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by Program Studi Teknik Mesin

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Effects of Root Opening on Physical and Mechanical Properties of the Double Side Welded of Ship Materials

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Abstract. The effects of root opening process parameters on the physical and mechanical properties of mild steel specimens of grade LR Gr A having dimensions 200 mm× 100 mm× 12 mm, welded by gas metal arc welding were investigated. The variation of root opening that used were 3 mm, 5 mm and 7 mm.The physical properties examined with microstructure, macrosructure, and corrosion using optical microscope and stereozoom. The mechanical properties were measured with respect to the strength, hardness and toughness using Universal Testing Machine, Vickers Microhardness, and Charpy method respectively. The test results show the base metal had a hardness of approximately 110 VHN and a maximum hardness of approximately 190 VHN that corellates with microstructure of weld metals. Microstructure of base metal and HAZ are ferite and perlite, while microstructure of weld zone are acicular ferrite and grain boundary ferrite.The corrosion rate of weld metals with various root opening categorized as materials having excellent corrosion resistance value. Welding joints with opening roots 3 mm and 5 mm can be used for construction. All welded specimens exhibited fracture at base metals

Introduction

Welding is a process of joining two materials. It is more economical and faster process than casting and riveting [1]. If the welding processes are not optimized with weld process parameters, the residual stresses also develops in the structure. The welding process parameters are voltage, shielding gas, weld current, weld speed, root gap, gas flow rate are having combined effects [2-5]. Among the arc welding processes stands out gas metal arc welding (GMAW) which use has increased in the last years due to its inherent flexibility [6, 7]. The weld-bead geometry produced by arc weld plays an important role in determining the mechanical properties of the weld and its quality [8].

In the year 2007-2011, in Indonesia, the percentage of the factors causing the sea accident by technical is 59 %. Ship structure is closely related to the design and ship production process. Almost 90% of the structural failure of the techniques most often fail is the structure of the stress concentration, where 36% of which is the failure of welded joints [9].

Materials and Welding Experimentals

Materials. In the present work, two low carbon LR Gr A steel specimens, with dimensions of 300 mm x 100 mm x 12 mm of each was used as the workpiece. The compositions of steel are shown in Table 1. These specimens were prepared with a x-shaped groove (double side welded), where the groove angle is 40° and the root face is 2 mm. The variation root's gap that used were 3 mm, 5 mm and 7 mm.

Table 1. Chemical compositions of LR Gr A Steel.

Chemical Compositions (%)				
C max	Mn min	Si max	P max	S max
0,21	2,5xC	0,50	0,035	0,035

Welding Processes. The constant Gas Metal Arc Welding (GMAW) used for making the test. The type of current was DCRP (Direct Current Reverse Polarity). GMAW is done by using the current 180A, gas flow rate 20 l/min, voltage 23 V, and the shielding gas that used were Argon. Welding consumable (filler) used in this experiment was ER 70S-6. The chemical compositions is shown in Table 2.

Table 2. Chemical composition of welding consumable.

Chemical Compositions (%)					
C	Mn	Si	S	P	Cu
0.06-0.15	1.40-1.85	0.80-1.15	0.035 max	0.025 max	0.50 max

Joints Characterizations. The metal welded butt joint was sectioned perpendicular to the weld centre. This cross section was cut, ground, polished, and etched as a precursor to microhardness measurements accordance with standard metallographic procedure ASTM E3-01. Vickers microhardness tests were conducted using a load of 200 g and a dwell time of 10 s. Optical Microscopy used to investigate microstructure of weld metal.

Corrosion testing is done by soaking the specimen in sea water and then weighed. The corrosion rate:

$$R = \frac{K\ x\ \Delta m}{AxTxP} \quad (1)$$

where,

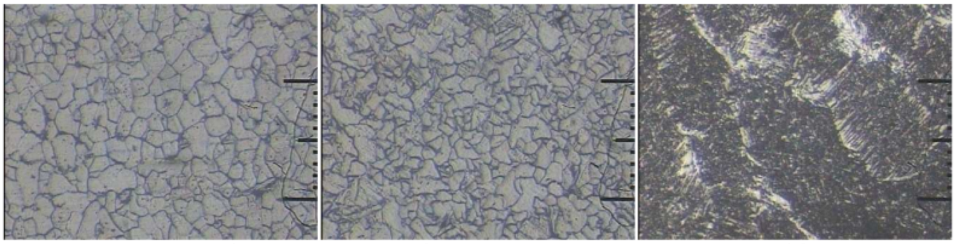
R = corrosion rate (mmpy)
K = 8.76 x 10^4
$\Delta m = m - m_0$ (gr)
A = cross sectional area (cm^3)
T = time (hour)
D = density (7.86 gr/cm^3)

Mechanical strength of weld metals were performed by impact toughness testing and tensile testing. Impact toughness testing performed using Charphy testing. Temperature's impact testing that used were -60ºC, -40ºC, -20ºC, 0ºC, 20ºC, and room temperatures. Liquid nitrogen is used to get the temperature <0°C. Standard specimens used were ASTM E23-96. The tensile strength were performed using a servo-hydraulic SHIMADZU universal testing machine. Tensile test specimens were prepared used ASTME8M standard.

Results and Discussions

Microstructure. Fotomakro can be seen in Fig. 1, while the microstructure of weld metals shown in Fig. 2. For LR Gr A steels used in this study, there exist different types of ferrite in base metal, HAZ, and the weld zone, which have various morphologies. Base metal mainly contains the equiaxed ferrite. However, weld zones and HAZ mainly contain acicular ferrite and grain boundary ferrite.

(a) Root opening 3 m (b) Root opening 5 mm (c) Root opening 7 mm
Fig. 1 Fotomacro of weld metals.



(a) Base metal (b) HAZ (c) Weld zone

Fig. 2 Microstructure of weld metals.

Microhardness Test. The hardness of base metal, Heat Affected Zone (HAZ) and weld metal is given in Fig. 3. The micro hardness was analyzed along the weld to base metal at increments of 1 mm and at a depth of 4 mm below the top surface of the weld. The base metal had a hardness of approximately 110 VHN and a maximum hardness of approximately 190 VHN, which is located in the weld and is explained by the formation of accicular ferrite and grain boundary ferrite within the weld caused by the melting and welding consumable in welding processes. Compared to equiaxed ferrite, there exists higher dislocation density and a large amount of sub boundaries within the acicular ferrite, thus exhibiting higher hardness value in the weld zone than that in the base metal [10, 11]. No softening was found in the HAZ, and no effect of root opening was observed on the peak hardness value.

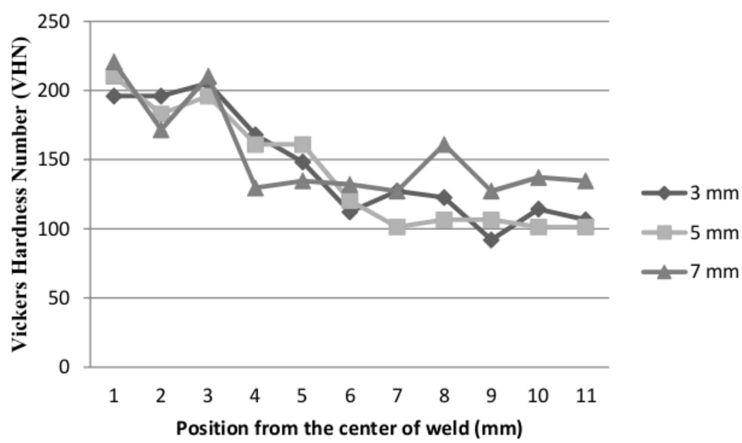


Fig. 3 Hardness of Weld Metal.

Corrosion. Corrosion test graph the value of corrosion rate of weld metals given in Fig. 4. The corrosion rate of weld metals with various root opening categorized as materials having excellent corrosion resistance value because it has a value between 0.2 - 0.1 mm py [12].

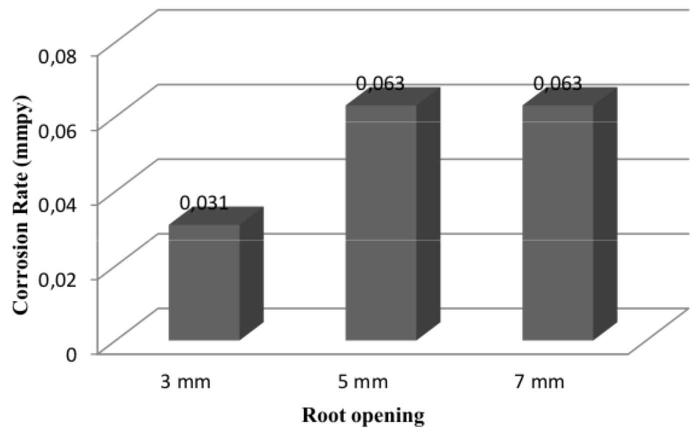


Fig. 4 Corrosion rate of weld metals.

Toughness Test. Fig.5 shows that the absorbed energy of weld metals. This graph shows that transition temperatures for weld metals with various root opening are between -20°C to 0°C. Transition temperature is the temperature at which the material properties change from brittle to ductile. At temperatures above the transition temperature, the weld metal has a ductile properties while at temperatures below the transition temperature of the metal having brittle properties.

Welding joints with opening roots 3 mm and 5 mm can be used for construction because the value of the absorbed energy at a temperature -50°C is 30 J and at the temperature 0°C is 100J [13].

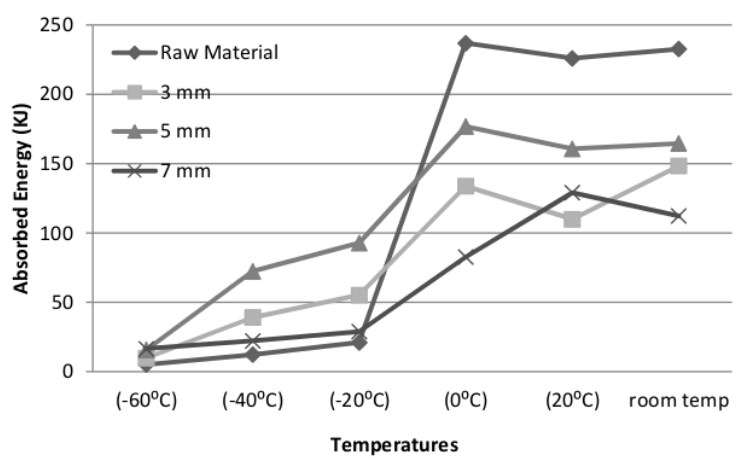


Fig. 5 Absorbed energy of weld metals.

Tensile Test. The results of tensile test shown in Fig. 6 and the fracture location of tensile speciments shown in Fig. 7. The smallest tensile strength welds with root opening 7 mm with value 300.3 Mpa. During tensile test, all welded specimens exhibited fracture at base metals (Fig. 7)

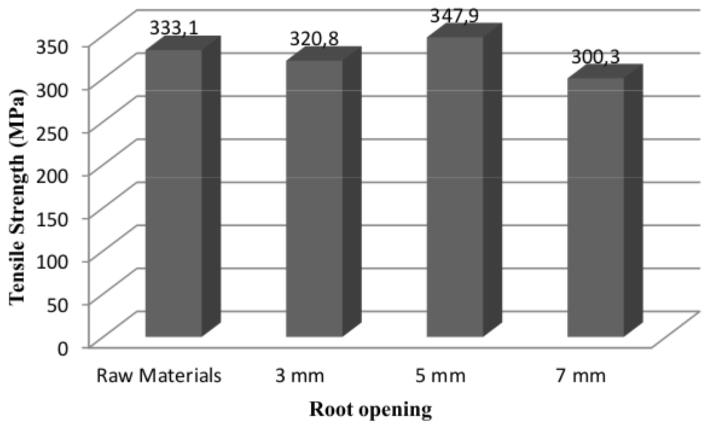


Fig. 6 Tensile strength of weld metals.

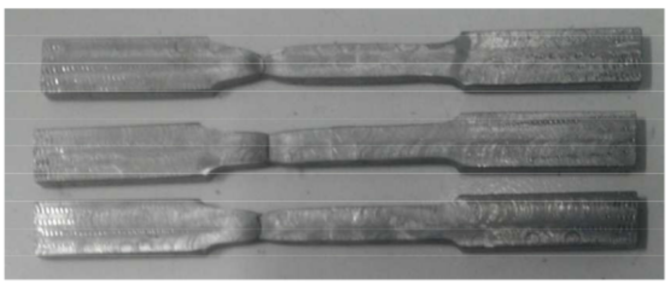


Fig. 7 Fracture location of tensile speciments.

Summary

The main results are summarized as follows:

1. Microstructure of base metal and HAZ carbon steel was ferrite and perlite while that of weld metal was acicular ferrite and grain boundary ferrite
2. The hardness of base metal approximately 110 VHN and a hardness of weld zone approximately 190 VHN due to the microstructure.
3. Welded joints with opening roots 3 mm and 5 mm can be used for construction because eligible absorbed energy value.
4. The transition temperatures of weld metals are at temperatures between -20^{0}C to 0^{0}C.

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