant Test

   Penetrant tests are perfomed in accordance with ASTM E 165 standards with work procedures in accordance with Figure 3 below.

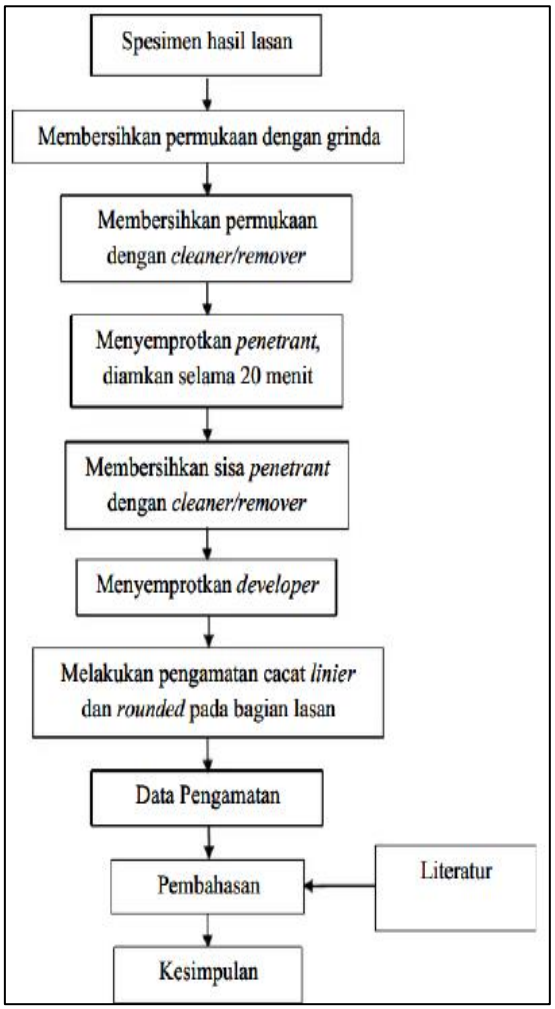

Figure 3. Penetrant Test Flowchart
(Source: www.researchgate.net)

The Liquid Penetrant Test method is a simplest NDT method. This method is used for finding defects in exposed surfaces of components solids, both metals and non-metals, such as ceramics and fiber plastic. Through this method, the defects in the material Will be vividly observed.(Siagian et al., 2022)

Table 1.
Visual Test results

Welder	WPS	Posisi	VT
Lukas Setya Pratama	WPS-GM-211-0055	1G	
Saipul Iksan	WPS-GM-211-0055	1G	
Yoga Aji Ramadhan	WPS-GM-211-0007	2G	
Ribut Setyanto	WPS-GM-211-0007	2G	
Suparmin	WPS-GM-211-0007	3G	
Wiji Sucipto	WPS-GM-211-0007	3G	

(Source: Personal Data)

Table 2.
Penetrant Test Results

Welder	WPS	Posisi	PT
Lukas Setya Pratama	WPS-GM-211-0055	1G	
Saipul Iksan	WPS-GM-211-0055	1G	
Yoga Aji Ramadhan	WPS-GM-211-0007	2G	
Ribut Setyanto	WPS-GM-211-0007	2G	
Suparmin	WPS-GM-211-0007	3G	
Wiji Sucipto	WPS-GM-211-0007	3G	

(Source: Personal Data)

Table 4.
Welder Qualification Status Data from Test Plate Specimens

Welder	WPS	Posisi	VT	PT	Status
Lukas Setya Pratama	WPS-GM-211-0055	1G	Accepted	Accepted	Terkualifikasi
Saipul Iksan	WPS-GM-211-0055	1G	Accepted	Accepted	Terkualifikasi
Yoga Aji Ramadhan	WPS-GM-211-0007	2G	Accepted	Accepted	Terkualifikasi
Ribut Setyanto	WPS-GM-211-0007	2G	Accepted	Accepted	Terkualifikasi
Suparmin	WPS-GM-211-0007	3G	Accepted	Accepted	Terkualifikasi
Wiji Sucipto	WPS-GM-211-0007	3G	Accepted	Accepted	Terkualifikasi

Results and Discussion

From the experimental results there were no defects after the visual test was perfomed. It can be seen in Table 1, the results exhibited that, the test is in accordance with AWS D1.1. and the data is continued to the next test, namely the Penetrant Test with testing standards in accordance with ASTM E 165.

From the Penetrant test results can be seen in table 2, the test is in accordance with the ASTM E 165 standard which can be seen in Figure 3. Referring to the data from the NDT Visual Test and Penetrant Test, it can be analyzed that the welding done by this Welder has good results. Based on the Penetrant Test Standard, it is known that the range of permitted Overlap defects is > 0.5 mm, for Linear misalignment defects is permitted > 2 mm, for Root concavity defects is permitted > 0.5 mm, for Crack defects is permitted > 0.5 mm, for Shrinkage Groove defects is permitted >0.5mm. It is known that the results of the welding done by the Welder found no defects in the form of Spatter, Underfill, Undercut, and Porosity which resulted in reduced strength of the material.(Kholis, 2012)

Based on the results of the Non-Destructive Test from six specimens with three welding positions and six different welders. Based on AWS D1.1 and ASTM E 165 standards so that an analysis of Welder Qualification Status Data from Test Plate Specimens can be made, As tabulated in Table 4.

The Table 4 revealed that it can be seen that the specimens tested by the researchers have passed the non-destructive test in the form of a visual test and a penetrant test and are appropriate. With the passing of all specimens, data is obtained that the welder used by PT. INKA (Persero) is a welder who has been qualified and complies with the applicable Standards. So that welder can be allowed to work on a project because it is considered to have met the required welder qualification standards.

After knowing that there are no defects that arise, the cause of the absence of defects and their reasons can be sought in the Welding process using a cause and effect diagram. Based on observations while at PT. INKA (Persero), the cause of disability is caused by several factors, namely humans, machines, methods and materials. In Figure 4 the following is a causal diagram, The defects was not found.

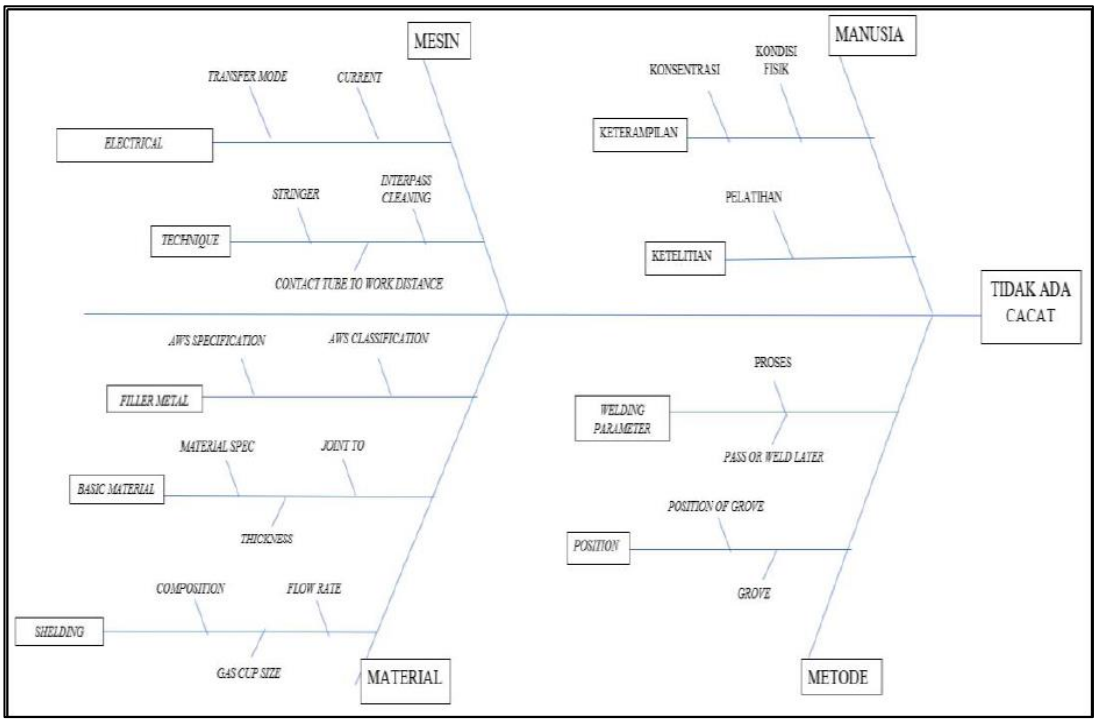

Figure 4. Cause and Effect Flowchart
(Source: Personal Data)

The success factors that cause no defects to arise in this Welding process are four according to Figure 4 above, is:

- Human
  The human factor is highly possible to be able to make mistake that can cause defects in welding.
- Machine
  Machine factors also have a chance in the welding process so that it produces a good product by not causing a defect.
- Materials
  Selective assessment of materials used
- Methods
  The method used in this welding is in accordance with WPS and WPQR.

Conclusion

From the Non Destructive Test data (Visual Test and Penetrant Test) on the results of welding specimen S355J2 there were no welding defects. Complies with WPS-GM-211-0007 and WPS-GM-211-0055.

Related factors are the use of machines in good condition, the factor of accuracy and skill of the welder who performs the welding and the selection of the right and good material. It is a factor that influences the success of this GMAW welding.

Thus, it can be concluded that Welders Lukas Setya Pratama, Saipul Iksan, Yoga Aji Ramadhan, Ribut Setyanto, Suparmin, and Wiji Sucipto have met the welding qualification standards set by PT. INKA (Persero), so that they are allowed to participate in projects that are being perfomed by PT. INKA (Persero).

Acknowledgments

I would like to thank PT. Industri Kereta Api (INKA) and the Metallurgical Engineering Study Program of the National Development University "Veteran" Yogyakarta who have helped this research and complete properly.

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