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Analysis of Welding Defects on the Deck of the Cargo Ship

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***Abstract* - The shipping industry is an important sector in supporting maritime transportation and logistics. In the process of building and repairing ships, welding is the main method in connecting structural materials, especially on the deck of ships that function as operational loads. However, the welding process does not always result in a perfect connection as it is affected by welding parameters, material conditions, operator techniques, and welding positions. This study aims to identify the types of welding defects that occur on the deck of the Cargo ship, analyze the causes, and determine prevention and repair efforts. The research method used is an analytical descriptive method through field observation, documentation, interviews, and literature studies. The results showed that the dominant welding defects found were porosity, undercut, slag inclusion, and spatter. The main factors causing these defects include inappropriate welding parameters, unclean material conditions, and suboptimal welding techniques. Prevention efforts can be carried out through controlling welding parameters, improving welder skills, and stricter quality control.**

Keywords: Welding defects, welding, ship deck, quality weld joints, cargo ship.

I. INTRODUCTION

The maritime and shipping industry is one of the main sectors in the global economy that has an important role in international trade, the shipyard is a place that is specifically made to support the process of building, repairing and maintaining ships and can be used to build other maritime facilities that are in accordance with the available facilities. Welding is the core stage of the fabrication process circuit. Based on the definition of the *Deutche Industrie Normen (DIN),* welding is a metallurgical bond on a metal or metal alloy joint that is carried out in a molten or liquid state. Welding is the process of combining two pieces of steel together by heating them to the point where the filler material fuses with the base metal and becomes one connected part (Risriki Widodo, 2024).

Shipbuilding almost 2/3 of the work is welding work. There are several variations of weld joints as options based on the thickness and quality of the material, and welding method. The results of welding are generally highly dependent on the skills of the welder. Weld damage both on the surface and inside is difficult to detect with simple testing methods.

In addition, because the welded structure is an integral part of the entire welded material body, the cracks that arise will spread widely quickly and may even cause serious accidents.

In general, welding ships has requirements from the Classification Board which supervises and provides the feasibility of the ship's construction force. To meet these requirements, the role of welders and technicians is very large, so that ships get good welding quality and can be accepted by ship owners and classification bodies (Sugeng Marsudi, 2021).

Quality is a benchmark to assess whether a product or service can meet the needs of consumers who have their own standards. Quality is the most fundamental factor for customer satisfaction. Of course, companies that produce products must pay attention to product quality and meet the criteria and rules to determine whether a product that will be produced in the good category or the product is not qualified or defective (Nafa Artha & Rr. Rochmoeljati, 2024).

Through Practical Work activities at Cargo Ship Maritime, the author had the opportunity to understand firsthand the welding process, the types of defects that occur in the field, and prevention and repair efforts according to applicable standards. It is hoped that as a result of this report, the author can contribute and understand in improving the quality of welding and safety of ship deck structures.

II. RESEARCH OBJECT

The research object in this internship study focuses on welding joints on the deck structure of the cargo ship, with special attention to welding defects that occur during the welding process as well as the repair of the deck structure. The

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analysis of the study includes the deck structure as the main observation area, weld joints on deck plates, stiffeners, and other supporting components. The welding process reviewed included the SMAW (Shielded Metal Arc Welding) and FCAW (Flux Cored Arc Welding) methods, with the identification of different types of weld defects such as porosity, undercut, slag inclusion, and spatter. In addition, the study also examines welding parameters that affect the quality of weld results, including current, tension, welding speed, and welding position. The condition and quality of the weld joints were then analyzed based on the findings of welding defects found in the structure of the ship's deck.

III. METHODS

This study used a descriptive qualitative and quantitative method to analyze welding defects on the deck structure of cargo ship. The research was conducted through direct observation, field data collection, and analysis of welding defects found during the repair and fabrication process.

The research methods applied in this study include:

1. Field Observation

To guarantee weld quality, traditional inspection methods such as visual testing, ultrasonic testing and magnetic particle testing are still widely used. While these approaches can effectively detect certain surface defects, they exhibit considerable limitations when faced with complex weld geometries or hidden internal flaws. For multilayer welds or deep subsurface defects in particular, conventional methods often fail to provide comprehensive and precise identification and localization. This shortcoming introduces potential quality risks and, in severe cases, may even compromise the safety of entire engineering structures (Yu Liang & Bo Jiang Yu, 2025).

2. Data Collection

Existing datasets in the field predominantly consist of radiographic or thermo graphic images, which, while effective for defect detection, require specialized and costly equipment that is not readily accessible in many industrial settings. Moreover, these modalities often lack the practicality needed for real-time scalable quality control within typical manufacturing environments (Melissa Tores & Kevin V, 2026).

Data were collected through:

a) Visual inspection of welding joints.
b) Documentation and photographs of welding defects.
c) Interviews with welders and supervisors.
d) Company welding reports and repair records.

3. Identification of Welding Defects

The welding defects found on the deck structure were identified and classified based on Welding Procedure Spesification (WPS). The defects analyzed in this study include porosity, undercut, slag inclusion, and spatter.

4. Analysis of Welding Parameters

Welding parameters such as welding current, voltage, welding speed, and welding position were analyzed to determine their influence on the occurrence of welding defects.

5. Evaluation of Weld Quality

The quality of welded joints was evaluated by comparing the inspection results with applicable welding standards and ship repair procedures used by the company.

6. Conclusion Drawing

Conclusions were drawn based on the results of observations and analyses to determine the dominant welding defects and the factors affecting weld quality on the deck structure of the vessel.

IV. RESULTS AND DISCUSSION

4.1 Overview of the Welding Process on a Ship Deck

Based on the results of observations during practical work activities at Cargo Ship Maritim, the welding process on the deck of the Cargo ship is an important part of the repair and fabrication of the ship structure. The ship's deck serves as the main horizontal structure that withstands various operational loads such as equipment loads, onboard work activities, as well as the influence of dynamic forces due to sea waves.

The welding process on the deck structure is carried out after the material preparation stage, steel plate cutting, and the initial assembly process (fit-up). At this stage, the deck plate relates to a reinforcing frame such as a longitudinal stiffener and a transverse frame using the electric arc welding method.

In practice in the field, the welding process is generally carried out using the following methods:

a) Shielded Metal Arc Welding

The definition of shielded metal arc welding is an electric arc welding process in which the heat energy for welding is

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generated by an electric arc formed between the metal electrodes wrapped in the workpiece (Berta Br Ginting, 2023).

The advantage of SMAW is its flexibility in various welding positions and ease of equipment. However, the productivity is relatively lower than that of the semi-automatic method because the electrode change is done manually. In ship deck work, SMAW is often used for repairs or hard-to-reach areas, SMAW welding can be seen as shown in Figure 1 below.

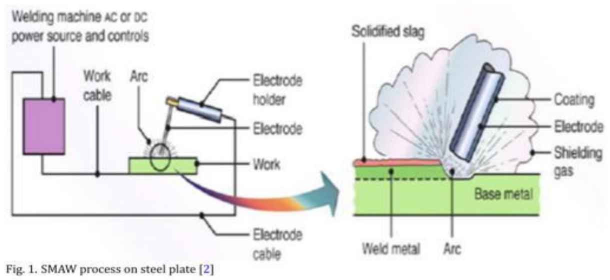

Figure 1: Shielded Metal Arc Welding

b) Flux Cored Arc Welding

In the ship production process, the plate connection process is generally carried out by welding, FCAW welding gas arc welding which uses welding wire as well as electrodes. The electrator is in the form of a wire roll whose movement is regulated by the motor drive wire feed.

These welds use CO2 as a arc protector. FCAW welding is an automated process that utilizes electrda wire roll to melt metals. In addition, FCAW welding has several advantages over general welding techniques, as it has better control and low steel weld tensile properties (Trisno Susilo, 2021).

FCAW is particularly effective for welding fillet joints on deck stiffeners as well as dull joints of deck plates with medium to thick thickness. On AHTS type vessels that have high operational loads, the use of FCAW helps to produce connections with good mechanical strength and processing time efficiency.

However, the FCAW process also has the potential to form defects such as slag inclusion, porosity, and spatter if the current, tension, or welding speed parameters are not properly controlled. Therefore, the implementation of welding procedures (WPS) as well as quality supervision is indispensable to ensure that the weld results meet the vessel classification standards, FCAW welding can be seen as shown in Figure 2 below.

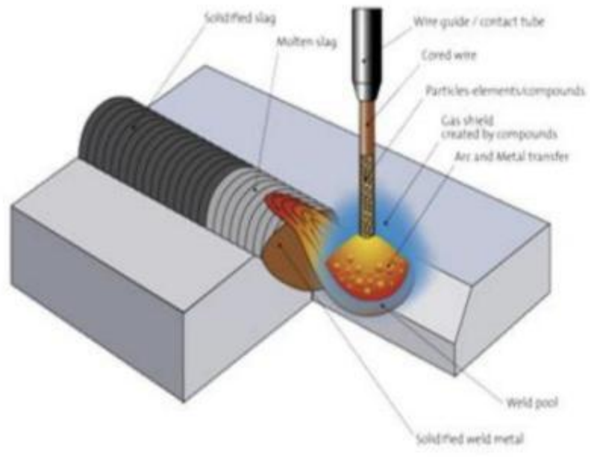

Figure 2: Flux Cored Arc Welding

The method was chosen because it has good penetration ability and can be used in various welding positions that are often encountered on ship structures.

However, during the welding process, several welding defects were still found that had the potential to reduce the quality of the weld joint. These defects are generally identified through visual inspections conducted by the Quality Control (QC) team.

4.2 Identification of Types of Welding Defects

Based on the results of direct observation in the welding area and the visual inspection process of the weld joints on the ship's deck, several types of welding defects were found that are common. These types of disabilities include:

4.2.1 Porosity

The porosity of the weld joint is an unacceptable defect because these cavities reduce the effective area on the weld metal and serve as a stress concentrator that makes the weld joint highly susceptible to premature failure (Carloz Adrian, 2025).

In the weld joint of a ship's deck, porosity generally appears in the form of small dots on the weld surface. These defects usually occur due to unclean surface conditions of the material or suboptimal gas protection during the welding process.

The main causes of porosity observed in the field include several critical factors that compromise weld quality. These consist of steel plate surfaces that still contain rust or dirt, the presence of moisture in the electrode or base material, unstable gas shielding during the welding process, and the use of excessively high voltage parameters. Each of these

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conditions contributes to the formation of gas pockets within the weld metal, ultimately resulting in porosity defects that weaken the integrity of the welded joints.

The existence of porosity can reduce the effective area of the weld joint and become the starting point for cracks if the joint receives repeated loads. The results of porosity welding defects can be seen in Figure 3.

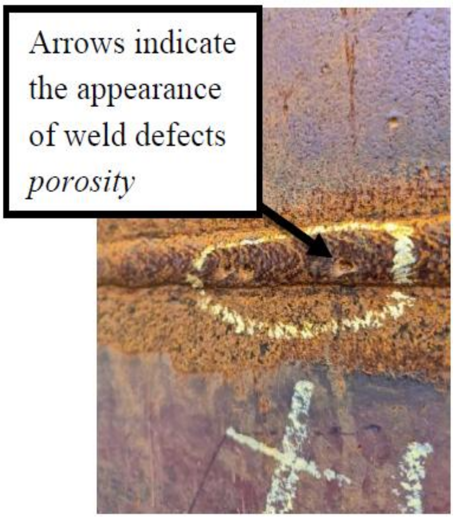

Figure 3: Porosity welding defect

4.2.2 Undercut

Undercutting is a fusion welding defect that appears as grooves at the end of the welded metal. Undercut irregularities form during welding, especially when currents are applied at very fast speeds. This reduces static strength and weld fatigue and results in a stress concentration in the welding zone. The height of the reinforcement, the contact angle of the weld bead, the width, depth, length, and radius of the undercut root, as well as other factors, affect the magnitude of the stress concentration factor (Memduh Kurtulmuş, 2023).

These defects usually appear on the edges of the weld beads and can be visually visible as thin grooves along the sides of the joint.

Some of the factors that cause undercuts include:

a) Too high welding current
b) Welding speed that is too fast
c) Imprecise electrode angle
d) Unstable welding techniques

Undercuts can cause stress concentrations at the edge of the weld joint, potentially reducing the strength of the structure, especially on the part of the deck that receives operational loads. The results of the undercut weld defect can be seen in Figure 4.

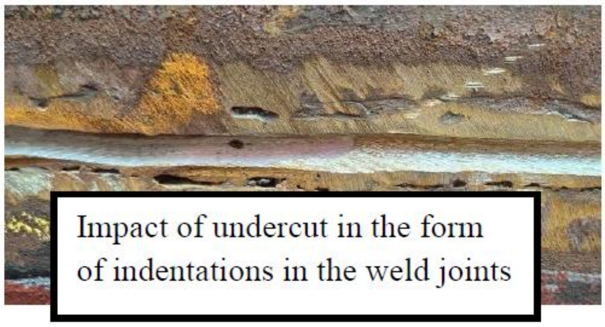

Figure 4: Undercut welding defect

4.2.3 Slag Inclusion

Slag inclusion is a process that occurs in the welded area where slag particles are trapped in the welded metal (Retno Hestiningrum, 2024).

This defect often occurs in welding processes that use flux-coated electrodes such as in the SMAW or FCAW methods.

This defect usually occurs when the slag cleaning process between weld layers is not done properly. In addition, improper welding techniques can also cause slag not to come out of the weld pool and end up trapped inside the weld metal.

Some of the causes of slag inclusion include:

a) Imperfect slag cleaning between weld layers
b) Improper electrode angle
c) Too low welding current
d) Unstable welding speed

Slag inclusion can cause internal discontinuity in the weld joint, thereby lowering the mechanical strength of the joint. The results of the slug inclusion weld defect can be seen in Figure 5.

Figure 5: Slug Inclusion welding defect

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4.2.4 Spatter

An unstable weld arch can cause spark of liquid weld pools, a phenomenon known as weld spatter. These sparks damage the quality of the product and require inefficient secondary processes along with associated costs for their removal. Imaging studies aimed at reducing splashes have been conducted, but little effort has been put into studying the behavior and measuring the splash (Young-Cheol Jeong, 2017).

Spatter does not necessarily affect the strength of the joint directly, but it can reduce the visual quality of the weld and increase the cleaning process time after welding.

Some of the factors contributing to spatter observed in the field include inappropriate current and voltage settings, instability of the electric arc, an excessively large stick-out length, and the use of an improper electrode angle. These conditions disrupt the stability of the welding process, causing molten metal droplets to scatter around the weld area, which not only reduces weld quality but also increases the need for post-weld cleaning and finishing.

If the spatter is not cleaned properly, it can interfere with the painting process and increase the risk of corrosion on the surface of the ship structure. The results of the spatter weld defect can be seen in Figure 6.

Figure 6: Spatter welding defect

V. CONCLUSION

Based on the results of the research conducted, several suggestions can be proposed to improve the quality of welding outcomes.

First, welding parameters should be carefully adjusted in accordance with the Welding Procedure Specification (WPS) to optimize results and minimize defects.

Second, material preparation must be improved by ensuring that the surface is thoroughly cleaned of rust, oil, and dirt before welding, thereby reducing the risk of porosity.

Third, welder skills need to be enhanced through regular training and supervision to ensure that welding techniques comply with established standards.

Fourth, the surveillance system should be strengthened by conducting regular and comprehensive inspections of welds, both visually and, when necessary, using non-destructive testing methods, to ensure that defects remain within acceptable tolerance limits.

Finally, further research is recommended to provide a more in-depth analysis using quantitative methods, such as tensile strength testing or residual stress evaluation, so that the study results become more comprehensive and scientifically robust.

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