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Gas Tungsten Arc Welding (GTAW) and Underwater Welding (UW) on Brass Propeller Repairs

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Abstract

Over time, marine building technology has experienced very significant developments and there are several variations of improvements that can be made to suit needs and conditions. A ship's propeller is a ship component that often experiences collisions with hard objects floating in the water which can cause the blades of the propeller to experience damage such as bending, cracking or breaking. In this case, the propeller should be repaired immediately so as not to disrupt the smooth operation of the ship. Repairing broken propeller blades can be done using a welding process. Welding is a technique of joining metals by melting part of the parent metal and filler metal with or without additional metal and producing continuous metal. Underwater Welding is a welding process that occurs in wet conditions, meaning that the electrode and object are in direct contact with air, while Gas Tungsten Arc Welding (GTAW) is an electric arc welding process that uses an untreated electrode that does not melt. This research was conducted to analyze the welding measurement results of Gas Tungsten Arc Welding (GTAW) and Underwater Welding on brass materials. To support the analysis process, testing activities are carried out including tensile tests (tensile test), hardness tests (hardness test) and macrographic observations on the results of welding materials.

Keywords: Propeller, Gas Tungsten Arc Welding, Underwater Welding

1. INTRODUCTION

Over time, marine building technology has experienced very significant developments and there are several variations of improvements that can be made to suit needs and conditions. A ship's propeller is a ship component that often experiences collisions with hard objects floating in the water which can cause the blades of the propeller to experience damage such as bending, cracking or breaking [1]. The ship's propeller itself functions as a producer of thrust on the ship which gets power from the main engine [2]. In this case, the propeller should be repaired as soon as possible so as not to disrupt the smooth operation of the ship. Repairing broken propeller blades can be done using a welding process [3]. Welding is a technique of joining metals by melting part of the base metal and filler metal with or without additional metal and producing continuous metal [4]. The welding process requires considerable preparation and precision so that the welding results are good and reduces defects in welding [5].
Underwater Welding is a welding process used for repair and maintenance of marine construction such as underwater pipes, offshore platforms and port equipment. This welding process takes place in wet conditions, meaning that the electrodes and objects are in direct contact with water [6]. Generally, the underwater welding method is used as an emergency connection when an incident occurs in waters and is temporary [7]. Gas Tungsten Arc Welding is welding which is usually called TIG (Tungsten Inert Gas). Tungsten electrodes are non-consumable electrodes which only function as creators of a flame arc which is used to melt the welding wire added from the outside and the objects to be joined into a single joint [8].
In previous research conducted by Haryadi, et al, tensile strength testing on seawater media welding results was 45.45 kg/mm2 and had a hardness of 137.7 HVN [9]. Furthermore, the research publication manuscript from Suprapto regarding the influence of the strength of brass welding on the TIG welding process and Oxy

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Acetylene Welding (OAW) showed that TIG welding results were better compared to OAW through tensile tests. In the tensile test of OAW welding, the strength was found to be 304,437 N/mm2 and in TIG welding it was 375,422 N/mm2 [10]. Furthermore, according to Mochammad regarding the analysis of the physical and mechanical properties of ship propellers in Oxy-Acetylene Welding (OAW) and Tungsten Inert Gas (TIG) welding, TIG welding results were obtained better than OAW through hardness tests, tensile tests and microstructure tests. The hardness value of the OAW welded joint test specimen was 38.25 High Rise Building (HRB) and the TIG welded joint test specimen was 38.70 HRB. Meanwhile, the tensile test results on the OAW welded test specimens were 91.85 N/mm2 and the TIG welded test specimens were 113.50 N/mm2 and for the microstructure of the parent metal of the OAW and TIG welded specimens there was no change, namely in the form of alpha phase and phase beta.
Based on the differences in welding methods above, an analysis of the comparative results of Gas Tungsten Arc Welding (GTAW) and Underwater Welding was carried out on the repair strength of brass propeller materials. To support the analysis process, hardness tests, tensile tests and macrographic tests were carried out on the welding results of brass materials. The method used in this research is the experimental method, namely direct experimental activities on test objects to see the results that occur in the Gas Tungsten Arc Welding (GTAW) and Underwater Welding welding processes for repairing brass propeller materials.

2. RESEARCH METHODS

2.1. Flow Diagram

Below is a research flow diagram

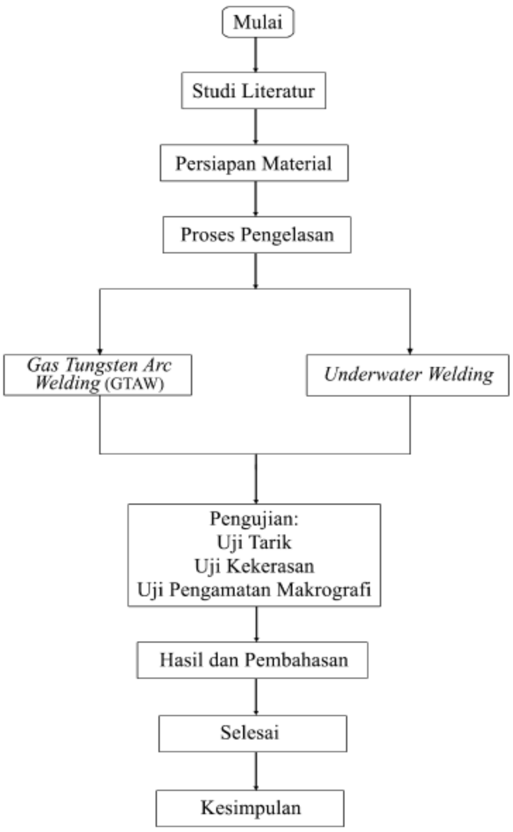

Figure 1. Flow Diagram

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2.2. Literature Study

.
Collecting literature includes collecting journals and previously written articles regarding Gas Tungsten Arc Welding (GTAW), Underwater Welding, propeller materials used, use of fillers, as well as use of bevel shapes and test standards.

2.3. Material Preparation

The material to be used is 2 brass plates measuring 300 mm x 30 mm x 5 mm and has the following specifications

Table 1. Material Specifications

No	Spec Inspection Item	Chemical Composition (%)
1	FR	5
2	PB	15
3	ZN	36
4	CU	65

Table 2. Mechanical Properties of Material without treatment

No	Mechanical Properties	
1	Tensile Strength (MPa)	315
2	Yield Strength (MPa)	97
3	Elongation (%)	65
4	Sheer Strength (Mpa)	220

2.4. Welding Process

Prior to the welding process, a bevel is made which is machined according to AWS D1.1 standards. For more details, see figure 2.

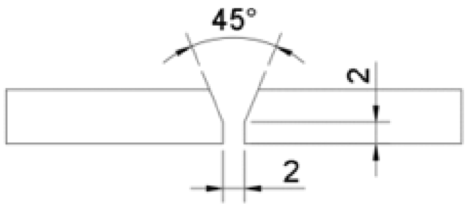

Figure 2. Bevel Making

After the bevel making process is complete, the material will be welded using Gas Tungsten Arc Welding and Underwater Welding (UW).


Figure 3. GTAW Classification Results

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Figure 4. UW welding results

In Figure 3 there are 2 welding layers. The first layer is used to connect the base welding part (root weld) and filler with an amperage of 145 A, a voltage of 22 V, and a travel speed of 180 s and the second layer is used to connect the keeping part or the top area of the weld (finishing) with an amperage of 160 A with voltage 22 V, and travel speed 255 s.
In Figure 4 there are 2 welding layers. The first layer is used to connect the base welding part (root weld) and filler with an amperage of 145 A, a voltage of 22 V, and a travel speed of 170 s and the second layer is used to connect the keeping part or the top area of the weld (finishing) with an amperage of 160 A with voltage 22 V, and travel speed 253 s.

2.5. Testing Process

Material tests are carried out to determine the quality of the material after treatment in the form of welding. This test is carried out using a tensile test, hardness test, macrographic observations.

Figure 5. Tensile test specimen

2.6. Results and Discussion

After the testing is complete, the next step is to present the results and discussion of the welding results of Gas Tungsten Arc Welding (GTAW) and Underwater Welding (UW).

2.7. Conclusion

Conclusions are obtained from the test results and analyzing them to answer the problem formulation of this research and provide references for further research to perfect this research.

3. RESULT AND DISCUSSION

This chapter explains the research results obtained from the material testing process carried out according to research methods as well as analyzing data or processing data obtained from testing both physically and mechanically from two welding processes. The data obtained are the results of the Tensile Test, Hardness Test and macrographic observations. The welding process used is:

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3.1. Tensile Test

Tensile testing is a test of materials to determine the ductility and toughness of a material against certain stresses and the increase in length experienced by the material. The tensile test results record the phenomenon of the stress-strain relationship that occurs during the tensile test process. Tensile testing machines are often needed in engineering activities to determine the mechanical properties of a material.

Figure 6. Tensile Test Results of Gas Tungsten Arc Welding Specimens

Figure 7. Tensile Test Results of Underwater Welding Specimens

Table 3. Tensile Test Results for GTAW and UW Specimens

No	Material Code	A0 (mm2)	Yield Strenght (Mpa)	Tensile Strenght (MPa)	Elongation (%)	Modulus Young (MPa)
1	UW	125	117.408	121.342	3%	3963.852
2	GTAW	125	120.516	208.574	13%	1564.312

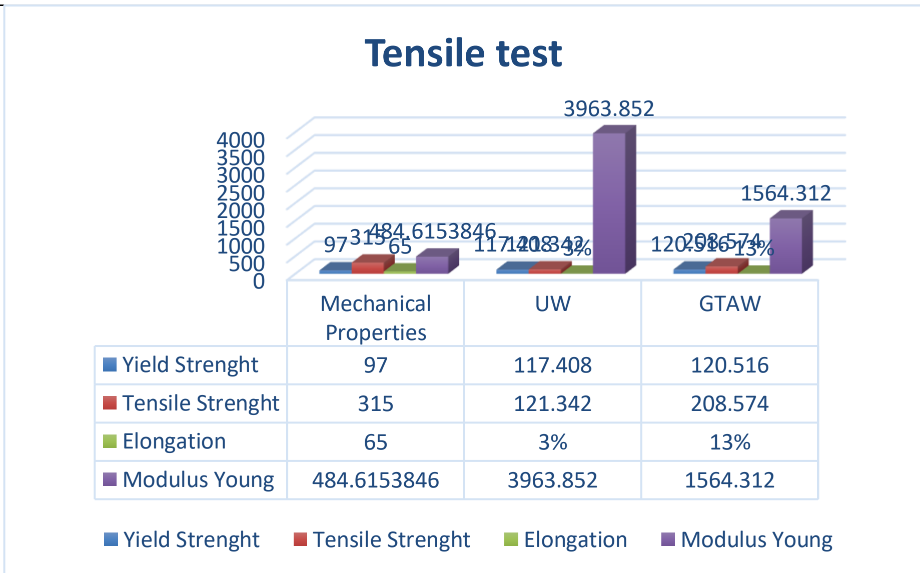

Figure 8. Tensile Test Graph

From the results of yield strength calculations in Gas Tungsten Arc Welding (GTAW) welding, it has a yield strength of 120,516 Mpa, Tensile strength 208,574 MPa and Young's Modulus 1564,312 Mpa. This shows that GTAW welding has a better modulus of elasticity compared to UW welding. This is because, if the Young's modulus value is higher, the specimen is less elastic.

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3.2. Hardness Test

The hardness test aims to determine the level of hardness of the test material which is related to the ductility properties of the material. Hardness tests are usually carried out on the base metal area, Head Affected Zone (HAZ), and welding results (weld metal) with reference to the BKI Vol. VI in 2022. The hardness test in this study used the Brinell method, namely in the form of a hardened solid ball.

Table 4. Hardness Test

No	Material Code	Hardness (HB)
1	UW	89.8
2	GTAW	78.4

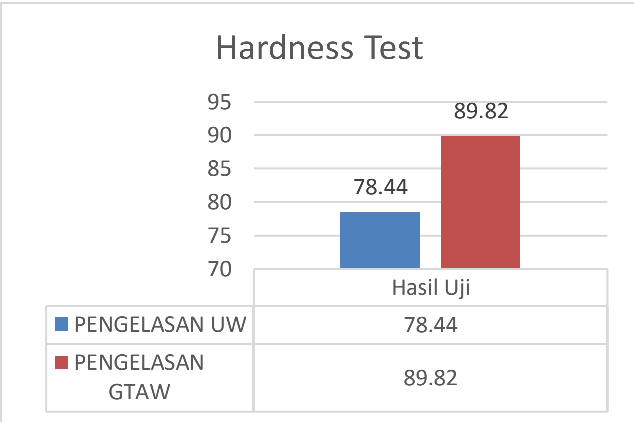

Figure 9. Hardness Test Graph

It can be seen that the hardness in the weld metal area in UW welding is 78.44 HB, and for GTAW welding it is 89.82 HB. So it can be concluded that Gas Tungsten Arc Welding (GTAW) welding has higher hardness compared to Underwater Welding (UW) welding.

3.3. Macrographic Observations

Macrographic observations are carried out to determine the conditions in welding or penetration and any defects that occur during welding.

Table 5. Macrographic Observations

No	Welding Type	Picture	Information
1	Gas Tungsten Arc Welding (GTAW)		Crack

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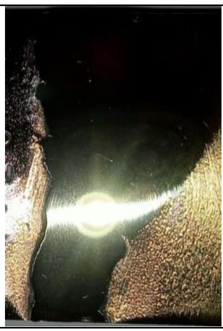
2	Underwater Welding (UW)		Exess Root Penetration

In the results of macrographic observations shown in table 3, a defect was found in Gas Tungsten Arc Welding (GTAW) welding, namely cracks, while in Underwater Welding there was also a defect, namely Excess Root Penetration. Crack or crack welding defects are caused by forced pressure when the material experiences deformation, while excess root penetration welding defects are caused by several things, namely the amperage used is too large, the environmental temperature is cold.

4. CONCLUSION

When viewed from ships that do not carry out the docking process, in technical analysis, the results of Gas Tungsten Arc Welding (GTAW) and Underwater Welding show that GTAW welding has a maximum tensile strength of 208,574 MPa, hardness in the weld metal area of 89.82 HB and welding defects in the form of cracks. Meanwhile, Underwater Welding has a maximum tensile strength of 121,342 MPa, hardness in the weld metal area is 78.44 HB and welding defects occur in the form of excess root penetration. So from the welding results, it can be compared that Gas Tungsten Arc Welding (GTAW) welding is better than Underwater Welding. In an economic analysis which aims to determine economic comparisons, it is found that Underwater Welding is more efficient than Gas Tungsten Arc Welding (GTAW). However, GTAW welding results are better than Underwater Welding.

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