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The Effect of Shielding Gas Mixture on Distortion and Corrosion of Gas Metal Arc Steel Welding

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***Abstract*—This researched aimed's is to determine the effect of the mixture of the shielding gas on distortion and corrosion of weld metals. Low carbon steel LR grade A in a thickness 12 mm were joined in multilayer double side joint types using GMAW (Gas Metal Arc Welding) with groove's gap 5 mm and groove angle's 40⁰ with variation of shielding gas composition. The composition of shielding gas that used were 100 % CO2, 100% Ar, and 50% Ar + 50 % CO2.**

Tests were carried in this study is the distortion testing, corrosion testing, tensile testing and hardness testing. Distortion testing is done by using a dial indicator. The results show the value of distortion welds with shielding gas 100% CO2, Ar 100% and mix CO2 + Ar (50%+50%) is 1.11 mm, 0.82 mm and 1.39 mm, respectively. Corrosion test results showed that the welds with a shielding gas CO2 and mix CO2+ Ar may qualify for use in joint of ship construction. While the tensile test results showed that all welds with a variety of shielding gas can have a value of nearly the same elongation. Welding metals has the highest hardness values.

Keywords—Distortion, Corrosion, Shielding Gas, GMAW

I. INTRODUCTION

There are three parts in ship construction, among others: the bow, hull and stern. All of them made up of plates and frames. The plates used in ship construction is steel plate with cross sectional form L, I, or T. In joints plates are almost all using welding process.

Biro Klasifikasi Indonesia (BKI) provide rules that in the process of welding in shipbuilding design using dual or double side weld.

Two of the major problems of any welding process are residual stress and distortion [1,2,3]. Residual stress is primarily caused by the compressive yielding as the results of the materials heats and expands during welding. It's occurs arround the molten zone [4].

To relieve some of the residual stresses caused by the welding process, the structure deforms, causing distortion. The welded component encounters various types of distortion such as longitudinal shrinkage, transverse shrinkage, angular,and bowing, [5].

Distortion is anavoidable problem in the assembly of welded structures. Expecially in case of large structures such as a ship as they are assembled sequently member by member [6].

These distortions are affected by heat input, joint type, plate thickness penetration [7]. Various material factors influencing the degree of distortion are coefficient of thermal expansion, thermal conductivity, yield point, and specific heat per unit volume [8].

The pitting corrosion resistance of steels is significantly affected by metallurgical parameters like, cold working, alloy composition, inclusions, heat treatment, grain size, sensitisation [9]

GMAW processes using shielding gas that serves to protect the molten dropled transferred across the arc and weld pool.Carbon dioxide (CO_2) generally used as a shielding gas due to its cheapness, but it use has been limited because of the problem of oxidation losses, spatter and poor all position performance [10]. On the other hand Argon (Ar) cannot obtained arc stability and the desired bead characteristic [11].

Therefore, CO_2 mixed with argon is being preferred as a shielding gas for mode of metal transfer, weld bead characteristics, inclusions distribution and arc stability. The use of different shielding gas produces hardness values and corrosion resistance are different [12]. The composition of shielding gas and filler wire in GMAW of HSLA steels determines mechanical properties inclusion characteristic, and microstructures [13].

II. MATERIALS AND WELDING EXPERIMENTS

A. Materials

The steel sheet that has been provided measuring 600 mm x 300 mm .The steel sheet used was LR Grade A steel plate with a thickness of 12 mm The chemical compositions of test materials are shown in Table 1.

TABLE I. CHEMICAL COMPSITION OF LR GRADE A

C	Mn	Si	P	S
0,21*max*	2,5xC% *min*	0,50 *max*	0,035 *max*	0,035 *max*

B. *Welding Processes*

The welding processes was multilayer double side welding. The parameters of welding are shown in Table 2. GMAW (Gas Metal Arc Welding) is done by using the current 180 A and gas flow rate 20 l/min.

TABLE II. PARAMETERS OF WELDING

Layer	Wire rate (mm/s)	Welding rate (mm/s)	Voltage (V)
1	100.4	3.16	28
2,3,4,7,8	100.4	5.56	26
5,6	100.4	3.16	28

Welding processes used butt joint types groove's gap 5 mm and groove's angle 40^0 with variation of shielding gas mixture. The composition of shielding gas that used were 100 % Ar, 100 % Co_2 and 50% Ar + 50 % CO_2.

C. *Joints Characterizations*

Distortion testing is done by using a dial indicator. Tests performed on welds that have been made with the mesh size of 1 x 1 cm.

Figure 1. Distortion methode test

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

$$R = \frac{K \; x \; \Delta m}{A \; x \; T \; x \; D} \qquad (1)$$

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)

The Vickers microhardness measurements across the base metal, HAZ (heat affected zone), and the weld nugget were carried out on the metallographic specimens with a load of 200 gr.

III. RESULTS AND DISCUSSIONS

A. *Distortion*

Figure 2 shows the results of welding distortion values with a variation of the shielding gas. The highest distortion value found on welds using mix shielding gas Ar and CO_2.

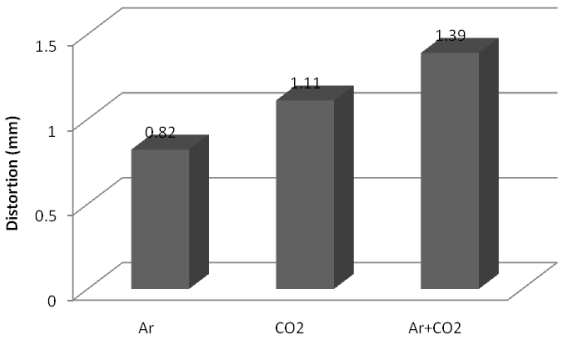

Figure 2. Distortion

Curve distortion test results can be seen in the picture 3, 4 and 5. The picture shows the buckling distortion in welding metals. The most common of distortion in welded structures is buckling distortion, which is caused by the compressive stress in the parent material [14].

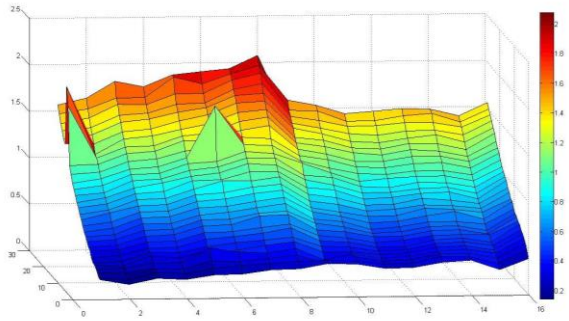

Figure 3. Curve distortion of welds with shielding gas Argon 100%

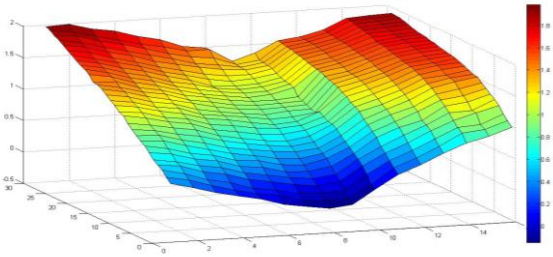

Figure 4. Curve distortion of welds with shielding gas CO_2 100%

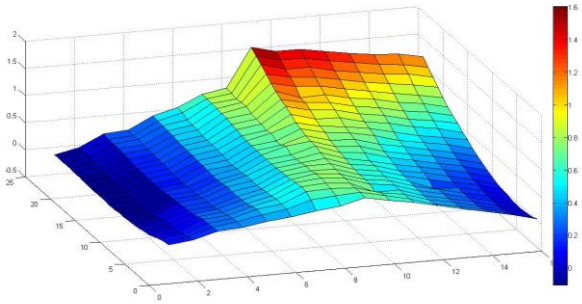

Figure 5. Curve distortion of welds with Shielding Gas Argon : CO_2 = 50 % : 50%

B. *Corrosion*

Corrosion test data presented in Table 3 and graph the value of corrosion rate of weld metals given in Fig. 6.

TABLE III. PARAMETERS OF WELDING

No	Shielding Gas	Mass (Gr)	Mass (Gr)	
			Day - 10	Day - 20
1	Argon 100 %	24.8093	24.7930	24.7610
2		24.8741	24.8735	24.8365
3	CO_2 100 %	25.1627	25.1318	25.1101
4		25.2431	25.2251	25.2025
5	Argon + CO_2	25.2802	25.2535	25.2295
6		24.9489	24.9028	24.8869

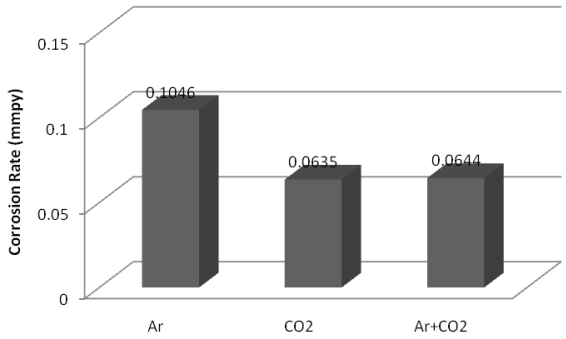

Figure 6. Corrosion of weld metals

The rate of corrosion to weld with shielding gas CO_2 and a mixture of argon and CO_2 categorized as materials having excellent corrosion resistance value because it has a value between 0.2 - 0.1 mmpy [9]. While for weld metals with shielding gas Argon has good corrosion resistance because it has a value between the range 1-5 mmpy.

C. Hardness

The number of hardness in the weld metal shown in Figure 7, while the distribution of hardness in the area of the weld metal, HAZ (heat affected zone) and base metal shown in Figure 8.

The hardness number of welds with a shielding gas argon and CO_2 same that 209.4 VHN, while for the weld metals with shielding gas mixture of argon and CO_2 has values lower by about 9%.

The highest hardness number found on weld metals compared with the base metal and HAZ due to the effect of heat welding and filler.

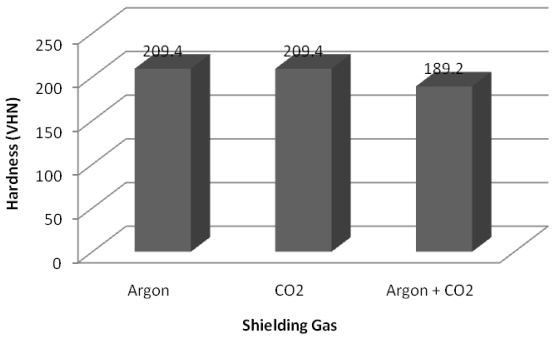

Figure 7. Hardness of Weld metals

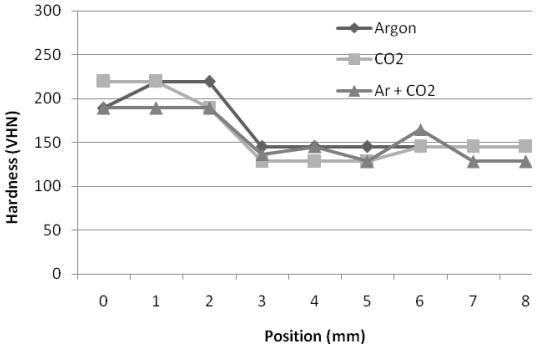

Figure 8. Hardness distributions of GMAW weld metals

IV. CONCLUSIONS

The main results are summarized as follows:

- The highest distortion value found on welds using mix shielding gas Ar and CO_2.
- Distortion that occurs in the weld metals with variation of the shielding gas is buckling distortion.
- The corrosion resistance values of weld metals with shielding gas Argon and CO_2 are exellent.
- For all shielding gas variations, there was no significant difference trends in the hardness of weld metal, HAZ, and the base metal

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