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ARTICLE

Design, fabrication of a semi-automatic welding fixture for circumferential joining of cylinders using tig welding

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A B S T R A C T

This paper presents the systematic approach of design, fabrication of a semi-automatic welding fixture for circumferential joining of cylinders and testing the welded samples obtained. The TIG welding unit is used to make a circumferential joining on tank and piping, which are fixed onto the welding fixture and several parameters such as the setting of voltage, current and travel speed (rotational speed) is used for fabrication setup. The fabrication fixture with a constant rotation speed is obtained by revolving the tank or pipe with an electrical adjustable speed control motor. The report is focused on the welding of the aluminum workpiece using TIG welding. The joint of mechanical properties is determined by a static tensile test, impact test, and hardness test. This fixture, all the parameters can be determined, and it's an easy way to get the constant shape of welding joint at all joining by using the welding fixture, the evaluation by determination of joining quality can easily be used, especially for circumferential joint on tank and piping with a cylindrical shape.

1. Introduction

A standard tank and piping are a product with a cylindrical shape designed to hold gases or liquids at a pressure substantially different from the ambient pressure. The pressure differential is potentially dangerous, and many fatal accidents have occurred in their development and operation (Ahmad et al., 2020). Consequently, their design, manufacture and operation are regulated by engineering authorities backed up by-laws. Generally, almost any material with good tensile properties that is chemically stable in the chosen application can be employed (Liu et al., 2004).

Many tanks and piping are made of steel and aluminum. To manufacture a spherical tank, as an example, forged parts would have to be welded together. Some mechanical properties of aluminum are increased by forging but welding sometimes reduces these desirable properties. In welding, to make the tank meet the international safety standard, selecting a fabrication standard is being used (Gibson et al., 2014). To apply a welding process for standard tank fabrication, the cylinders of the tank are usually made from flat plates, which are rolled and then welded along longitudinal joints. On the other hand, circumferential joints attach end closures to the cylinder and weld rolled plates along with the tank if plate size availability or rolling machine capacity is restricted. Weld types are usually different for longitudinal and circumferential joints, and therefore the joint stresses in a tank must satisfy the requirements (Gottlieb et al., 2010).

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Nomenclature and abbreviation	
Amp	Ampere
CW	Clockwise
CCW	Counterclockwise
T	Thickness
N	Rotational Velocity

The circumferential joint of the cylindrical shape is being controlled as it is fixed on the fixture for constant rotation speed. The output of joining is a pair of the workpiece with the same thickness and diameter. The general welding parameters in the fabrication of tanks and piping usually depend on weld techniques consisting of voltage, current (ampere) and travel speed (mm/min). The welding equipment using the Tungsten Inert Gas (TIG) also considers the wire speed feed factors. The performance of a wire feed system can be crucial to the stability and reproducibility of TIG welding (He et al., 2014).

The welding voltages, or arc voltages, is determined by the distance between tip of the electrode and the workpiece. In the constant voltage system, the welding voltage is controlled by the arc length held by the welder and the voltage sensing wire feeder. To sure the constant speed of welding, the support jig is being developed. The other welding current parameters significantly affect the deposition rate, weld bead size and shape, and weld penetration (Giedt et al., 1989).

The standard of design and fabrication of the tank and piping is per the ASME Code Section VIII. The specific requirements apply to several classes of material used in pressure vessel construction and fabrication methods such as welding, forging, and brazing (Barabash et al., 2010). The present work is devoted to establishing a constant welding fixture model that created the outcome of workpieces by welding effect through the different parameters set on the TIG welding unit. The investigation on the tensile strength, hardness and impact test while viewing the structure under the microscope be carried out. The main objective of this project is to design, fabricate a welding fixture for welding the cylinder circumferentially using the TIG process and test the welded samples. A specified welding standard and procedures were used to evaluate the welding quality.

2. Materials and Methods

2.1. Experimental preparation

The experiment preparation includes the welding equipment (Circumferential welding apparatus) and the cylindrical shape of the workpiece (piping and tank). The experiment conducts by following 3 significant steps as below.

Step 1: Setup the workpiece

1. The workpiece is set up using the cylindrical shape (commonly piping and tank) in pairs (same diameter and same thickness) as shown in Fig. 1.
2. Place the workpiece between the clamps and tight them and check for parallelism. Set the rotational motion of the workpiece.

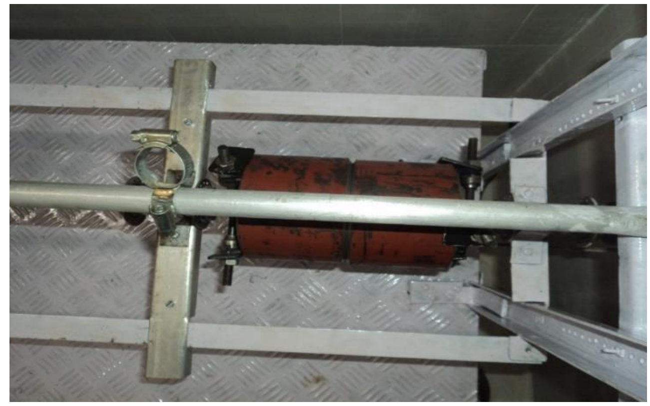

Fig. 1. Experimental setup workpiece to the fixture

Step 2: Setup the workpiece

1. The workpiece is already in position and tighten up. Set the welding nozzle at a 45° to 60° angle to the workpiece. The nozzle's proper distance to the workpiece is set up when the actual model is already in action, as shown in Fig. 2.
2. The nozzle in the position between the pairs of the workpiece. The nozzle is grasped by the adjustable holder, which is controlled by linear movement and angles.

Fig. 2. Setup the nozzle in position with the workpiece

Step 3: Start-up the workpiece movement

1. Workpiece rotation is attained by rotating the drive shaft at the bottom, which links together with the speed control motor.
2. The rotation of the work piece must come first before the welding to make sure the practical welding is on the initial condition.
3. Test run the rotation of the workpiece for confirmation that the welding wires are in position along with the workpiece.
5. By manual observation, the welding process takes place until the end position of rotation, which needs the operator to shut off and stop the workpiece rotation, as shown in Fig. 3.
6. Loosen all the grasp parts, the work piece is taken out and check the weld part.

7. Check the welding quality and perform the actual welding.

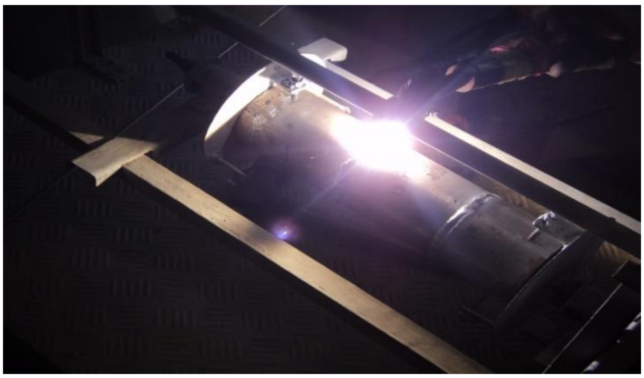

Fig. 3. Rotation of the workpiece

2.2. Procedure

Step 1: Firstly, an aluminium workpiece of 75mm d is taken.
Step 2: An Aluminium Welding fixture
Step 3: Nozzle fixed to the fixture
Step 4: Nozzle tip in connection to the workpiece
Step 5: TIG welding setup
Step 6: Welding process in constant rotation
Step 7: Workpiece after welding
Step 8: Weld obtained

2.3. Welding voltage (V)

The welding voltage is determined by the distance between the tip of the electrode and the workpiece. In a constant voltage system, the welding voltage is adjusted by the knob on the front of the power source because the machine maintains a given voltage which maintains a certain arc length. In a constant current system, the welding voltage is controlled by the arc length held by the welder or equipment and the voltage sensing wire feeder. The arc voltage required for an application is dependent on the electrode size, joint and base metal thickness (Pal et al., 2008). In this project, the dependent variables are fixed based on current facilities has at KKTM Balik Pulau. From experiences, the weld bead becomes flatter and more expansive when the other parameters are held constant and the arc voltage increases. The penetration increases up to an optimum voltage level and then decrease (Daniyan et al., 2020).

2.4. Testing and analysis

The testing that is conducted under this project consists of tensile test, hardness test and impact test. Testing is done to reveal the mechanical properties of the material after welding.

2.4.1. Tensile Test

To conduct a tensile test, a suitable workpiece by shape and size must be suitable. This workpiece must have a known cross-sectional area and suitable gauge length for the test conditions. Once a suitable test workpiece has been obtained, the workpiece is loaded into the test machine using good grippers. The actual machine that is used for testing the workpiece.

2.4.2. ASME standard and application

The ASME conducts one of the world's most extensive technical publishing operations through its ASME Press, holds numerous technical conferences and hundreds of professional development courses each year, and sponsors numerous outreach and educational program (Dym et al., 2005). For this project, the similarity of using the ASME codes for standards and procedures is applied in the boiler and pressure vessels. The application of the ASME standard focuses on testing the material or generally conducted on a destructive test.

4. Results and discussion

4.1. Welding joint

The workpiece is being cut using the specimen cutter provided at USM Nibong Tebal, and the result of the quality welding by multiple settings on the TIG welding unit (voltage, current and travel speed) is analyzed. As the cylindrical requirement to stand with the load, the destructive mechanical test is applied on the workpiece used to relate with the quality of the welding joint.

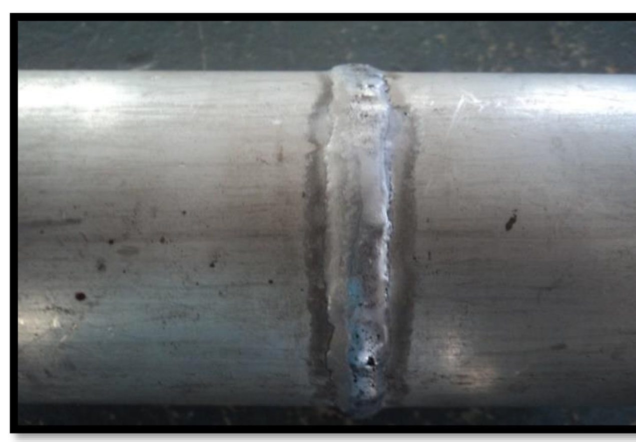

Fig. 4. Circumferential welded joint

The result for the circumferential welding joint is evaluated on its impact test and tensile test. The illustrated welding joint effect by TIG welding on cylinder shape can be seen in Fig. 4.

4.2. Destructive Test

In destructive testing, a sample portion of the welded specimen is required. These samples are subjected to loads until they fail. The failed pieces are then studied and compared to known standards to determine the quality of the weld. The most common types of destructive testing are tensile test, impact test of welding joint and hardness tester to evaluate the stand of welding (Chao, 2003). As the circumferential joint of welding, the test shows that the fabrication fixture produces a good joint quality by its constant feed.

4.3. Testing Results

As mentioned before, the parameters being set on the welding unit to conduct the welding test are voltage, amperes, and the travel speed of the workpiece. The voltage and travel speed can be regulated for the welding test, but the amperes are automatically determined by the welding unit itself, which depends on the arc length and voltage selected.

4.4. Tensile test

The results obtained by tensile test are dimensions of weld specimen considered for testing

Width (b) = 14mm
Thickness (t) = 3mm
Area of weld (A) = b x t
= 14 x 3
= 42 mm^2

The maximum tensile strength of aluminium is about 125MPa
Tensile strength obtained = 70MPa
The maximum yield strength of aluminium is about 55MPa
Yield strength obtained = 32MPa

4. Conclusion

The end of the session shows that evaluating the welding quality is already being carried out by fabricating the welding fixture and measuring the output based on the circumferential joint on cylindrical shape using TIG welding. It can be sure that the implication from the adjustment of voltage and travel speed had many impacts to form, strength, hardness, and joint quality. Using this fixture, all the parameters can be determined because of an easy way to get the constant shape of the welding joint at all joins. Additionally, the application of Aluminum can be differentiated and determined of the maximum and minimum level of parameters setup. The larger output from a determination of parameters differentiation was the workpiece with an outer diameter of 75mm, which is shown with all adjustable parameters act to produce the quality of joining. It causes by the thickness of the workpiece (4mm) rather than other workpieces. Although using the different outer diameters of the cylinder, it does not influence the adjustment unit and the quality of joining because the thickness is a major rule to stand with the strength, hardness, and impact of pressure. In the end, by using the welding fixture, the evaluation by determination of joining quality can easily be used, especially for circumferential joint on tank and piping with a cylindrical shape.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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