Mechanical Properties and Microstructure of LR Grade A Thick Plate Welded by Double Side Gas Metal Arc Welding

Yustiasih Purwaningrum[1, a *], Triyono[2,b], Tegar Rileh Argihono[1], and Ryan Sutrisno[1]

[1]Mechanical Engineering Department Faculty of Industrial Engineering Islamic University of Indonesia, Jl. Kaliurang km 14,5 Yogyakarta Indonesia

[2]Mechanical Engineering Departement Faculty of Engineering Sebelas Maret University Surakarta Indonesia

[a]yustiasih.purwaningrum@uii.ac.id, [b]triyono@uns.ac.id

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Abstract. Mechanical and microstructure of double side weld with various angle groove was studied in this research. LR Gr A steel plates (12 mm thickness) were welded using GMAW with corresponding 180 A, 23 V, and 20 l/min respectively with current, voltage, and gas flow. Shielding gas and filler metals used are argon and ER 70S-6. The angle groove that used were 20^o, 40^o and 60^o. The measured of mechanical properties with regard to hardness, toughness and strength using, Vickers hardness test, Charpy impact test and tensile test respectively The microstructure examined with optical microscope. The results show hardness of weld metals with the angle groove 20^o, 40^o and 60^o are 190.38; 200.64; and 157.8 VHN respectively. The transition temperatures of weld metals are at temperatures between -20^{o}C to 0^{o}C. Weld metals with all variations of the groove angle has a value of less than 0.1 mmpy. Microstructure of base metals and HAZ were ferrite and perlite. While the microstructure of weld metals are accicular ferrite, grain boundary ferrite and Widmanstatten ferrite.

Introduction

The weakest region of weld metals are caused by inhomogeneity within the weldment, residual stress, stress concentration and inclusion of impurities. There are the caused of a large number of failure in industry [1]. Double side welding process has some advantages that increased penetration welding [2],and decrease the quantity of weld metals (fig.1). The reduced of volume groove weld result in higher quality weld deposits because weld defect proportional to the volume of weld metals. Fig 1 shows that double groove detail offering a 50 % decrease weld volume. The angular distortion of weld metals can reduce because of the balancing the quantity of weld metal about in centerline [3]

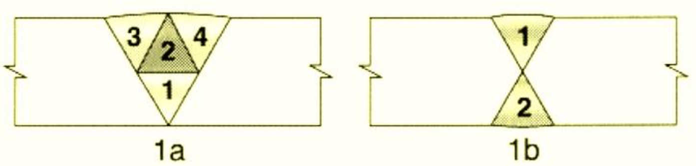


Figure 1. Groove of Weld [2]
1a. Single Groove (V Groove) 1b. Double Groove (X Groove)

The welding process parameters are voltage, weld current, weld speed, root gap, shielding gas, gas flow rate are having combined effects [4-7] to properties of weld joints. The quality and mechanical properties of welds determined by the weld geometry [8]. Because of the inherent flexibility, GMAW usage has increase in the last years among the arc welding processes [9,10]

Experimental Procedures

Two plates of LR Gr A were joined by double side GMA in a groove weld in a butt joint configuration. The plate thickness was 12 mm. Welds were produced with Gas Metal Arc Welding

(GMAW) using a current 180 A, voltage 23 V, gas flow rate 20l/min. The welding filler and shielding gas used were ER 70S-6 and Argon.

The hardness distribution, toughness and microstructure were investigated through Vickers Microhardness, Charphy impact testing and Optical Microscope respectively. The Vickers Hardness testing used indenter under 200 grf for 5 seconds. Charpy testing is done by using temperature variations. Temperatures used are -40^{o}C, -20^{o}C, 0^{o}C, 20^{o}C and room temperatures. Standard specimens used were ASTM E23-96. Optical microscope used with 200x magnification.

Resuts and Discussions

Hardness. The hardness values of double side welds with angle groove's variation are shown in Figure 2. The average value of weld metals hardness is higher than the base metal and HAZ for all variation angle groove.

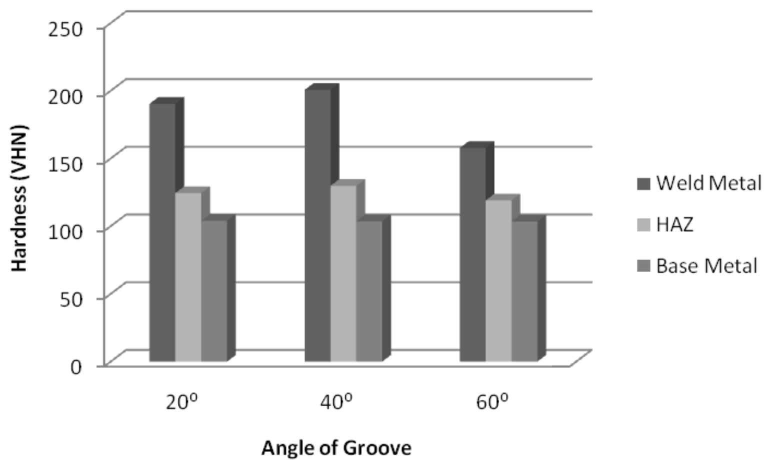


Figure 2. Hardness of weld metals

Toughness. The comparison of the impact energy for double side weld specimens are shown in Fig. 3 below. Figure 6 shows that the transition temperature at a temperature between -20^{o}C to 0^{o}C. Transition temperature is the temperature at which the material properties change from brittle to ductile.

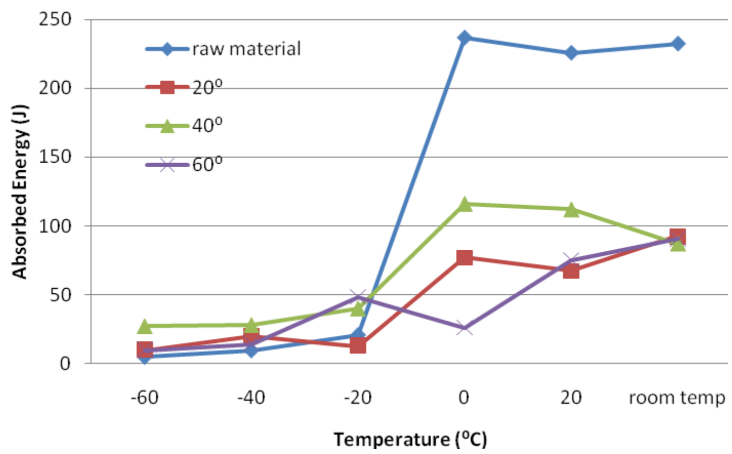


Figure 3. Absorbed Energy of weld metals

Tensile Strength. The results of the tensile tests carried out on the samples are recorded in Fig. 4. The result shows that weld metals with angle groove 20^o have lowest tensile strength. This is consistent with the results of microstructure showing the specimen with a groove angle 20^o has a structure that is dominated Widmanstatten ferrite.

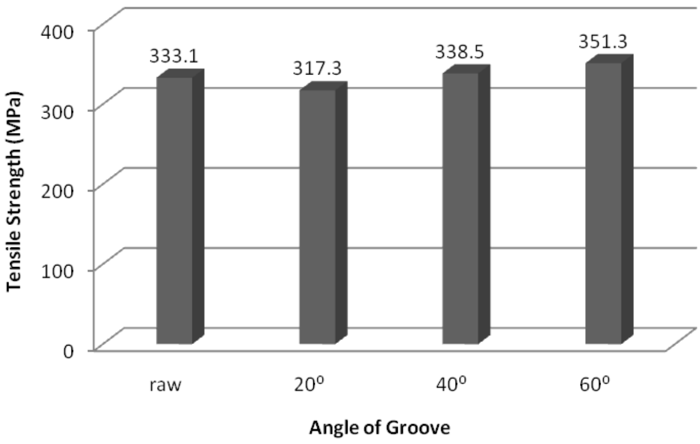


Figure 4. Tensile strength of weld metals

Corrosion Rate. The highest value of corrosion rate found in welds with groove angle 40° is 0.0921 mmpy (Fig.5). But all welds can categorized as materials having exellent corrosion resistance value [12].

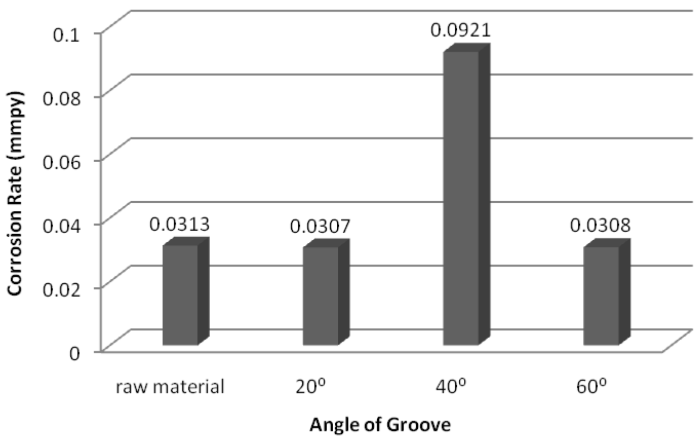
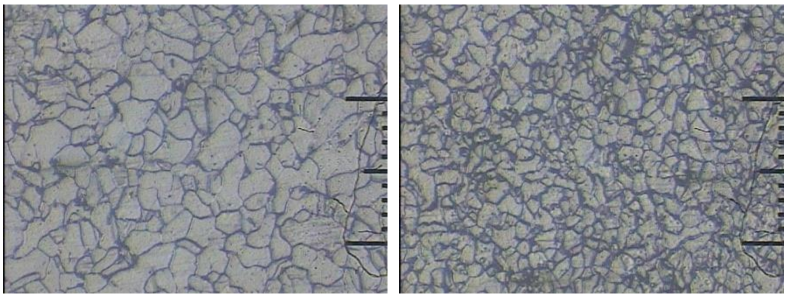


Figure 5. Corrosion rate of weld metals

Microstructure. The double-sided welds showed no porosity and/or defects through the weld thickness (fig.6). The microstructurs present in welded can be classified into varous zones, i.e. base metal (BM), heat affected zone (HAZ) and welding zone [11].

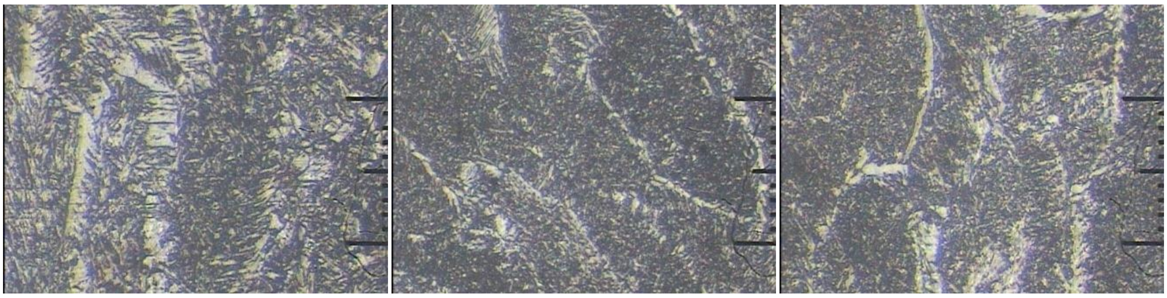
Figure 6. Macrostructure of double side weld metal



(a) (b)

Figure 7. Microstructure of double side weld metal
(a) Base metal (b) HAZ

Fig.7 shows the microstructure of base metal (a) and HAZ (b). There were no significant changes in the microstructures of base metal and HAZ aluminum for all variations of angle groove. The microstructures of base metal and HAZ were ferrite and perlite. The thing that distinguishes them is the size of grain size.



(a) (b) (c)

Figure 8. Microstructure of double side weld metal with groove of angle
(a) 20^o (b) 40^o (c) 60^o

The microstucture of welding metal are acicular ferrite, Widmanstatten ferrite and grain boundary ferrite (Fig.4).Microstructure formed because the welding heat in this area has gone through critical point and in this area there is the addition of filler.

Summary

Basing on the carried out tests, the effect of angle groove on double side weld, can be conclude :

- Microstructure of weld metals were accicular ferrite, grain boundary ferrite and Widmanstatten ferrite.
- Weld metals hardness is higher than the base metal and HAZ for all variation angle groove.
- The transition temperatures of weld metals are at temperatures between -20^{o}C to 0^{o}C.
- The value of tensile strength of welds good and has a value about the same as the base metal.
- Weld metals have exellent corrosion resistance value.

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