Welding Quality Assessment for Oil and Gas Industry by Comparison of Mechanical Testing Properties and Microstructure Analysis

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Abstract. WBS testing is the procedure of substantiation on material after a completed welding process to determine the material properties and behavior such as strength properties and forming properties. The conventional testing for determining strength properties of material involve parameters such as tensile strength, shear strength, toughness, brittleness and rigidity. On the other hand, the forming properties testing is performed to inspect elasticity, plasticity, ductility, malleability and hardness of the welded components. The importance of WPSs in the welding technology and how the WPSs is performed at the point around the welding procedure should be defined clearly. Thus, this project investigates the welding quality assessment in the industry by comparison of several testing methods (such as tensile and bend test) following determined acceptance criteria by American Welding Society (AWS D1.1). This research also aims to investigate the metallurgical aspects of welding joint by looking into different locations which as HAZ, weld metal and base metal. The investigated results are macro and microstructure observation, hardness distribution and also the density of the allocated area. This project will serve to develop a further understanding of welding and to find out the correlation between various testing methods that have been used. The welding quality assessment by comparison of mechanical testing properties and microstructure analysis are carried out to determine the property of the affected points. Then, the welding evaluation is determined by performing non-destructive and destructive testing methods. The comparison between the mechanical testing properties and microstructure analysis is made to determine welding quality of Shielded Metal Arc Welding. The acceptance criteria for both non-destructive and destructive testing were referred to American Welding Society (AWS) standard. Furthermore, this research is conducted to investigate the function of welding procedure specification in evaluation of welding quality assessment especially in oil and gas industry.

1. Introduction

Fabrication of products in manufacturing industry and construction companies requires some type of joining process for attach the components for structure completion. There are three main categories in material joining processes which is adhesive bonding, mechanical fastening and welding. Welding are different from others joining process because the joint process in welding is very strong and permanent [1]. The joint that made by welding are not easily separated and that is why welding has their procedure that must be followed. Welding also can be economical process than mechanical fastening and adhesive bonding because the capability to create joint permanently[2]. According to American Welding Society
different types of welding processes with different sources and method to joint metal. Then most commonly used electric arc welding today in fabrication service is Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GTAW), Gas Tungsten Arc Welding (GTAW), Flux-Cored Arc Welding (FCAW) and Submerged Arc Welding (SAW)[3]. All the welding has different purpose and application. Welding is one of the joining processes that commonly use in the industry, especially in oil and gas industry [4].

Welding can be defined as a joining process that is intended to make the material at the joint surfaces as homogeneous as possible with the base material. The homogeneity between base material and weldment area is according to the chemical composition, metallurgical, mechanical properties or physical characteristics. The source of the welding process is created by electric power supply. The welding machine will produce the electric arc that heat the material until its melting temperature. Established electric arc is created between the gap of an electrode and the metal to be welded. The electric arc will form a molten pool at the parent metal and dissolve with welding material. During this process, this molten pool must be protected from the atmosphere to prevent it reacts with the surrounding air that may cause the material at joining become brittle [5]. This can be avoided by using welding electrode with flux insertion or applying shielding gas around the molten arc while welding process is running. The use of shielding gas or flux coated on the electrode is depending on the application material and purposes the joints are used. However, in most cases, melting the material between the parts will not create a strong weld connection. Thus, the usage of filler compound is recommended to assure the mixing of electrode and welded parts. Filler compounds has been used commonly in industry to increase the overall effectiveness of the weld. However, it depends on the welding process whether the electrode is already purchased with filler metal in it or the filler metal is used separately during welding process. The other factor of welding effectiveness is the electric power supply itself. The type of current that usually use in the welding process may be either alternate current or direct current [6].

To achieve high welding quality is not only depending on the welder itself, but also depending on the parameter that have been used. The good parameter will give the parent metal matching with the filler metal. The good weld quality must achieve certain physical and chemical properties to meet the service requirement of the welded part.

2. Welding Evaluation

The quality of welding can be tested using several testing methods in welding quality assessment. Welding test is important to analyse the welding quality in term of the strength, mechanical properties, welding characteristics and the metallurgical aspects [4]. Weld testing is one of the procedure in welding evaluation and has its determined methods. There are three methods to evaluate the welding which is by visual inspection, non-destructive testing and destructive testing. Visual inspection must be done first; followed by non-destructive testing and destructive testing. The reason is non-destructive and destructive testing is a high cost evaluation method and required skilled person to perform the test[7]. Visual inspection does not require special equipment and tool but only need experience person to examine the quality of the welding. In visual inspection, only internal defect can be detected such as surface crack, surface irregularities, spatters, contour defect etc. The person that has a responsibility to perform visual inspection is called welding inspector.

There are two classes in welding test which is destructive and non-destructive test. Non-destructive testing is most popular and commonly used in welding evaluation because material in non-destructive testing does not undergoes destruction and can be reused. It’s different from destructive testing which material use in destructive testing undergoes destructive and cannot be used again [5]. Non-destructive testing becomes necessary for welding evaluation, particularly in oil and gas fabrication because this testing method gives evaluation figure of the internal defect occurs in the welded joint. The common non-destructive test used today is Dye Penetrant Test (DPT), Magnetic Particle Inspection (MPI), Radiographic Test (RT), Ultrasound Test (UT) and Eddy Current Test. The selection of test is depend on the material thickness, type of the welding used, and the possible defect occur [6]. Destructive test is carried out to determine the strength of the material, material toughness and metallurgical aspect. Destructive test is usually made for the welding procedure and welder approval. The most popular test under destructive test categories is tensile test, bend test, hardness test and macroscopic test. Other test
such as impact toughness test and nick break test also can be used to determine the fracture surface of the weld metal for flaws and to check the root penetration and fusion.

2.1. Tensile Test

Tensile test is the most widely used to determine the mechanical properties of materials. The tensile strength of an alloy is most commonly measured by placing a test specimen in the jaws of a tensile machine. According with American Welding Society (AWS B4.0:2007-Tension Test) the data obtained from tensile test may include the Ultimate Tensile Strength, Yield Strength, Yield Point if occurs, percentage of elongation, percentage of reduction area, stress strain diagram and mode of fracture. The tensile machine will apply stretching stress by gradually separating the jaws. The amount of stretching needed to break the specimen is measured and recorded. From this test, the yield strength also can be measured. Yield strength is the amount of stress a material can withstand without permanent deformation [8].

The relationship between average normal stress and average normal strain can be explained more on stress strain diagram. The stress-strain diagram consists of two regions which is elastic and plastic region. In elastic region, the material will return into the original shape when the load is removed while in plastic region; is the area where the material tends to fracture. Plastic region consists of the yielding, strain hardening, necking and fracture point. The tensile test guided is refer to American Welding Society (AWS B4.0:2007) standard[9]. It describes the methodology, specimen guidance and the calculation used for tensile test analysis. The specimen is called dog bone shape was prepared according to the thickness range and specimen shape whether tabular or plate shape. Different thickness must have a different dimension measurement.

3. Welding Quality Assessment

Several experiments were selected to get the answers regarding the objective of this project. Some experimental work has their standard and code that must be followed to ensure the result obtained is valid and standardized. In this project, the specimen and testing preparation were done in Labuan Shipyard and Engineering Sdn. Bhd. Shielded Metal Arc Welding process is used for preparation of the welding sample and has been monitored by welding engineer. The specimen undergoes several testing techniques consist of non-destructive test and several destructive test to evaluate welding quality of the specimen.

3.1. Sample Preparation

Selection of the material and the welding procedure specification (WPS) has been done according to the project given by Labuan Shipyard and Engineering (LSE). All the parameter and the procedure for welding have followed the WPS which were given and monitored by welding engineer. The material has been selected is A36 mild (low carbon) steel grade and have 15 mm thickness. The procedure including the parameter used in sample preparation is simplified from Welding Procedure Specification tabulated in Table 1.

The summary of welding procedure specification tabulated in Table 1 is taken from LSE Welding Procedure Specification. To control the influences of welding quality by human skills, welding processes were performed by a qualified welder in the company. The final welded specimen then undergoes visual inspection before proceed to other non-destructive testing and destructive testing [10]. The visual inspection only analyzes the weld surface to check any discontinuity and irregularities at the connections. Visual inspection is performed by qualified welding inspector in the company.
Table 1. Summary of Welding Procedure Specification.

|   | Material | A36 mild (low carbon) Steel |
|---|----------|-----------------------------|
| 2 | Joints   | Joints Design: Single Vee  |
|   |          | Multiple Pass: Yes          |
| 3 | Filler Metal | Welding Process: SMAW         |
|   |          | Electrode: E7017 (root)     |
|   |          | : E7018 (2nd Pass)          |
| 4 | Position | Position Groove: IG         |
|   |          | Weld Progression: Dragging  |
| 5 | Pre heat | Preheat temperature: 50°C   |
|   |          | Interpass Temperature Maximum: 250°C |
|   |          | Preheat Method: Propane Gas |
| 6 | Electrical characteristics | Current polarity: DCEN/DCEP |
|   |          | Welding technique: weaving  |
|   |          | Cleaning method: Grinding & Brushing |
|   |          | Electrodes spacing 1.0mm – 3.0mm |

| Run no. | Filler metal | Current | Volt (V) | Heat input (kJ/mm) |
|---------|--------------|---------|----------|--------------------|
|         | Size(mm)     | class   | Polarity | Amperage           |
| 1       | 2.6          | E 7016  | DCEN     | 55 – 74            | 1.0 – 2.8          |
| 2 - n   | 3.2          | E 7018  | DCEP     | 110 - 150          | 24 – 26            | 1.0 – 2.8          |

3.2. Experimental works

In the second phase under methodology process, experimental work was performed to examine the welding quality assessment and to analyze the material characteristic before and after welding process. In this stage size and shape of the specimen must be prepared according to standard testing specification to obtain good and accurate results from the experiments. Non-destructive testing method must be done first followed by destructive testing.

3.2.1. Radiography Test

The radiographic test used x-ray as a source and automatic x-ray machine. The purpose of the x-ray is to identify defect occurs at the welding area. Parameter that used is 225KV of voltage and 3000 µA of current. The X-rays were emitted from the tube and pass through the workpiece to be inspected. Parts that have less obstruction to X-rays, such as cavities or inclusions, allow increased exposure of the film. The film is developed to form a radiograph with cavities or inclusions indicated by darker images. Section thickness increases (such as weld under-bead) appear as less dense images. Radiographic test must be conducted with qualified operator that have valid radiographic test certificate. The result has been recorded for reference.

The preparation of the specimen for radiographic test involve cleaning process and preparation of image quality indicator (IQI). Before performing the test, several criteria such as IQI sensitivity and defect discontinuity are set to determine the quality of the radiographic film. The sensitivity of film can be measured using image quality indicators (IQI’s) tool.

IQI’s or penetrameters are used to measure radiographic sensitivity and the quality of the techniques used. Several standards use for IQI’s such as British Standard (BS EN 462), American Standard (ASME
SE 1025) and German Standard (DIN 62). For this experimental purpose the British Standard (BS EN 462-1) was used. Selection of IQI’s must be suitable with the material of the specimen. Simple calculation is used to calculate the sensitivity of the film and how many wires should appear on the film to comply with the standard.

\[
\text{Thickness of thinner wire visible} = \frac{\text{sensitivity}}{(100 \times \text{total weld thickness})}
\]

\[
\text{Thickness of thinner wire visible} = \frac{2}{(100 \times 20\text{mm})}
\]

\[
\text{Thickness of thinner wire visible} = 0.4,
\]

Inspection results can be obtained by visually check the radiography film. From the calculation above, minimum of 4 elongated wires are permissible to pass the radiographic testing procedure.

3.2.2. Spectrometry Test
Spectrometry test is performed to determine the chemical composition of the material at the base and weld metal. The chemical composition of the material will determine the weldability of the material and influence the welding joint quality. There is no specific standard use for spectrometer test and the sample preparation is according the ability of the machine itself. The chemical composition of the mild steel has been compared at two different zone; weld metal and base metal using spectrometer.

3.2.3. Destructive Test (Tensile and Side Bend Test)
Tensile test is the common destructive testing method to determine the mechanical behaviour of the material. The welding quality also can be defined through the tensile test while observing the fracture location of the specimen. It also used to measure the transverse tensile strength under static loading of a butt joint employing butt welds.

Side bend test was carried out to determine the soundness of the weld metal and HAZ in a cross section. The selection of side bends instead of root and face bend test is according to the thickness range. This may be preferred to the transverse bend test on thick materials. It is also used on processes or procedures expecting lack of fusion. The acceptance criteria for bend test are in accordance to AWS D1.1 in which the length of flaw must not exceed 3mm at any direction by visual examination.

3.3. Microstructure Observation
Scanning Electron Microscopic (SEM) observation is performed in this project to observe the fracture surfaces of the material due to overloading failure. The specimen used for microscopic observation is taken from tensile test specimen. The fracture area of the specimen has been cut into small pieces to fit into Scanning Electron Microscope Machine (SEM). Figure 1 shows the specimen used for scanning electron microscopic analysis. The location of the specimen is set to produce clear image in the monitor. The resulted image resolution can be set until the final microstructure can be identified.

The purpose of macrostructure observation is to analyze the internal defects, surface defects and geometric defects with type, size based on previously determined acceptance criteria [11]. The sample of macrostructure and microstructure must undergo several processes such as grinding, polishing and etching. The purpose is to get a fine surface area so that the microstructure will appear under metallurgical microscopic. Procedure for microstructure and microstructure observation is almost similar except the magnification factor must be adjusted. Specimen is polished and etched to gain quality microstructure result. Next, microscopic optical viewer is acquired for microstructure analysis with suitable magnification level. The magnification started with 10x and 20x and lighting is adjusted to produce clear view of the sample microstructure. The microstructure picture of the test specimen is recorded. The same observation was taken for three different places of the surface area for comparison of the microstructure taken [12].

The samples shown in Figure 1 were placed under the lens and image of the microstructures was then captured by CCD camera.
4. Result and Discussion
This chapter explains the detail of the experimental work that has been done in previous section. The detail of the result from non-destructive and destructive testing was discussed further. The information from the result have been used to make an analysis to evaluate the welding quality assessment. The discussion focused on the Shielded Metal Arc Welding Process and the effect on microstructure analysis in weld metal, heat affected zone (HAZ) and in base material. The discussion will be based on the results from all the testing techniques used for evaluation of welding quality assessment. In addition, the quality evaluation of the welding is based on welding procedure specifications provided. This chapter also explains the detail of the effect of applying the correct welding technique with the formation of microstructure analysis.

4.1. Welding Surveillance Check
The welding surveillance check was done during welding to control the important variable such as voltage, current travel speed and heat input. These variables have major effect in the formation of microstructure in weld metal and heat affected zone and the mechanical properties of material. For example, very high heat input control will increase the chances of distortion from occurs and will give heat affected zone become more brittle[13]. Table 2 shows the result of welding surveillance check for the welded sample. Is consists the information of the voltage, current, travel speed, and heat input.

Table 2. Welding Surveillance Check

| Interpass | Voltage (V) | Current (A) | Time/pass (min) | Travel speed (mm/min) | Heat input (kJ/mm) | Inter-pass Temperature (°C) |
|-----------|------------|------------|-----------------|-----------------------|--------------------|-----------------------------|
| Root      | 20         | 65         | 9.11            | 31.6                  | 2.47               | 243                         |
| 2         | 24         | 123        | 3.33            | 86.5                  | 2.05               | 310                         |
| 3         | 25         | 125        | 2.29            | 125.8                 | 1.49               | 329                         |
| 4         | 28         | 124        | 3.42            | 84.2                  | 2.47               | 330                         |
| 5         | 26         | 123        | 2.19            | 131.5                 | 1.46               | 350                         |
| 6         | 27         | 126        | 1.54            | 187.0                 | 1.07               | 381                         |
| 7         | 25         | 123        | 2.23            | 129.1                 | 1.43               | 390                         |
| 8         | 24         | 122        | 2.06            | 139.8                 | 1.26               | 400                         |
| 9         | 24         | 122        | 2.18            | 132.1                 | 1.33               | 421                         |
| 10        | 23         | 124        | 2.19            | 131.5                 | 1.30               | 431                         |
| 11        | 25         | 123        | 2.16            | 133.3                 | 1.38               | 381                         |
| 12        | 26         | 126        | 2.22            | 129.7                 | 1.52               | 390                         |

4.2. Radiography Results
Typical defect can be detected and measured using x-ray radiographic testing (RT) technique such as porosity, slag inclusion, undercut, and surface crack etc[14]. Interpass slag inclusion about 2mm length as shown in Figure 2 was detected after performing a radiographic test. Interpass slag inclusion defect
occurs due to lack of cleaning process after multiple pass welding. Darker area shows the lowest density while lighter areas indicate the high density of the material. Slag inclusion also due to the flux from filler metal that trapped into between passes of the welding.

![Figure 2. Specimen for scanning electron microscopic observation](image)

### 4.3. Chemical Composition Analysis

Chemical composition of the as-received sample was performed by using Arc Spark Optical Emission Spectrometer. It was taken after the specimen has been welded. The effect of the chemical composition of the specimen also has been compared with the mild certificate of the material supplied. The standard chemical compositions of S275JR mild steel grade is shown in Table 3. Three number of sparks that applied at the surface with different location which is base metal and weld metal are shown in Table 3.

**Table 3. Comparison of the Chemical Composition**

| Chemical composition (S275JR mild steel grade) | Percentage (%) | Mild certificate* | Experimental (spectrometer) |
|-----------------------------------------------|----------------|-------------------|-----------------------------|
|                                               |                | Base metal        | Weld Metal                  |
| 1 Iron (Fe)                                   | 98.4           | 97.9              | 97.5                        |
| 2 Carbon (C)                                  | 0.18           | 0.22              | 0.165                       |
| 3 Manganese (Mn)                              | 1.05           | 1.4               | 1.56                        |
| 4 Copper (Cu)                                 | 0.01           | 0.019             | 0.023                       |
| 5 Phosphorus (P)                              | 0.023          | 0.0034            | Less than 0.001             |
| 6 Sulphur (S)                                 | 0.002          | 0.0029            | 0.0047                      |
| 7 Silicon (Si)                                | 0.29           | 0.256             | 0.53                        |
| 8 Chromium (Cr)                               | 0.01           | 0.022             | 0.030                       |
| 9 Nickel (Ni)                                 | 0.01           | 0.012             | 0.012                       |
| 10 Molybdenum (Mo)                            | 0.004          | 0.013             | 0.013                       |
| 11 Aluminium (Al)                             | 0.042          | 0.095             | 0.137                       |
| 12 Cobalt (Co)                                | 0.00           | 0.0036            | 0.0023                      |
| 13 Niobium (Nb)                               | 0.001          | 0.0095            | 0.012                       |
| 14 Vanadium (V)                               | 0.001          | 0.0022            | 0.011                       |
| 15 Stannum/Tin (Sn)                           | 0.001          | Less than 0.001   | Less than 0.001             |

### 4.4. Macrostructure and Microstructure Analysis

Examination of the microstructure in various zone of the cross-sectional welding area often specified with taking a photo of micrograph for record purpose. The weld area must be examined to see the penetration of the specimen, but the information obtained is very limited due to the size of the specimen and the limitation of the microscope. The objective the macrostructure observation is to observe the
penetration of the weld area and the quality of the weld. Figure 3 show the macrostructure development at different zone. It clearly shows the fusion line between heat affected zone, weld metal and the base metal of the specimen. From the macrostructure analysis, there are 12-layer welding interpass have been observed between the welding joint.

Figure 3. Specimen for scanning electron microscopic observation

Microstructure analysis is necessary to analyse the microstructural changes different region which is base metal, weld metal and heat affected zone. For the microstructure analysis purposes, the welding samples are observed to figure the changes in grain size, microstructure element and shape. It is observed that there are changes in microstructure at base metal and after welding process. The differences or changes in microstructure at base metal, heat affected zone and weld metal shown in Table 4. The images were magnified at 10x and 20x.

From the result of microstructure, there are no discontinuities or defect detected on the weldment area. The multiple-pass welding makes the weld metal change in formation of microstructure. This result will be used as reference in welding terminology and welding quality assessment evaluation. The microstructure observation is taking from 3 different points at the specimens. Table 4 shows the result of the microstructure formation at different location and different magnification of the specimen. From the observation, there are no changes in microstructure in parent metal. The properties of steel depend upon the microstructure. From the result, formation of polygonal ferrite and grain boundary ferrite (A) clearly shown in base metal as illustrated in Table 4. Formation of small region of pearlite (B) also can be seen in the base metal under microstructure observation at 10x magnification and 20x magnifications. Formation of pearlite and ferrite was clearly shown under 20x magnifications. Base metal shows course grain boundary compare to weld metal and heat affected zone. The size of the grain boundary will affect the strength, ductility and the toughness of the material.
Table 4. Microstructure analysis under different region in welded mild steel

| Location | Microstructure of Mild Steel |
|----------|-----------------------------|
|          | 10 x magnification | 20 x magnification |
| Base Metal | ![Base Metal 10x](image1.png) | ![Base Metal 20x](image2.png) |
| HAZ      | ![HAZ 10x](image3.png) | ![HAZ 20x](image4.png) |
| Weld Metal | ![Weld Metal 10x](image5.png) | ![Weld Metal 20x](image6.png) |

The microstructure in the weld metal is significantly changed due to re-melting and solidification process. The metallurgy of the fusion zone of weld metal are totally different between the parent and base metal. Composition of the filler metal such as fine oxide particle was designed to create a good welding quality in term of the strength and toughness by producing a fine grain structure. Formation of acicular ferrite (D) in weld metal is due to solidification rate weld metal region. Based on the result, formation of martensite (D) at the weld metal and the degree of martensite formation is dependent on the temperature. Grain boundary ferrite (E) also appears in weld metal region but it appears in small region. It is due to carbon content between weld metal and base metal.

According to compositional analysis result, weld metal has less carbon content compare to base metal. Grain boundary ferrite and polygonal ferrite was decreased as increasing in carbon content. The
manganese also gives big influence on the grain boundary size and polygonal ferrite formation. Increasing in manganese percentage in weld metal makes the grain boundary ferrite become smallest from base metal. Grain boundary ferrite (C) also have been appears on heat affected zone area. Other microstructure element has been identified in heat affected zone region which is grain boundary ferrite, small amount of martensite and bainite. There is no acicular ferrite in HAZ region. Acicular ferrite is important because it provide relative toughness and strong microstructure. This is the reason why the weld metal has high toughness compare to heat affected zone.

In addition, polygonal ferrite in weld metal, heat affected zone and base metal was consider not beneficial to toughness of mild steel. The major microstructure changes are on the grain size of the material. The changes in grain size due to temperature different from welding process.

4.5. **Destructive Analysis**

Figure 4 show the hardness value taken from different location of the specimen which is base metal, HAZ and weld metal. The hardness value is different at the different location according to the temperature different and chemical composition. Weld metal indicate the highest of the hardness value compare to HAZ and base metal. This was affected by the metallurgy of the weld metal and affected by the carbon content between weld metal and base metal. Theoretically martensite that exist in the weld metal will make the weld metal became harder and more brittle. This analysis was proven by tensile strength test where the fracture occurs at the base metal instead of weld metal.

5. **Conclusion**

From the observation and experimental performed, it can be concluded that the chemical composition in material have influence the mechanical properties of mild steel with the change in their microstructure during welding process. It effects the welding quality in terms of its strength and required lifespan to suit the joint purposes.

5.1. **Chemical composition**

From the spectrometry testing, the apparent changes are on the weight percentage of chemical composition of the mild steel before and after welding. The change is between base metal and weld metal. There are no additions of new or loss of the composition element in mild steel, but the change is on increasing and decreasing of the percentage of chemical composition.

5.2. **Properties of material**

The properties of mild steel are different between base materials and the weld metal. The major different is on the mechanical properties of the mild steel. The effect of mechanical properties is on the strength of the material. Tensile test result was proven that weld metal has high strength compare to base metal, but it depends on the use of correct welding procedure specification. The material undergoes welding process also increase in hardness value and it can be seen in different location of the material after performing welding process which is base metal, heat affected zone (HAZ) and the weld metal [15].
5.3. Macrostructure and microstructure analysis

The temperature increase during welding and solidification rate results in reducing of grain size of microstructure. The grain sizes of the structure become smaller and apparent under the microscope. Besides that, the elements of microstructure also change after welding process has been done. The changes are on the microstructure element from formation of ferrite and pearlite to another element such as bainite and martensite. It can be seen in heat affected zone and weld metal region. The microstructures depend on the temperature of welding and on the chemical composition of filler metal used. The high temperature will carry out the enlargement of grain size of the microstructure. The microstructure will influence the mechanical properties of the material.

5.4. Evaluation of welding quality

The quality of the welding can be evaluated by using non-destructive and destructive test methods and by comparison of mechanical properties of material and microstructure analysis. The changes in microstructure have influence in the quality of the welding by decreasing and increasing of the mechanical properties of the material. In addition, welding procedure specification play importance role in the quality of the welding because it gives the specific procedure of welding process from the parameter until the technique used.

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The sample preparations of the welding are done successfully by following the Welding Procedure Specification (WPS) given. All the result analysis on microstructure and mechanical properties will be use as additional information to the Labuan Shipyard and Engineering company.

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