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Design and manufacturing of Welded Vacuum Testing (WVT) tool

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Abstract

To ensure the quality of welded joints in the hull area, welding testing is very important and must be carried out. But unfortunately, currently the quality testing process of welded joints was still limited to penetrant tests and lime tests. The purpose of this study was to obtain a portable welding testing machine that was able to obtain fairly accurate test results on hull welding defects using a vacuum system. The research method is experimental by involving data collection through field experiments, testing is carried out with the resulting weld defect research subjects and the length of testing time on 1G and 3G position welding. The results of the study by compared tests among Welded Vacuum Testing (WVT) machines, Magnetic Particle tests (MP), and Penetrant Tests (PT). The three experiments detected leaking weld defects, spark sparks, pinholes, overlaps, and undercuts. For test results with machines made, welding defects that were successfully detected were leaks in the 1G position welding workpiece and undercut in the 3G position welding workpiece. Air bubbles at a vacuum pressure of 0.2 bar are detected, meaning that there is a defect in the welded joint. This tool can be used in bilge testing.

Keywords:

Quality of welded joints, ship hull, portable welding testing machine, welding defects.

1 Introduction

Weld testing is a very important step in ensuring the quality of welded joints. The quality of welding becomes a very important factor to ensure the strength and durability of the resulting structure. In general, there are two types of weld testing, namely nondestructive [1] and destructive testing [2]. However, there are still very limited quality testing machines, especially portable and easy to use on the hull.

Currently, welding testing is often conducted using various methods, including tensile tests [3–5]. There is also a compressive test so that it looks cracked in joints that have low quality [6-7]. Similarly to weld tests with prototype portable imaging systems, the ultrasonic imaging feature is examined for its ability to predict areas of weld joint quality [8]. There is also macroscopic testing of electric welded joints [9-10].

A range of Non-Destructive Testing (NDT) methods are used in the welding industry, each with its limitations. Kah [11] highlights the specific limitations of radiography, eddy current, and ultrasonic inspection, while Kumar [12] emphasizes the need for a thorough understanding of these limitations in NDE inspection programs. Reichert [13] proposes the use of machine vision technology, particularly laser-based, structured-light machine vision, to overcome the subjectivity and time constraints of visual testing. Olalere [14] underscores the importance of integrating advanced welding techniques with NDT methods to enhance safety and identify flaws and defects. The vacuum method in welding quality testing can be one of the most effective and accurate ways to identify weaknesses or defects in metal welding. In particular, developing equipment that uses a vacuum to test welding joint quality enhances the effectiveness of this method.

The importance of design welding vacuum test quality in welding technology is underscored by several key factors. Mazlan [15] highlights the correlation between welding current and the welding process, with specific values indicating good welding or the presence of defects. Olabi [16] emphasizes the role of residual stresses in determining the quality of welded parts, further underscoring the need for stringent quality control measures. Li [17] further supports this, stressing the importance of a robust quality management system in welding technology. Stavridis [18] provides a comprehensive overview of quality assessment methods in laser welding, further highlighting the need for rigorous testing and quality control measures in welding technology. The design of the welded joint quality testing machine is an important step in the development of welding technology. By using this tool, it is hoped that welding quality testing can be carried out more effectively and efficiently at various welding-related locations. The development of this tool in the welding industry is very important, especially in the hull of ships. Ships and equipment that are classified as completed must carry out operational testing on the hull [19], machine and electrical installations including impermeability tests [20], operational test and load tests of tanks, hatch caps, and hull doors, ramps.

To ensure good welding quality, tools are needed that can test and detect defects or weaknesses in welding, to answer the need for effective and efficient welding quality testing methods, a welding joint quality testing machine is needed. By utilizing the vacuum method, this portable tool ensures accurate and reliable welding quality testing.

Welding quality testing machines with the portable vacuum principle are a significant development in the welding industry because they are more effective and efficient. In addition, the development of this tool is of great importance in ensuring the overall quality and reliability of welded structures in construction and manufacturing [21]. Furthermore, the welded joint quality testing machine serves to identify and detect defects or weaknesses in metal welding.

These machines play an important role in ensuring the safety, durability and structural integrity of welded components, thus contributing to the overall success of the welding project. This machine represents a significant advancement in the hull welding industry, offering a portable solution for testing welding quality across various locations.

2 Research Methods/Materials and Methods

This research was conducted experimentally by identifying needs, designing tools, and making components, assemblies, and tests which were then analyzed by comparing the performance of Welded Vacuum Test (MVT) tool with two NDT tests that are commonly used in welding joints, namely Magnetic Particle test (MT) and Penetrant Test (PT). The stages of research are shown in Fig. 1.

2.1 Design of Welded Vacuum Testing (WVT) Machine

The design process using software inventor 2020 [22] includes designing; vacuum boxes, vacuum pump machine casings, casing covers, impermeable rubber and glass.

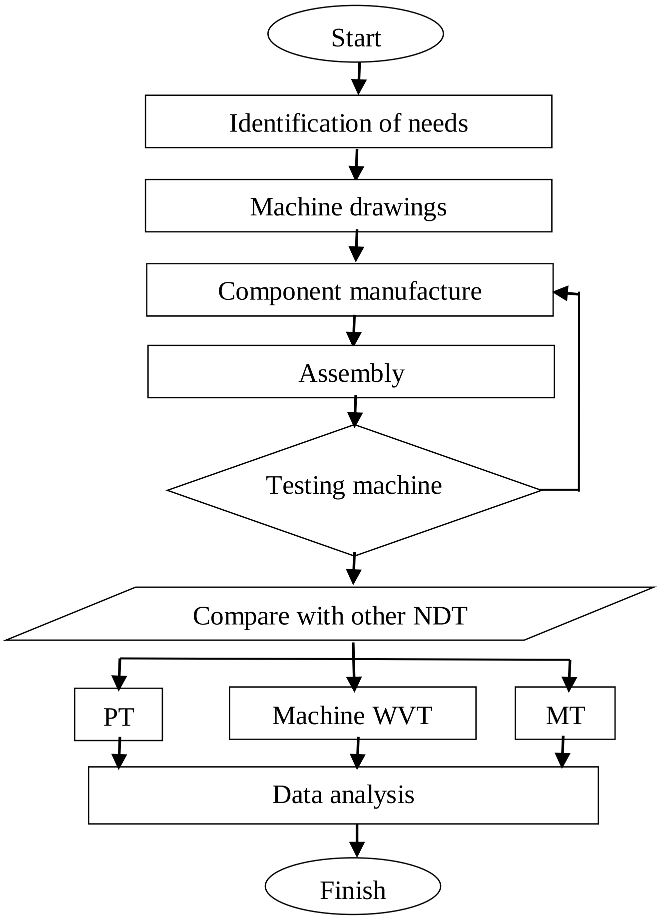

Fig. 1. Tool research process flowchart.

The explanation of the research flowchart is: starting with identifying the needs by discussing with PT IKI what the needs of testing the quality of the weld. Furthermore, machine drawings are made based on consideration of the need for vacuum welding tests. Next, make components namely boxes, pressure gauges, hoses, and vacuum machines. Furthermore, assembly is accomplished by connecting the box to the hose, along with the pressure and vacuum machines. Then a cob test is carried out if it does not succeed in detecting welding defects, then imperfect components are made, but this study goes well and then continues by comparing other defect tests, namely penetrant and magnetic. Furthermore, a comparative analysis was carried out between the three test methods carried out, namely WVP, PT, and MT machines, and ended with the preparation of a report.

2.2 Manufacturing Welded Vacuum Testing (WVT) Machine

The manufacturing process of the machine involves several steps: first, cutting iron plates to the specified design dimensions, followed by welding these plate pieces together to form the vacuum box casing for the vacuum pump machines. Next, foam is installed on the bottom of the vacuum box casing. Finally, the box is connected to the vacuum device by installing pipes and integrating a pressure gauge.

2.3 Testing Manufacturing Welded Vacuum Testing (WVT) Machine

The process begins with testing the quality of welded joints using specialized testing machines. Initially, the 1G welded joint is prepared by applying soapy water to its surface. Subsequently, the testing machine's box is affixed to the 1G specimen. The materials tested by this machine are then compared to those tested by traditional NDT welding defect testing equipment commonly used in the welding industry.

2.4 Data Retrieval Manufacturing Welded Vacuum Testing (WVT) Machine

The data collection method is that we take data on a welded joint quality testing machine (WVT), against a workpiece of 1G. The process of using a WVT machine using soapy water foam media to make it appear that the defect is located in the vacuum box. Data taken, the types of defects that occur in the testing process.

3 Results and Discussion

The results obtained from this study generally consist of the design, manufacture, testing of welding joint quality testing machines, data collection and finally comparison with other non-destructive tests.

3.1 Detailed Engineering Drawings Welded Vacuum Testing (WVT) Machine

Fig. 2 is a drawing of the design of the welded joint quality testing machine that has been designed. In Fig. 2, the design of the welding joint quality testing machine with the main components consisting of a vacuum box, vacuum pump machine casing, casing cover, impermeable rubber, and glass then adding the design of the vacuum pump machine, vacuum manometer, air faucet, hose nepel, on/off switch, nuts, and bolts.

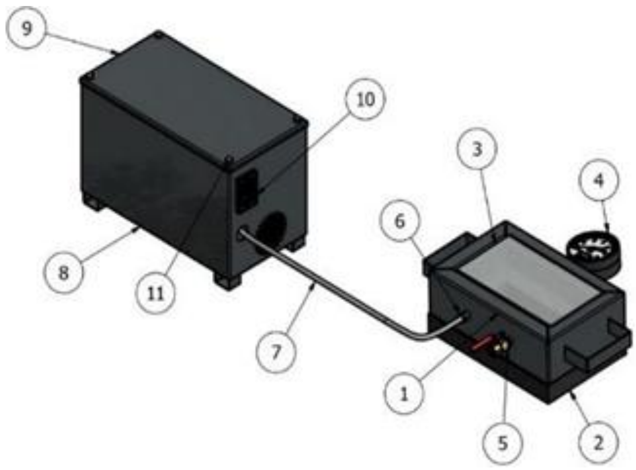

Fig. 2. 3D WVT machine design.

The description of Fig. 2 is:
1. Impermeable box
2. Impermeable rubber
3. Glass
4. Manometer
5. Air shells
6. Air hose nepel
7. Air hose
8. body vacuum welded joint machine
9. Case cover
10. Stores on/off
11. Bolt the case cover.

In Fig. 3, it can be seen a picture of impermeable rubber tape that will be installed on the box, which serves to isolate air from inside the box out of free air.

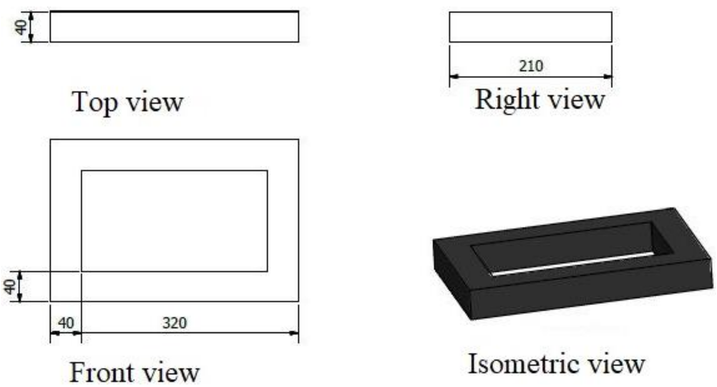

Fig. 3. Impermeable rubber.

In Fig. 4, it can be seen that a 2-dimensional and 3-dimensional vacuum box, this vacuum box is sticking to the connection area that is checked for defects.

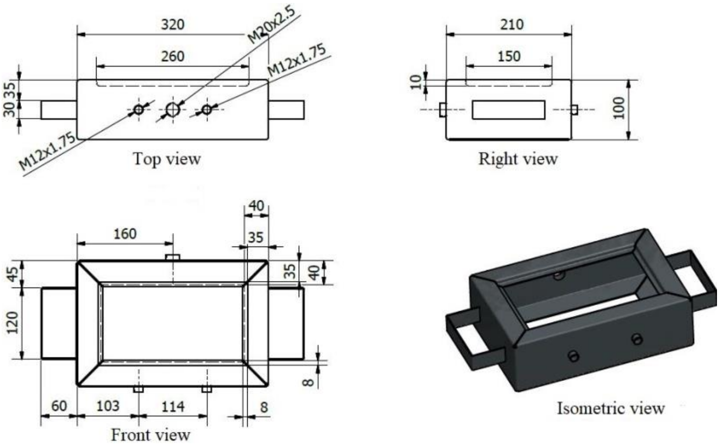

Fig. 4. Vacuum box.

3.2 Making Welded Vacuum Testing (WVT) Machine

In Fig. 5, it can be seen that the results of making a WVT machine with three main parts are: vacuum box, hose, and vacuum tool.

Fig. 5. Making WVT machine.

3.3 Testing of Welded Vacuum Testing (WVT) Machine

The testing of the tool involves comparing the Welded Vacuum Test machine (WVT) with the laser connection testing method. Laser connection testing is widely utilized in the hull connection welding industry. Two different types of welded joints, each with a workpiece length of 30 cm, undergo testing for 15 minutes. The tests include magnetic particle inspection and penetrant testing. Machine data retrieval involves categorizing the number of defects and calculating the average percentage of weld defects detected. In the initial test, visual inspection reveals weld defects such as pinholes, spatters, overlaps, and undercuts. In the subsequent test, the vacuum test machine, designed specifically to detect leaks in welded joints of the workpiece, is utilized.

In Fig. 6(a) we can see the testing process with vacuum test testing. The types of weld defects detected are 2 cracks, 2 undercut areas, and 2 leaks. In Fig. 6(b) we can see the testing process with a magnetic particle test. The types of weld defects detected were 6 undercut, 2 cracks, and no leak detected. Furthermore, in Fig. 6(c) you can see the testing process with a penetrant test. The types of weld defects detected were 10 leak areas, 10 undercut areas, and 2 cracks. This shows that the welding vacuum test can be used to detect all three defects.

3.4 Comparison Chart between WVT Machine and other Standard Tests

In Fig. 7, we can see a bar graph of the comparison test results of three welding quality test methods, namely vacuum welding test (WVT), penetrant test (PT), and magnetic particles (MT) for WVT testing, defects were detected in the form of cracks with 2 points, leaks with 2 points, and undercuts with 2 points. For PT testing, defects were detected in the form of cracks with some 2 points, leaks with a number of 10 points, and undercuts with a number of 10 points. For MT testing, defects were detected in the form of cracks with 2 points, undercuts with a number of 6 points, and for leak defects were not detected. The WVT testing is more effective at detecting leak defects compared to MT testing. This indicates that testing with a welded vacuum test engine is very good to use when testing hulls in the field. This is in line with research conducted by researchers [23] by comparing the chalk test, air pressure test, and vacuum test.

(a) Photo of WVT machine function test

(b) Photo testing specimens with magnetic particles (PT)

(c) Photo testing specimens with Penetrant Test (PT)

Fig. 6. Photo testing samples with (a) WVT machine, (b) magnetic particle (MT), and (c) Penetrant Test (PT).

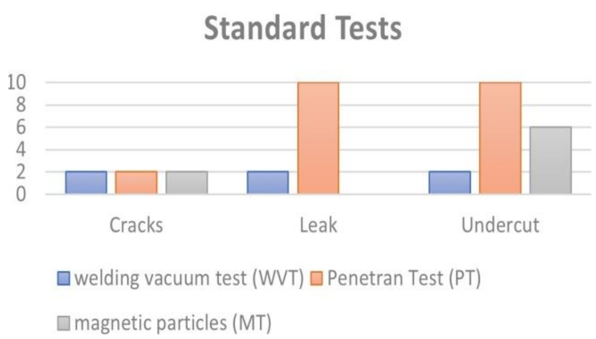

Fig. 7. The comparison graph of the first and the second test duration.

4 Conclusion

Based on the design, manufacture, and testing of welding joint quality testing machines, machines can be designed to build and function properly, and are able to detect cracks, leaks, and undercut defects.

Based on the results of the comparison test of non-destructive test tools between magnetic particle test, penetrant test, and vacuum test. Vacuum tests can detect defects cracks, undercuts, and leaks. Welding Vacuum Test (WVT) is more able to detect leak defects compared to magnetic particle (MT). However, it still detects less number of undercut defects compared to the Penetrant Test (PT).

One of the advantages of this portable vacuum welding quality test tool where this tool can detect weld defects until it penetrates behind or down the welded workpiece material (leakage).

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