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Techniques For Handling Deformation Welding Of Ship Building Construction Supporting Elements

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Abstract

Deformation is a change in shape due to stress in the metal caused by expansion of the weld metal during the heating and cooling process which has the potential to reduce the structural strength and operational efficiency of the ship. The forms of deformation due to the welding process on supporting elements of ship construction are shrinkage deformation, corner deformation, deformationbuckling, and longitudinal deformation. This research analyzes the factors that cause welding deformation in supporting elements of ship construction, identifies existing welding deformation handling techniques, and analyzes the effectiveness of deformation handling techniques to maintain the structural integrity of ship buildings. It is hoped that this research can make a scientific contribution in improving the quality, aesthetics and safety of ship construction, as well as increasing the efficiency of the shipbuilding production process. The research method used is in the form of a literature study by accessing library documents or secondary data from existing case studies. This deformation is caused by heat in the material, the expansion coefficient and the heat propagation coefficient. Techniques for handling welding deformation on supporting elements of ship construction can be applied by heating (firing) and cooling. This will provide excellent results if carried out with the correct procedures in handling deformations that occur between supporting elements of ship construction during the fabrication process.

Keywords: Deformation, Ship Construction, Welding

1. INTRODUCTION

Ship building construction is a complex structure and must comply with applicable classification standards, and have a very high level of accuracy. This is because the ship is a floating structure that experiences hydrostatic forces and cargo loads from the ship itself, so it is important to meet safety standards. One of the stages that plays an important role in forming supporting elements for ship building construction is the welding process. If the welding process is incorrect it will cause damage such as reducing the accuracy of the product, while the residual welding stress that occurs can reduce the resistance of the welded joint and cause rupture due to brittleness [1].

Deformation is a change in shape due to stress on the metal caused by expansion of the weld metal during the heating and cooling process which has the potential to reduce the strength of the ship's structure and the operational efficiency of the ship [2]. The deformation that occurs can be elastic deformation or plastic deformation. Elastic deformation occurs if the load acting on the material is removed and the material can return to its original shape. On the other hand, plastic deformation occurs if the load acting on the material is removed, but the material cannot return to its original shape [3].

During the welding process, the weld metal and base metal experience thermal strain in the weld line area during the heating and cooling process. This strain is accompanied by plastic changes that produce internal forces, which cause impact, buckling, and rotation [4]. The forms of deformation during the welding process in supporting elements of ship building construction include shrinkage deformation, corner deformation,

buckling deformation and longitudinal deformation [5].
The following are several cases of deformation in the fabrication process of supporting elements for ship building construction, such as shrinkage deformation due to welding, namely longitudinal shrinkage and transverse shrinkage, as in Figure 1, which are caused by plate thickness, weld metal weight, and welding gaps. Furthermore, in the construction of welded joints there is a change in shape and size due to shrinkage or expansion, as in Figure 2. This is categorized as corner deformation which can occur in butt joints and T welded joints (fillets) where weld deformation fillets are twice as large as butt joint welds [6].
Furthermore, if deformation is not controlled it can cause cracks, permanent deformation and even fatal structural failure [7]. Variability in the mechanical properties of materials and differences in handling become challenges in controlling deformation [8]. Therefore, appropriate techniques for handling welding deformation on supporting elements of ship building construction are needed according to the case at hand to maintain the quality of ship building construction.

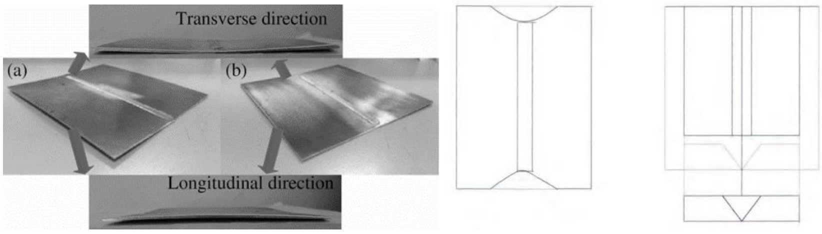

Figure 1. Longitudinal and Transverse Shrinkage [6]

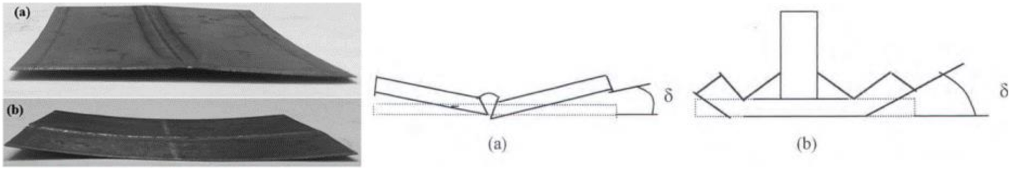

Figure 2. Angular Deformation of (a) Butt Joint and (b) Fillet [6]

The aim of this research is to analyze the factors that cause welding deformation in supporting elements of ship building construction, identify existing welding deformation handling techniques, and analyze the effectiveness of these deformation handling techniques in maintaining the structural integrity of ship buildings. Thus, it is hoped that this research can make a scientific contribution in improving the quality, aesthetics and safety of ship building construction, as well as increasing the efficiency of the ship building production process.

2. METHOD

The research method used is in the form of a literature study which is carried out by accessing library documents or secondary data from existing case studies such as scientific articles, books and research reports related to welding deformation in supporting elements of ship building construction. Furthermore, the results of this literature analysis will form the basis of a strong understanding of the problem of welding deformation in ship construction, which will become the basis for developing recommendations regarding more effective handling techniques in an effort to increase the integrity and strength of ship building construction.

3. RESULT AND DISCUSSION

3.1. Factors Affecting Deformation

The process of welding supporting elements for ship construction in ship construction is very complex, so deformation often occurs. Several factors greatly influence the welding process which causes deformation, namely: [6]

a. Heat in the material
b. Expansion coefficient price
c. Price of heat propagation coefficient

3.2. Deformation Handling Techniques

Deformation occurs due to the plate surface becoming uneven due to the welding heating process. There are two ways to straighten the plate due to deformation, namely by heating and cooling. The following is a more complete explanation.

1.Heating (Firing)

To overcome deformation, treatment is needed so that the surface can return to its original straightness, which is known as firing. Firing is a procedure used to increase the strength and ductility of a plate after bending [9].

a.Straightening with Line Heating

Line heating is carried out in areas of ivory or thick plates with large deformations in the outward direction [10]. Heating is carried out on the outer side plate with the line heating sequence as in Figure 3.

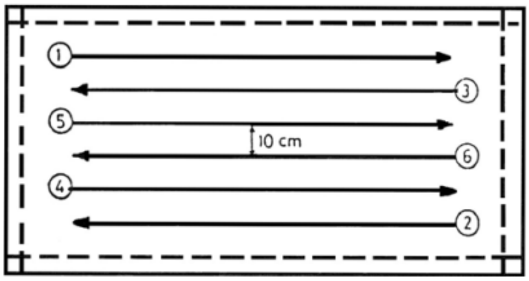

Figure 3. Line Heating (Line Heating) [10]

b. Straightening with a Cross System

Cross heating is used for small deformations with very good results. This method does not depend on the direction of deformation, it only needs to follow the sequence [10], as in Figure 4.

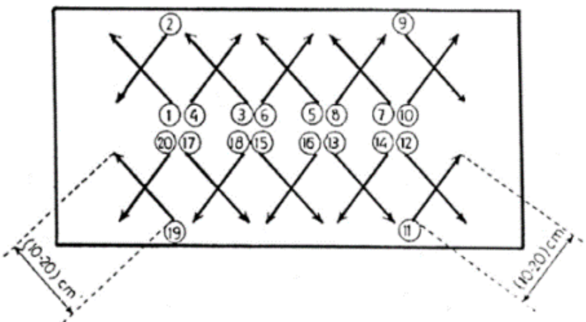

Figure 4. Transverse System Heating (Cross Heating) [10]

c. Straightening with Spot Heating

Spot heating is applied simultaneously with line heating to avoid large shrinkage, according to Figure 5. This method is used for thin plates located between two adjacent tusks. There are no special rules for the size and distance between heating points [10].

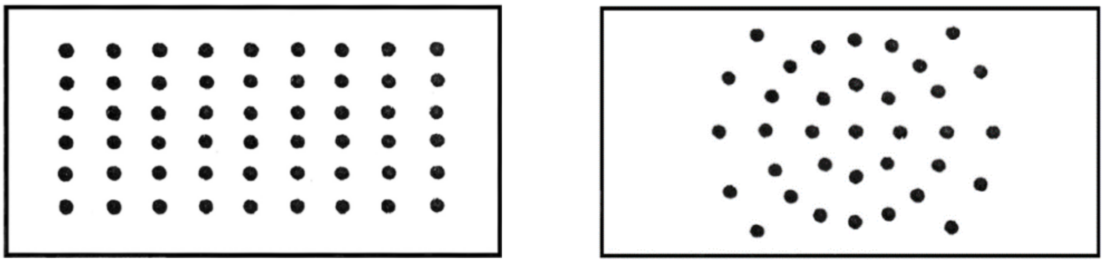

Figure 5. Spot Heating [10]

d. Straightening with Triangle Heating

Triangle heating is intended for longitudinal deformation of the profile. Method A is for deformation in the inward curvature direction while methods B and C are for deformation in the outward curvature direction [10]. For more details, it is shown in Figure 6.

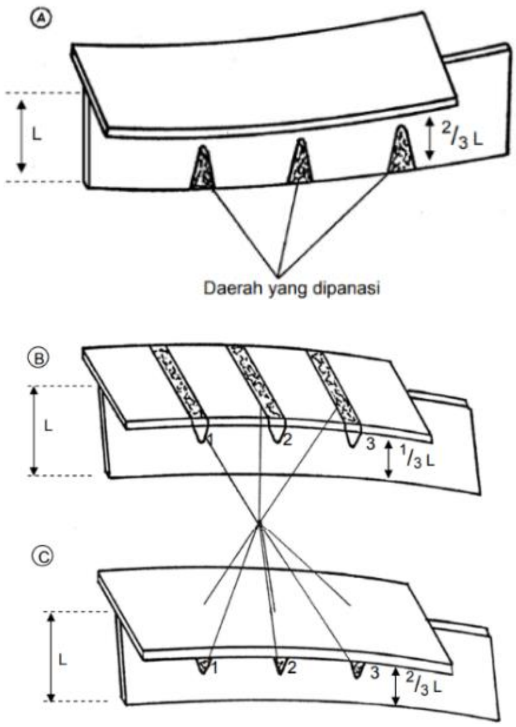

Figure 6. Triangle Heating [10]

e. Straightening with Circular Heating

Circular heating (ring heating) is used together with straight heating as the final heating, according to Figure 7. This heating is used for large deformations [10].

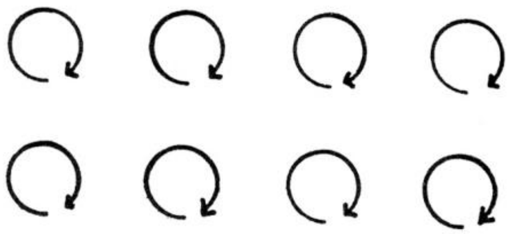

Figure 7. Circular Heating (Ring Heating) [10]

f. Straightening with Heating Two Arrows

Two-dart heating (pine needle heating) is used for small deformations with good results, according to Figure 8. This method does not depend on the direction of deformation [10].

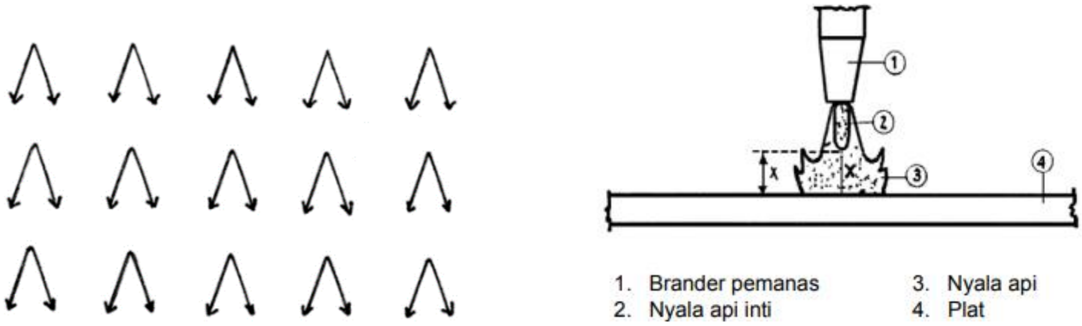

Figure 8. Circular Heating (Pine Needle Heating) [10]

The distance and heating speed can be seen in Table 1, while the heating speed can be seen in Table 2 [10].

Table 1. Heating Distance

No	Plate Thickness (mm)	Heating Distance : x (mm)
1	3 - 4,5	-2 – 0
2	6 - 8	0
3	10 - 14	0 – 3
4	16 - 22	3 – 4
5	24 - 28	4 - 5
6	30 - ...	6 - 10

Table 2. Heating Speed

No	Plate Thickness (mm)	Brander Number	Heating Speed (mm/mt)
1	3 – 4,5	0,500	0,800 – 1,500
2	5 – 8	1,000	0,700 – 1,000
3	9 – 12,7	1,600	0,500 – 1,000
4	13 – 16	2,000	0,400 – 0,800
5	17 – 22	2,500	0,350 – 0,800
6	23 – 28	3,150	0,300 – 0,600
7	29 - ...	3,500	0,250 – 0,500

2. Cooling

After heating, the next step is the cooling process which consists of three types [10], namely:

a.Cooling uses water for the plates with a temperature of 6500C for 9 – 12 mm plates.
b.Cooling uses air for the plates with a temperature of 9000C for plates over 12 mm.
c.Cooling uses water and air for plates with a temperature of 9000C. Air cooling up to 5000C is then cooled

using water intended for thin plates

3.3. Overcoming deviations in deformation due to the welding process

Deviations in shape in welding not only reduce its accuracy and strength, but also require more time and effort to straighten it again. Therefore, as much as possible to avoid this shape deviation before welding is carried out. The following is how to overcome deformation deviations at the pre- and post-welding stages.

1. Before Classification

The method used is to first straighten the part to be welded according to the specified dimensions and shape, choose the right electrode for the material to be welded, choose the right seam shape, choose the right welding procedure, and use a quality welder [6] .

2. During Welding

To avoid deformation, you can do the following, such as making sure there is a weight on each side that can bend. Welding must be carried out continuously, if it is carried out continuously, the plate will warp [9].

3. After Welding

The method used is to reduce heat input, reduce the weld metal, especially by reducing the length of the weld, the number of layers, and the correct groove shape, choosing the right welding sequence, applying pressure to the part to be welded, and changing the initial shape in the opposite direction to the direction of deformation [6].
In general, methods for correcting deformation deviations due to welding are divided into two groups. First, mechanical refinement includes rolling, pressing, forging, and beating. Repairs using mechanical methods are not only long and difficult to implement, but the results obtained are not good. Meanwhile, the second improvement is thermal improvement in the form of heating (firing). This method was chosen because it is easy to do, produces better results than mechanical methods and small material damage during the firing process is carried out with the right technique.

4. CONCLUSION

In ship construction, deformations that may occur due to the welding process on supporting elements of ship building construction include shrinkage deformation, corner deformation, buckling deformation and longitudinal deformation. Factors such as heat in the material, expansion coefficient, and heat propagation coefficient play a role in causing this deformation. To overcome this deformation, it is necessary to apply appropriate welding deformation handling techniques.
Recommendations for improving the integrity and strength of ship building construction through addressing welding deformation include:

1. Expanding the scope of research to cover more deformation-causing factors and relevant treatment techniques.
2. Conduct further research with more detailed methods, including case studies and direct experiments to validate results.
3. Provides more specific and detailed recommendations for each type of deformation that occurs, as well as appropriate handling techniques.
4. Encourage collaboration between researchers, engineers and ship industry practitioners to implement effective solutions in ship construction practices.

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