The Effect of Root Gap on Bending Test Using FCAW Welding On SS 400 Steel Materials At 3G Position

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Abstrak

Penelitian ini bertujuan untuk menganalisa pengaruh root gap terhadap pengujian bending pada material baja SS 400 dengan ketebalan yang berbeda yaitu 10 mm dan 12 mm menggunakan pengelasan FCAW (Flux Core Arc Welding) pada posisi 3G Vertical up tanpa backing ceramic. Penelitian ini menggunakan metode kuantitatif, standar yang digunakan dalam pengujian yaitu ASME section IX (2019). Hasil penelitian diperoleh kesimpulan pada spesimen dengan ketebalan 10 mm, didapatkan nilai tertinggi pada variasi root gap 4,4 mm dengan nilai bend stress sebesar : 467,48 MPa. Kemudian pada spesimen dengan ketebalan 12 mm, didapatkan nilai tertinggi terdapat pada variasi 3 mm dengan nilai bend stres sebesar: 805,37 MPa.

Kata Kunci: *FCAW, Root Gap, 3G Vertical up, bending test, bend stress, Baja SS 400.*

Abstract

This study aims to analyze the effect of the root gap on bending test of SS 400 steel materials with different thicknesses of 10 mm and 12 mm using FCAW (Flux Core Arc Welding) welding in the 3G Vertical up position without backing ceramic. This study uses quantitative method, and the standard used in the test is ASME section IX (2019). The results of the study concluded that in specimens within the thickness of 10 mm, the highest value was obtained at the root gap variation of 4.4 mm with a bending stress value of: 467.48 MPa. Then on the specimen with a thickness of 12 mm, the highest value was found in a variation of 3 mm with a bending stress value of: 805.37 MPa

Keywords: *FCAW, Root Gap, 3G Vertical up, bending test, bending stress, SS 400 Steel.*

1. Introduction

With the development of technology to support and realize infrastructure development and improvement programs as well as the development of transportation access, it is necessary to prepare experts in accordance with the required fields of expertise, one of which is welding experts in various specifications of welding activities. One of the development programs that have been planned by the Indonesian government is the sea highway development program, with the aim to improve maritime connectivity in Indonesia. The sea highway itself is a development of infrastructure and the maritime transportation sector, to support the program. These include the construction of ports as well as the addition and rejuvenation of the number of ship fleets.

Welding techniques have a great influence on science, Welding methods are still developing but nonetheless they already provide quality product results, so knowledge of welding techniques is needed to achieve the desired results with welding processes that can be carried out to achieve optimal results. [1]. the welding process, the swinging of welding electrode performed by a welder also affects the characteristics of the weld, the shape of the electrode swing for welding is the welder's own choice regardless of the strength of the welded joint. With the presence of different welding movements, it will give different weld joint strength results at each connection [2].

The Flux Core Arc Welding method uses a shielding gas to protect the molten metal through the evaporation of the flux core by arc heat, in this welding method also produces slag or metal shields that must be cleaned between the weld lines to keep the weld from slag inclusion. This welding method can use a mixture of gases used to take advantage of different gas characteristics, the gas mixture most commonly used for welding carbon steel is a commercial mixture of 75% argon and 25% CO2, the FCAW welding method has good flexibility for alloy steels, alloy materials often included in the wire core. [3]. SS 400 steel material is a type of low carbon steel with a carbon content of 0.12-0.20% and has a tensile strength of 400-560 MPa which is often used as a construction frame, including construction frames in ship buildings such as ship hull construction parts, steel this type is relatively easy to find in the market at a low price. [4].

Based on field inspections, the root gap in the world of shipyards is usually between 0 to 3 mm. A welding technician said that if you use a root gap beyond 3mm, the level of difficulty during the welding process is very high, from there for structural steel work, it is very important to pay attention to, one of which is the width of the root gap because it is an essential variable. In the welding process, if changes are made in the width of the root gap in the essential variable, it can affect the value of the tensile strength of a material

Quoted from Pratama [5] on the comparison of tensile, bending, and micrographic strengths of SS400 steel welded joints due to FCAW welding with variations in butt-joint types and welding positions with a bending stress of 558.88 MPa. Meanwhile, SS 400 steel with U butt-joint type with 2G welding position has an average tensile strength of 400.66 MPa, an average strain of 37.67%, and an average modulus of elasticity of 7.92 GPa. And has a bending stress of 555.53 MPa.

Quoted from Nata et al [6] analysis of the bending test strength of shielded metal arc welding (SMAW) SS400 material using e6013 welding wire with various variations of electric current with the results of the bending test strength, The average value of the bending test strength for 90A current strength, the average bending stress is 1.305 N/mm^2. For the current strength of 100A, it is the largest of all with 1.387 N/mm^2. The lowest value is achieved at 80A with an average bending stress of 1.256 N/mm^2.

Quoted from Azwinur et al [7] Has conducted research on the effect of different types of SMAW welding electrode on the mechanical properties of the SS400 material, the results of the bending test value on the root bend with the lowest value comes from the E7010-P1 electrode by 29.88 kgf.mm2, followed by the E7018 electrode, which is equal to 31.50 kgf.mm2, and finally with the highest value on the E7016 electrode of 38.87 Kgf.mm2.

Based on the introduction above, it is necessary to do further research on the root gap with the title "The effect of root gap on bending test using FCAW welding on SS 400 steel materials at 3G position" with the aim to analyze the effect of Root Gap variations on the Bending test.

2. Method

Researchers use the following implementation procedures:

2.1. Material Preparation and Making The Specimen

In this phase, the first step is to determine the materials to be used and the manufacture of welding seams used for research

2.2. Determining The Material

In this study, the material used is SS400 steel (Structural Steel 400) with different thicknesses, namely: 10mm and 12mm

2.3. Determining The Root Gap

This study uses different variations of the Root Gap, namely: 2mm, 3mm, 4.4mm and 4.6 mm.

2.4. Determining The Electrode

For this study, the researchers used the welding wire (Atlantic) Flux Cored Wire For Mild Steel CHT711 AWS A5.36 E71T1-C1 with an electrode diameter of 1.2mm used for root welding processes (penetration), filler (filler), and capping (finish).

2.5. Determining The Welding Position

In this study, the researchers used the FCAW welding method with the welding process using the 3G Vertical Up position.

2.6. Making The Butt-Joint

In this study, the researchers used V / Single Vee butt-joint on SS-400 steel materials and is bevel / cut side of the plate Angle of Bevel 30o with Included Angle 60o.

3. Results and Discussion

Data analysis using the ASME (American Society of Mechanical Engineers) Section IX standard [8] [9], in Figure 1 which shows the manufacture of bending test specimens according to the ASME Section IX 2019 standard with Code QW-462-3 (a) [10]

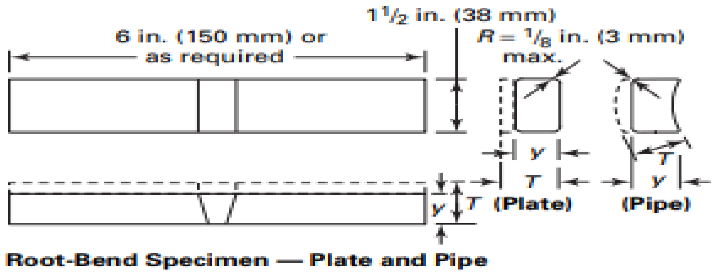

Figure 1. Bending Test of Root Bend ASME Code QW-462.3 (a) Standard.
(Source: ASME Code QW-462.3(a), 2019)

Results and discussion to determine the value of bending strength using the ASME Section IX (2019) standard.

Bending Test

Bending test is a method of Destructive Testing (DT) which is a material damaging test. This test can be used to determine the results of the mechanical properties of the test.

From the results of the bending test for the root bend position, the bending stress / bending strength value is obtained from the formula $\sigma = \frac{M.C}{I}$ with the derivation of the formula as follows:

$$M = \frac{\text{f (load)}}{2} \cdot \frac{\text{l (length of specimen)}}{2} \quad (1)$$

$$M = \frac{\text{f .l}}{4}$$

$$C = \frac{1}{2}\ \text{material thickness} \quad (2)$$

$$I = \frac{1}{12} \cdot w \cdot t^3 \quad (3)$$

$$I = \frac{1}{12} \cdot \text{thickness} \cdot (\text{thickness})^3 \quad (4)$$

$$\sigma = \frac{M.C}{I} \quad (5)$$

Explanation:

M = Is the highest moment value of the specimen
C = Is the distance from the center to the surface of the specimen
I = Moment of inertia

From the results of the tests carried out on the Root Gap variation of 2 mm in the root bend position with a specimen thickness of 10 mm, the bending stress value was obtained.

$$M = \frac{f\ (\text{load})}{2} \cdot \frac{l\ (\text{length of specimen})}{2}$$
$$M = \frac{39{,}71}{2} \cdot \frac{29}{2}$$
$$M = \frac{39{,}71 \cdot 29}{4} = \frac{1{,}151}{4}$$
$$M = 287{,}90$$
$$C = \frac{1}{2}\ \text{material thickness}$$
$$C = \frac{10}{2} = 5$$
$$I = \frac{1}{12} \cdot w \cdot t^3$$
$$I = \frac{1}{12} \cdot 38 \cdot (10)^3$$
$$I = \frac{1}{12} \cdot 38 \cdot 1000$$
$$I = \frac{1}{12} \cdot 38{,}000$$
$$I = 3{,}166$$
$$\sigma = \frac{M.C}{I}$$
$$\sigma = \frac{287{,}90 \cdot 5}{3{,}166} = \frac{1{,}439}{3{,}166} = 454{,}51\ \text{MPa}$$

From the results of the tests carried out on the Root Gap variation of 3 mm in the root bend position with a specimen thickness of 10 mm, the bending stress value was obtained

$$M = \frac{f\ (\text{load})}{2} \cdot \frac{l\ (\text{length of specimen})}{2}$$
$$M = \frac{36{,}65}{2} \cdot \frac{29}{2}$$
$$M = \frac{36{,}65 \cdot 29}{4} = \frac{1{,}062}{4}$$
$$M = 265{,}71$$
$$C = \frac{1}{2}\ \text{material thickness}$$
$$C = \frac{10}{2} = 5$$
$$I = \frac{1}{12} \cdot w \cdot t^3$$
$$I = \frac{1}{12} \cdot 38 \cdot (10)^3$$
$$I = \frac{1}{12} \cdot 38 \cdot 1000$$
$$I = \frac{1}{12} \cdot 38{,}000$$
$$I = 3{,}166$$
$$\sigma = \frac{M.C}{I}$$
$$\sigma = \frac{265{,}71 \cdot 5}{3{,}166} = \frac{1{,}328}{3{,}166} = 419{,}63\ \text{MPa}$$

From the results of the tests carried out on the Root Gap variation of 4,4 mm in the root bend position with a specimen thickness of 10 mm, the bending stress value was obtained

$$M = \frac{f\ (load)}{2} \cdot \frac{l\ (length\ of\ specimen)}{2}$$
$$M = \frac{40{,}83}{2} \cdot \frac{29}{2}$$
$$M = \frac{40{,}83 \cdot 29}{4} = \frac{1{,}184}{4}$$
$$M = 296{,}01$$
$$C = \frac{1}{2}\ material\ thickness$$
$$C = \frac{10}{2} = 5$$
$$I = \frac{1}{12} \cdot w \cdot t^3$$
$$I = \frac{1}{12} \cdot 38 \cdot (10)^3$$
$$I = \frac{1}{12} \cdot 38 \cdot 1000$$
$$I = \frac{1}{12} \cdot 38{,}000$$
$$I = 3{,}166$$
$$\sigma = \frac{M.C}{I}$$
$$\sigma = \frac{296{,}01\ .\ 5}{3{,}166} = \frac{1{,}480}{3{,}166} = 467{,}48\ \text{MPa}$$

From the results of the tests carried out on the Root Gap variation of 4,6 mm in the root bend position with a specimen thickness of 10 mm, the bending stress value was obtained

$$M = \frac{f\ (load)}{2} \cdot \frac{l\ (length\ of\ specimen)}{2}$$
$$M = \frac{36{,}36}{2} \cdot \frac{29}{2}$$
$$M = \frac{36{,}36 \cdot 29}{4} = \frac{1{,}054}{4}$$
$$M = 263{,}61$$
$$C = \frac{1}{2}\ material\ thickness$$
$$C = \frac{10}{2} = 5$$
$$I = \frac{1}{12} \cdot w \cdot t^3$$
$$I = \frac{1}{12} \cdot 38 \cdot (10)^3$$
$$I = \frac{1}{12} \cdot 38 \cdot 1000$$
$$I = \frac{1}{12} \cdot 38{,}000$$
$$I = 3{,}166$$
$$\sigma = \frac{M.C}{I}$$
$$\sigma = \frac{263{,}61\ .\ 5}{3{,}166} = \frac{1{,}318}{3{,}166} = 416{,}31\ \text{MPa}$$

From the results of the bending test for the 12 mm thickness with 2 position namely the root bend position and the face bend position, the bending stress / bending strength value is obtained from the formula $\sigma = \frac{M.C}{I}$ with the derivation of the formula as follows:

$$M = \frac{\text{f (load)}}{2} \cdot \frac{\text{l (length of specimen)}}{2}$$

$$M = \frac{\text{f.l}}{4}$$

$$C = \frac{1}{2} \text{ material thickness}$$

$$I = \frac{1}{12} \cdot w \cdot t^3$$

$$I = \frac{1}{12} \cdot \text{thickness} \cdot (\text{thickness})^3$$

$$\sigma = \frac{M.C}{I}$$

Explanation:

M = Is the highest moment value of the specimen

C = Is the distance from the center to the surface of the specimen

I = Moment of inertia

From the results of the tests carried out on the Root Gap variation of 2 mm in the root bend position with a specimen thickness of 12 mm, the bending stress value was obtained

$$M = \frac{\text{f (load)}}{2} \cdot \frac{\text{l (length of specimen)}}{2}$$

$$M = \frac{71{,}89}{2} \cdot \frac{29}{2}$$

$$M = \frac{71{,}89 \cdot 29}{4} = \frac{2{,}084}{4}$$

$$M = 521{,}20$$

$$C = \frac{1}{2} \text{ material thickness}$$

$$C = \frac{12}{2} = 6$$

$$I = \frac{1}{12} \cdot w \cdot t^3$$

$$I = \frac{1}{12} \cdot 38 \cdot (12)^3$$

$$I = \frac{1}{12} \cdot 38 \cdot 1{,}728$$

$$I = \frac{1}{12} \cdot 65{,}664$$

$$I = 5{,}472$$

$$\sigma = \frac{M.C}{I}$$

$$\sigma = \frac{521{,}20 \cdot 6}{5{,}472} = \frac{3{,}127}{5{,}472} = 571{,}45 \text{ MPa}$$

From the results of the tests carried out on the Root Gap variation of 3 mm in the root bend position with a specimen thickness of 12 mm, the bend stress value was obtained. But because in this specimen the root bend position is different from the previous specimen, this specimen's material has been eroded by 1 mm which has changed the thickness of the previous material from 12 mm to 10 mm, due to during the process of making the bending test specimen, it must be levelled until the weld metal part is not visible.

$$M = \frac{\text{f (load)}}{2} \cdot \frac{\text{l (length of specimen)}}{2}$$

$$M = \frac{70,34}{2} . \frac{29}{2}$$
$$M = \frac{70,34 . 29}{4} = \frac{2,039}{4}$$
$$M = 509,96$$
$$C = \frac{1}{2} \text{ material thickness}$$
$$C = \frac{10}{2} = 5$$
$$I = \frac{1}{12} . w . t^3$$
$$I = \frac{1}{12} . 38 . (10)^3$$
$$I = \frac{1}{12} . 38 . 1000$$
$$I = \frac{1}{12} . 38,000$$
$$I = 3.166$$
$$\sigma = \frac{M. C}{I}$$
$$\sigma = \frac{509,96 \ . \ 5}{3,166} = \frac{2,549}{3,166} = 805,37 \text{ MPa}$$

From the results of the tests carried out on the Root Gap variation of 4,4 mm in the root bend position with a specimen thickness of 12 mm, the bending stress value was obtained

$$M = \frac{\text{f (load)}}{2} . \frac{\text{l (length of specimen)}}{2}$$
$$M = \frac{70,92}{2} . \frac{29}{2}$$
$$M = \frac{70,92 . 29}{4} = \frac{2,056}{4}$$
$$M = 514,17$$
$$C = \frac{1}{2} \text{ material thickness}$$
$$C = \frac{12}{2} = 6$$
$$I = \frac{1}{12} . w . t^3$$
$$I = \frac{1}{12} . 38 . (12)^3$$
$$I = \frac{1}{12} . 38 . 1,728$$
$$I = \frac{1}{12} . 65,664$$
$$I = 5,472$$
$$\sigma = \frac{M. C}{I}$$
$$\sigma = \frac{514,17 \ . \ 6}{5,472} = \frac{3,085}{5,472} = 563,78 \text{ MPa}$$

From the results of the tests carried out on the Root Gap variation of 4,6 mm in the root bend position with a specimen thickness of 12 mm, the bend stress value was obtained. But because in this specimen the root bend position is different from the previous specimen, this specimen's material has been eroded by 1 mm which has changed the thickness of the previous material from 12 mm to 10 mm, due to during the process of making the bending test specimen, it must be levelled until the weld metal part is not visible

$$M = \frac{f\,(load)}{2} \cdot \frac{l\,(length\ of\ specimen)}{2}$$
$$M = \frac{69{,}90}{2} \cdot \frac{29}{2}$$
$$M = \frac{69{,}90 \cdot 29}{4} = \frac{2{,}027}{4}$$
$$M = 506{,}77$$
$$C = \frac{1}{2}\ material\ thickness$$
$$C = \frac{10}{2} = 5$$
$$I = \frac{1}{12} \cdot w \cdot t^3$$
$$I = \frac{1}{12} \cdot 38 \cdot (10)^3$$
$$I = \frac{1}{12} \cdot 38 \cdot 1000$$
$$I = \frac{1}{12} \cdot 38{,}000$$
$$I = 3.166$$
$$\sigma = \frac{M.C}{I}$$
$$\sigma = \frac{506{,}77\ .\ 5}{3{,}166} = \frac{2{,}533}{3{,}166} = 800{,}33\ \text{MPa}$$

Judging from the results of the bending Test, the results on 10 mm and 12 mm thickness specimens with different Root Gap variations, namely: 2 mm, 3 mm, 4.4 mm, and 4.6 mm without using a ceramic backing, are not so significantly different in the bending stress values, from these results it is known that what raises the value of bending stress is the thickness of the specimen. In addition, the toughness of the welded metal can be said to be very good in terms of the bending angle formed seen in all test specimens, the Root Bend position is able to be bent up to 180o angle

4. Conclussion

From the results of the bending test, it was found that the specimen with the Root Bend position in this study has no significant effect on the value of bending stress/bending strength, it is proven that the bending stress value has a small difference in value with a percentage of 10%. In this study, the bending stress value with a thickness of 10 mm obtained the highest value in the root gap variation of 4.4 mm with a value of 467.48 MPa, the lowest bending stress value in the root gap variation of 4.6 mm with a value of 416.31 MPa. While at a thickness of 12 mm, the highest bending stress value was found in the root gap variation of 3 mm with a value of 805.37 MPa, for the lowest bending stress value in the variation in the root gap variation of 4.4 mm with a value of 563.78 MPa.

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