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Reducing Corrosion Rate by Welding Design

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***Abstract:-* The paper addresses the importance of welding design to prevent corrosion at steel. Welding is used to join pipe, profiles at bridges, spindle, and a lot more part of engineering construction. The problems happened associated with welding are common issues in these fields, especially corrosion. Corrosion can be reduced with many methods, they are painting, controlling humidity, and also good welding design. In the research, it can be found that reducing residual stress on the welding can be solved in corrosion rate reduction problem.**

Preheating on 500^{o}C and 600^{o}C give better condition to reduce corosion rate than condition after preheating 400^{o}C. For all welding groove type, material with 500^{o}C and 600^{o}C preheating after 14 days corrosion test is 0,5%-0,69% lost. Material with 400^{o}C preheating after 14 days corrosion test is 0,57%-0,76% lost.

Welding groove also influence corrosion rate. X and V type welding groove give better condition to reduce corrosion rate than use 1/2V and 1/2 X welding groove. After 14 days corrosion test, the samples with X welding groove type is 0,5%-0,57% lost. The samples with V welding groove after 14 days corrosion test is 0,51%-0,59% lost. The samples with 1/2V and 1/2X welding groove after 14 days corrosion test is 0,58%-0,71% lost.

***Keywords:-* welding, corrosion, pre-heating, residual stress.**

I. INTRODUCTION

Corrosion is depravation of essential properties in a material due to reactions with its environment. Millions of dollars are lost each year because of corrosion. Much of this loss is due to the corrosion of iron and steel, although many other metals may corrode as well. (Kadry, 2008). Welding process can make some changes of microstructures, formation of residual stresses due to the non-uniform temperature distribution during the welding thermal cycle. The changes in microstructures and surface conditions are non-uniform. Each different zone of a weldment is expected to have different corrosion behavior. (Xiong, Tan, & Forsyth, 2013)

Welding process become very important since almost all of joint in engineering system using various kind of welding process. Researcher tries to solve side effect of welding process, including corrosion.

The corrosion behaviour and microstructure of Al6061 alloy welded by GTAW (Gas tungsten arc welding) and followed by various heat treatments have been researched. The microstructure of both weld metal (WM) and base metal (BM) was investigated using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). Corrosion behavior was investigated in 3.5 wt.% NaCl aqueous solution. The results showed that BM consists of Fe-rich coarse intermetallic particles. (Nikseresht, Karimzadeh, Golozar, & Heidarbeigy, 2010)

Some mechanical properties and corrosion behavior in five zones from the weld metal to base metal of a 2205 duplex stainless steel joint, which was welded by double-pass tungsten inert gas arc welding with filler wire was investigated. Results of the research showed that a great deal of secondary austenite appeared in weld metal due to the reheat of second pass welding and coarse ferrite grains were formed near the fusion line, while other zones had the similar microstructures with a different austenite content. (Geng, Sun, Guo, & Wang, 2015).

The resistance to prevent corrosion of AISI 2205 duplex stainless steel plates joined by Gas Metal ArcWelding (GMAW) under the effect of electromagnetic interaction of low intensity (EMILI) was evaluated with sensitive electrochemical methods. Weldings were made using two shielding gas mixtures: 98% Ar + 2%O_2(M1) and 97% Ar + 3% N_2(M2). Plates were welded under EMILI using the M1 gas with constant welding parameters. The modified microstructural evolution in the high temperature HAZ and at the fusion area induced by application of EMILI during welding is associated with the increase of resistance to localised corrosion of the welded joints, which made by GMAW using the shielding gas M2 without the application of magnetic field presented high resistance to general corrosion. (García-Rentería, Morelos, Hernández, Pérez, Ochoa, & Sánchez, 2014)

The above information, each step of process will affect the materials. In the welding process, corrosion can be prevent with good design process. Welding process consist of some matters including groove weld design and preheating. Groove weld design closely related with heat on the welding process. Pre-heating related with stress on the steel. In this research, correlation between seam weld design, pre-heating and corrosion was studied. Welding process will change some properties of steel. Good process design can be choosen to prevent corrosion or reducing corrosion rate.

II. MATERIALS AND METHODE

A. Samples of experiment

In this tudy, ferritic malleable iron (SAE grade G 3500) with various groove weld design was used. The composition of (wt%) of iron as follow Al 0,2% - Si 0,54% - K 0,29% - Ca 0,41 - Mn 1,02% - Fe 97,55%.

B. Pre heat welding treatment

The malleable iron heat at various temperature before welding. Temperature choosen was 400^{O}C, 500^{O}C, and 600^{O}C. Holding time for pre heat was 30 minutes.

C. Welding process

SMAW (Shielded Metal Arc Welding) machine used to joint the samples. The filler metal used B 14 and RB 26 from kobe steel. In this study, groove design was V, 1/2V, X, and,. ½ X

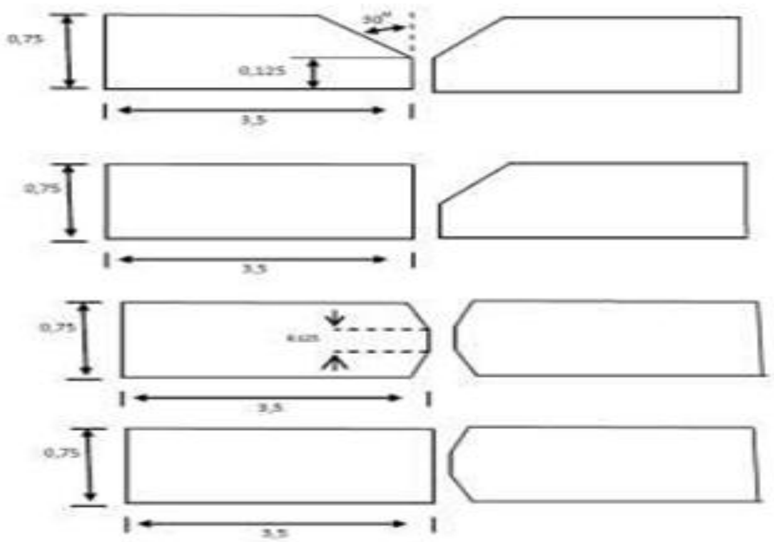


Fig 1 : Groove welding design

In order to get the maximum quality of welding process, sertified welder was employed. The electric current for welding process was about 80-130 ampere. The current adjusted based on the layer of welding process. Mechanical and chemical properties of the filler metal described as follows:

Kobe Steel RB 26

C%	Si%	Mn%	P%	S%
0,008	0,30	0,37	0,012	**0,010**
	YP (Mpa)	TS (Mpa)	El %	
	450	**510**	**25**	

Kobe Steel B 14

C%	Si%	Mn%	P%	S%
0,10	0,10	0,43	0,015	**0,007**
	YP (Mpa)	TS (Mpa)	El %	
	410	**460**	**32**	

D. Corrosion testing

For corrosion testing, special samples was prepared. Part of welded iron was cut on the HAZ area. The dimension of Samples for corrosion testing is 5x5x25 mm. This testing use NaCl 5% solution.

III. RESULT AND DISCUSSION

A. Effect of Pre heating

Cooling rate on the welding process will make small temperature gradient at freezing process. Small cooling rate will reduce formation of residual stress. On the high preheating temperature, cooling rate will be reduced. So solidification processes also become slow. It causes the grain have enough time to grow, and hardness of the material will be down.

Preheating on the welding process intends to reduce cooling rate on the heat affected zone. It means if steel welded without preheat, cooling rate will be faster. Giving pre heat will reduce cooling rate, and also make temperature uniform at heat affected zone so temperature gradient also become smaller.

B. Residual stress

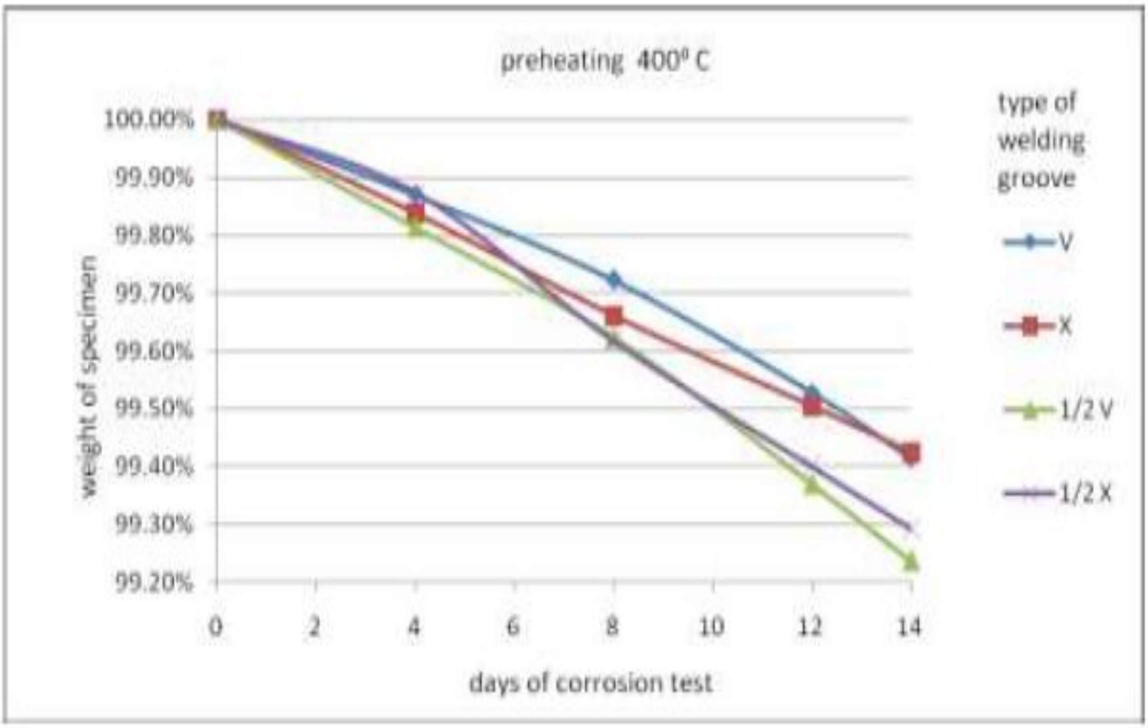
Residual stress compressed stress or tensile stress without any external load from the outside, the external load that is a force or temperature changes. Residual stress based on the size of stress on the grain. Residual stress called macro stress if it entranced some grains. The other called micro stress if it residual stress happened on the boundary or inside the grain. (wibowo, 2007)

This residual stress can be useful but it can also be useless. If the load tension and there is a residual compressive stress in the material then the residual stress will give a negative resultant material to reduce the effect of the load. Conversely, if there is a residual tensile stress in the material which has tensile load will provide a positive resultante and if the resultant more than yield, it will begin the fracture.

C. Corrosion Rate

As explained before, type of groove weld and heating temperature could affect corrosion rate on steel. For heating temperature 400 ^oC, the graphic on table 1 explained the effect of welding groove type on corrosion rate. Corrosion rate can be seen from lost of specimen weight.

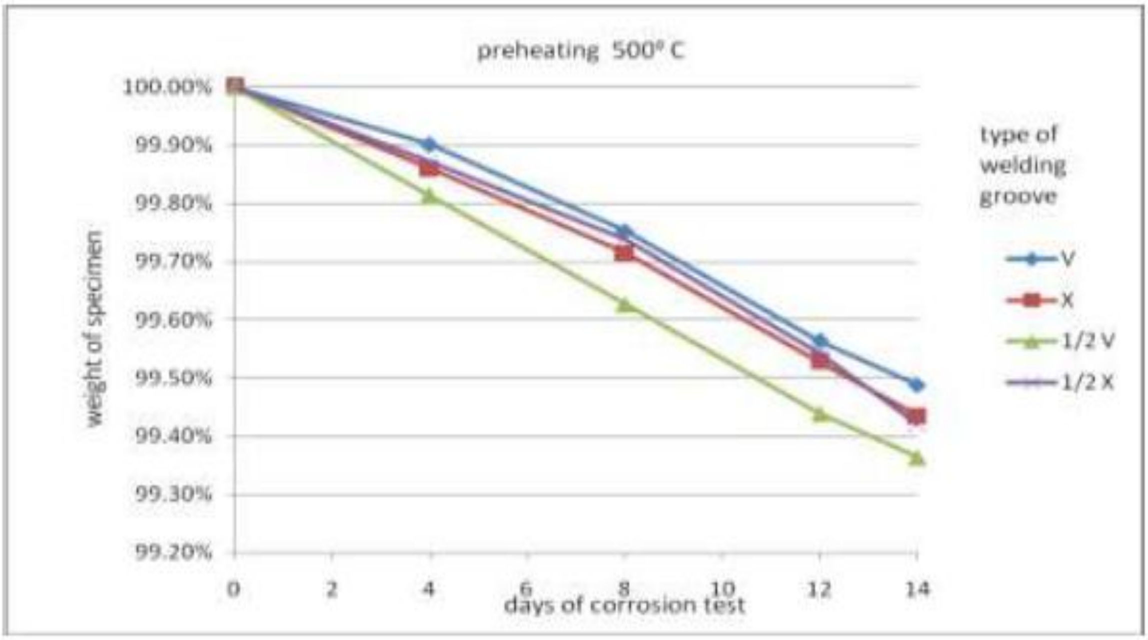
Tabel 1: Weight of specimen vs days of corrosion test after preheating 400^{o}C



The graphic on tabel 1 showed that X welding joint has a highest corrosive resistant. After corrosion test for 14 days, the material testing 0,57% lost. While ½ V welding groove is the worst in corrosion resistant, because after 14 days corrosion test material testing 0,76 % lost.

The samples with 500^{0}C preheating can be seen on tabel 2:

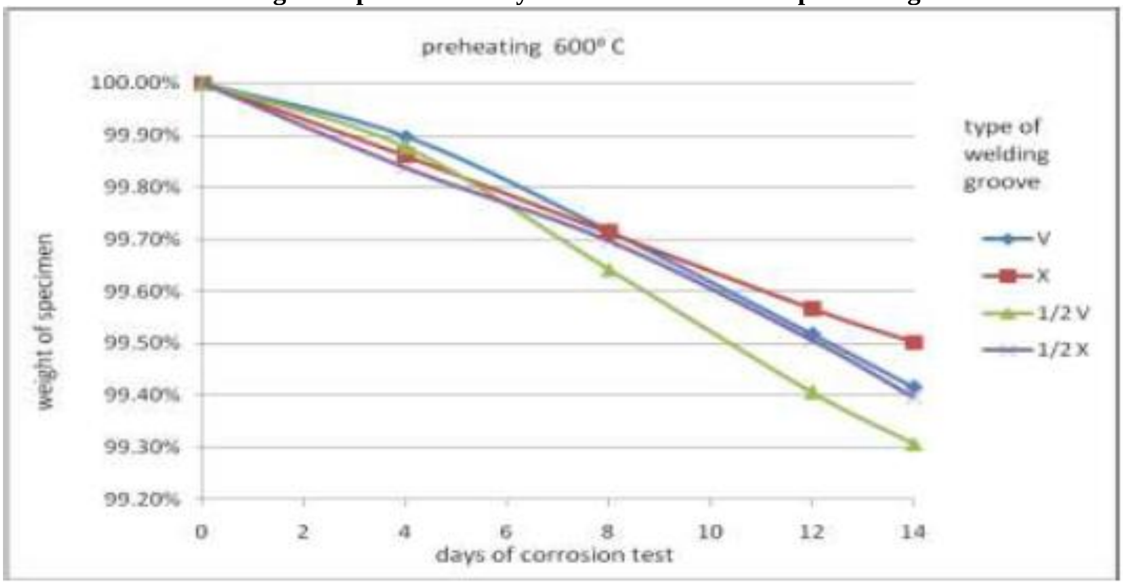
Tabel 2: Weight of specimen vs days of corrosion test after preheating 500oC



The graphic on tabel 2 showed that V welding joint has a highest corrosive resistant. After corrosion test for 14 days, the material testing 0,51% lost . While ½ V welding groove is the worst in corrosion resistant, because after 14 days corrosion test, material testing 0,61 % lost.

The samples with 600^{0}C preheating, can be seen on tabel 3:

Tabel 3: Weight of specimen vs days of corrosion test after preheating 600oC



The graphic on tabel 3 showed that X welding joint has a highest corrosive resistant. After corrosion test for 14 days, the material testing 0,50% lost. While ½ V welding groove is the worst in corrosion resistant, because after 14 days corrosion test material testing 0,69 % lost.

On the graphic tabel 1 , 2, and 3 by preheating on 500^{o}C and 600^{o}C give a better condition on reducing corrosion rate, than after preheating 400^{o}C condition. For all welding groove type, material with 500^{o}C and 600^{o}C preheating after 14 days corrosion test is 0,5%-0,69% lost. Material with 400^{o}C preheating after 14 days corrosion test is 0,57%-0,76% lost.

Welding groove type also influence corrosion rate. X and V type welding groove show better condition to reduce corrosion rate than ½ V and 1/2 X welding groove. After 14 days corrosion test, the material with X welding groove is 0,5%-0,57% lost. The material with V welding groove after 14 days corrosion test is 0,51%-0,59% lost.

After 14 days corrosion test, material with ½ X welding groove 0,58%-0,71% lost. Material with 1/2V welding groove after 14 days corrosion test 0,61%-0,76% lost.

The different corrosion rate of samples can be caused by residual stress which happened after pre heating and welding process. Preheating on 600^{o}C reduce cooling rate. X and V welding groove caused high temperature on the materials, so the residual stress reduced.

Residual stress tested laboratory shows that some residual stress value can be explained below:

- Sample with C6 code (using X groove welding and 600^{o}C preheating) 1,7 Mpa
- Sample with E2 code (using ½ V groove welding and 400^{o}C preheating) 5,2 Mpa

Fig.3 shows corrosion on the sample. The corrosion is called pitting corrosion.

Fig.3: Pitting Corrosion

Pitting corrosion happened under certain conditions, especially at high concentrations of chlorides (such as sodium chloride in sea water), high temperatures and exacerbated by low pH (i.e. acidic conditions). (Kadry, 2008). Clorides attack the iron and high residual stress causes fast corrosion rate.

IV. CONCLUSION

The results obtained of this study can be summarized as follow:

a. Reducing corrosion rate can be solved by welding design process. The heat on the welding process must be controlled.

b. Reducing corrosion rate by controlled residual stress on the welding process can be done by: pre heating 500-600^{o}C for 30 minutes using X or V welding groove design

REFFERENCES

[1]. García-Rentería, M., Morelos, V., Hernández, R. G., Pérez, L. D., Ochoa, G. E., & Sánchez, J. G. (2014). Improvement of localised corrosion resistance of AISI 2205 Duplex Stainless Steel joints made by gas metal arc welding under electromagnetic interaction of low intensity. *Applied Surface Science*, 252–260.

[2]. Geng, S., Sun, J., Guo, L., & Wang, H. (2015). Evolution of microstructure and corrosion behavior in 2205 duplex stainless steel GTA-welding joint. *Journal of Manufacturing Processes*, 32-37.

[3]. Kadry, S. (2008). Corrosion Analysis of Stainless Steel. *European Journal of Scientific Research*, 508-516.

[4]. Mizhar, S., & Pandiangan, I. H. (2014). Effect of Heat Input To microstructure, hardness and toughness In SMAW welding of 2.5 inch Diameter Steel Pipe. *Jurnal Dinamis Vol.II,*, 16-22.

[5]. Nikseresht, Z., Karimzadeh, F., Golozar, M., & Heidarbeigy, M. (2010). Effect of heat treatment on microstructure and corrosion behavior of Al6061 alloy weldment. *Materials and Design* , 2643–2648.

[6]. Wibowo, a. (2007). Effect of Residual Stress of Frequency on Tones Bronze. *Seminar Nasional Teknologi 2007 (SNT 2007)* (pp. B.2-.B5). Yogyakarta: UGM.

[7]. Xiong, J., Tan, M. Y., & Forsyth, M. (2013). The corrosion behaviors of stainless steel weldments in sodium chloride solution observed using a novel electrochemical measurement approach. *Desalination*, 39-45.