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EFFECT OF CURRENT -WELDING ON THE CORROSION BEHAVIOR OF LOW CARBON STEEL (1020) TIG WELDING JOINTS IN 3.5% NACL

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Abstract: Welding is one of important industrial processes, therefore many techniques are development to get an efficient and low cost welding for different kinds of materials. In this research, the corrosion behaviors studied of many welded joints which were implemented using (TIG Welding) method on Low carbon steel 1020 AISI at constant voltage, welding speed and variable DC current for each pass. Microstructure of weld zones, according to standard ASTM (G71-31) a number of corrosion examination samples are equipped with the measurements of (15 x 15 x3) mm which distributed into the many groups. Corrosion test was done by electrochemical methods for all specimens in environments of 3.5% NaCl solution. Corrosion rate is calculated using the Tafel equation. The results which obtained shows increase in corrosion rate of the weld joint which made at four passé with decreasing DC current for each pass compared with other weld joints and base metal but the increasing in DC current of the weld joint which carried out at three passes improved the corrosion rate compared with weld joint also carried out at three pass but include decrease in DC current.

Keywords: *Low carbon steel, TIG welding process, mechanical properties of weldments.*

1. Introduction

Low carbon Steel is greatly used in engineering structures in the fabrication of "oil pipelines, building structures and bridges". The ability of low carbon steel to weld was influenced by numerous variables containing chemical composition, physical qualities and thermal variables. (TIG) welding is an arc welding procedure that applies using tungsten electrode for generated the arc which supply the temperature for welding process. The weld area is sheltered from atmospheric pollution by means of inert gas (usually argon or helium), and then a filler metal is applied to complete the weld process. "GTAW" is generally applied to joint thin sections of stainless steel and non-ferrous metals like" aluminum, magnesium, and copper alloys". Method grants the operator more control over the weld than competing procedures like shielded metal arc welding and gas metal arc welding, allowing for stronger and higher quality of welds. [1- 3]
However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques "Fig.1" shows the mechanism of welding [4].

Corrosion is an electrochemical behavior that happens when an electrolyte film generates on the external surface of the metal. The amounts of the corrosion basically rely on the period that the external surface is exposed. Number of factors effect on the corrosion behavior of low carbon steel welded joints and the most effective factors are the chemical composition of the metal and the type of welding process used. This is because the welded metal go through different metallurgical changes through the weld reigns [5, 6].

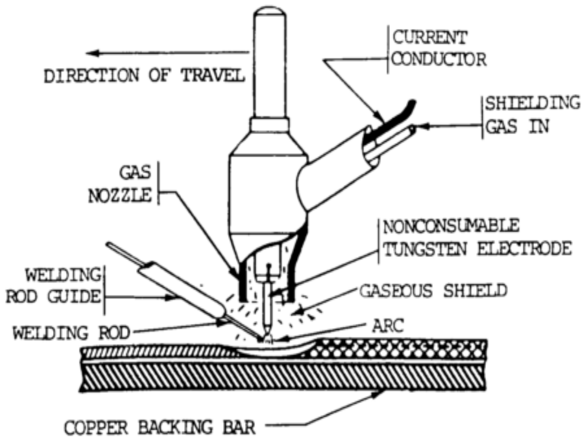

Figure 1. Gas tungsten arc welding method [4].

Many researchers studied the subject as:-

Rana A. Majed [7] studied the mechanical equities which contained micro hardness, tensile strength “and corrosion conduct of “low carbon steel” weld joints and base metal. Welding process are carried out by “Arc, MIG and TIG welding. The obtained consequences refer that micro hardness of TIG, MIG welding joint was larger than arc welding, but tensile strength in arc welding was more, compared with the TIG and MIG. The corrosion conduct of low carbon weld joint was performed by potentiostat in 3.5% NaCl to show the polarization counteraction and determine the corrosion rate from data of linear polarization by “Tafel extrapolation method”. The results indicate that the TIG welding rise the corrosion current density and anodic Tafel slop, while reduce the polarization counteraction compared with un welded low carbon steel. Cyclic polarization were evaluated to show the counteraction of samples to pitting corrosion and to determine the forward and reveres potentials. The consequences show shifting the forward, opposite and pitting potentials toward active direction for weldments samples compared with unwedded sample.

I.O. OLADELE, et al [8] studied the mechanical equities as tensile, hardness and bending and corrosion conducted, microstructure change of a disparate metal Austenitic Stainless steel304L welded with Mild Steel by” Gas Tungsten Arc Welding (GTAW) method” and ER308L as filler metal with single V to obtain butt joint at 5mm in thickness. The corrosion conduct was examined in 3.5 wt.% NaCl by “potentiodynamic polarization electrochemical” .The results of the tensile and hardness “characteristic of the disparate weld drop among that of the austenitic stainless steel and the mild steel base metals while the bending strength for the disparate metal joint appears as the best. Austenitic Stainless Steel (ASS) presented large thermodynamic stability in 3.5wt% NaCl solution compared with the DMWJ which have large counteraction to corrosion than the mild steel in same medium.

Amrinder SinghIn, et al [9] studied the microstructure and hardness in weld region influenced of heat obtained from using TIG welded process to join the sheets of EN 31 steel with Mild Steel using diverse filler metals. The thermal equalities such as hardness and microstructure of the welded joints occupied across the weld region were estimated by Taguchi way using “(welding current, gas flow rate and filler metal)” as factors which having three points respectively (low, medium and high). In demand to know the microscope.

Muna Khethier, et al [10]studied the corrosion conduct of low carbon steel weld joint using “Tungsten Inert Gas welding” and based metal .Steel sheets were prepared with many styling V- angles 30°,45°,60° and square butt joint .corrosion was tested using potential state in 3.5% NaCl Media . The consequences revealed that base metal was well corrosion counteraction and welded joint with V-angle of 30° was a smaller amount of corrosion rate compared with other angles (45°,60° and 90°). The consequences of the microstructure it is apparent that the joint style or regular form of weld has a significant role in the welding procedure, when the preparing angle value of the weld gets greater, the faults gets less because of the rise in heat quantity in the weld area.

This paper aims to study the effect of DC current which was used to weld low carbon steel AISI1020 plats by Gas tungsten arc welding with variable value for each pass on corrosion behaviors.

2. Experimental Work

2.1. Metal Selected

A1SI (1020) low-carbon steel is used and the chemical analysis which was carried out by Spectrometer in the General Company for Mechanical Industries are listed in "Table 1".

Table 1. The chemical analysis of low carbon

Elements wt%	Real value	Standard value
C	0.2	0.18-0.2
Si	0.009	0.01
Mn	0.5	0.3-0.6
Ni	0.04	
Mo	0.005	
Cu	0.44	
Co	0.009	
Al	0.009	
Ti	0.009	
S	0.05	
P	0.04	

2.2. Preparation of Weld joint

A number of plates were made from the selected metal with a dimension of (150x 120 x6)mm with Two edge equipped to complete welding on Butt Straight and single V angle 45 °as shown in "Fig.2"

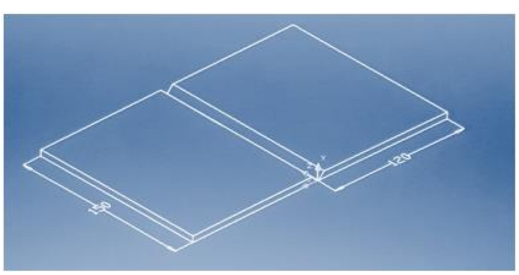

Figure 2. Weld joint dimension.

2.3. Welding process

The welding process was carried out by TIG method using variable current and constant voltages as shown in "Table 2". The plates were prepared to obtain many weld joints from each state which was represented by symbols(B,C,D) and the symbol (A) was given to the plate with out welding. The filler metal analyses listed in "Table 3" and the quantity of argon inert case was 10 liter in minute and "Fig.3", show the weld joints.

Table 2. Show welding process conditions

Weld state symbol		B	C	D
No. of passes		4	3	3
Current (AmP)for each pass	1	275	240	230
	2	210	220	240
	3	200	180	290
	4	175	-	-
Voltage (Volute)		20	=	=
Heat Imput (Joule)		1815	1650	1848

Table 3. The Chemical analysis of Wire filler ER70S-3.

Element wt%	Standard	Real value
C	0.06-0.15	0.07
Si	0.45-0.75	0.52
Mn	0.9-1.4	1.19
S	0.02	0.022
Ni	0.15	-
Cr	0.025	-
Cu	0.5	0.4
P	0.025max.	0.012

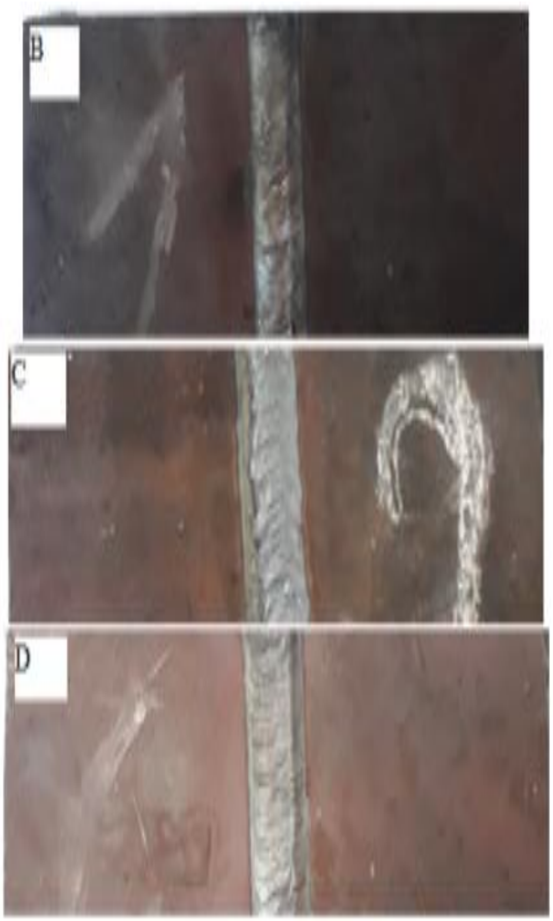

Figure 3. The photo of weld joints.

The heat input amount as mentioned by Sindo Kou [11] is calculated by the following equation:

$$\text{Heat Input}=543 x I x V x 60/S \quad (1)$$

Where
I = Current (ampere)
V= Voltage (Volt) and S…Welding speed (m/min).

After the welding procedure, the welded joints are examined using "X-ray radiography" .Faulty joints are left out. Weld joints without defects are used for equipped corrosion examination samples.

2.4. The Investigation of Microstructure Test

Many specimens from TIG weld joints zones were equipped for the microstructure test which was consist of grinding using the SiC emery paper having grit of the (220,320,500 &1000) and then polished using diamond past of size (1μm) with special polishing cloth. Etching method was carried out using Nital solution of (98% alcohol +2%HNO_3). Then specimens were washed with water and alcohol and dried. Optical examination of specimens is carried out using optical microscope equipped with camera and linked to a computer. The microscoping results are shown in "Fig. 4"

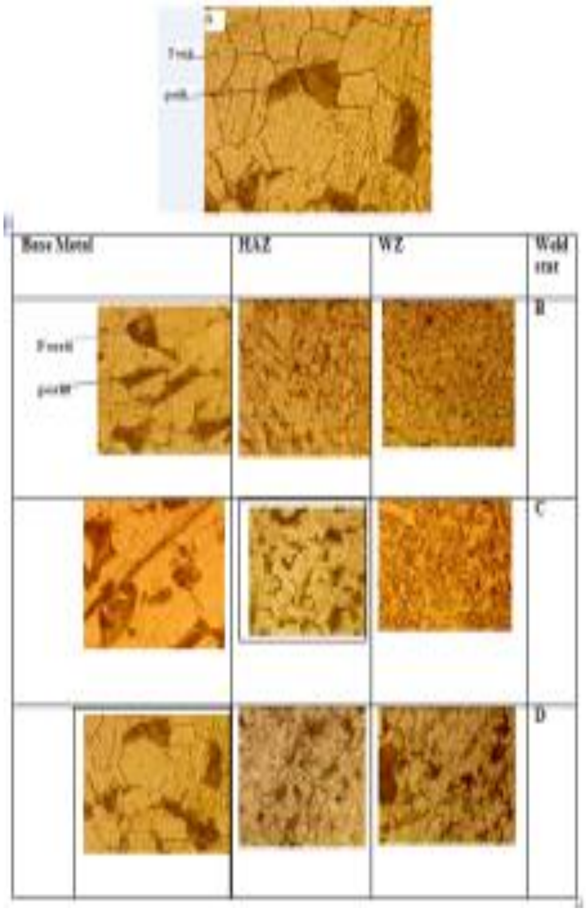

Figure 4. The micro structure of all specimens(A,B,C,D) (x50) having (perlit+ferrit).

2.5. Examination of C corrosion

Several samples for corrosion examination are prepared from weld and base metal agreeing to the standard ASTM (G71-31) in size (15x15x3) mm to immersed in the 3.5% NaCl solution with PH of 6.6 to complete corrosion factors like corrosion potential (Ecorr) and corrosion current (Icorr) at each time .Cell current readings were taken during a short laggard scavenge of the potential. The scavenge is taken from (-250to + 250) mV relative to (OCP). Scan rate defines the quickness of the potential scavenge in $mV.s^{-1}$and it is fasting (10) mV .The examinations were made by a WENKING Mlab multi channels potentiostat and SCI-Mlab corrosion measuring system from Bank Electronics-Intelligent control GmbH, Germany 2007, as shown in "Fig. 5a, b". the corrosion rate agreeing to Tafel equation as shown in equation (2)[12] the obtained outcomes were registered in "Table 4" ,The Polarization curves of the all welding specimens and base alloys in 3.5%NaCl show in "Fig. 6" and the shape of corrosion in "Fig. 7".

$$C.R\ (m.p.y) = 0.13 * Icorr * eq.wt / \rho \qquad (2)$$

Where

(m.p.y) refers to mille-inches per year

(Icorr) is the corrosion current density ($\mu A/cm^2$)

(Eq.wt) refers to equivalent weight of the corroding species,

ρ= volume density of the corroding species, (g/cm^3).

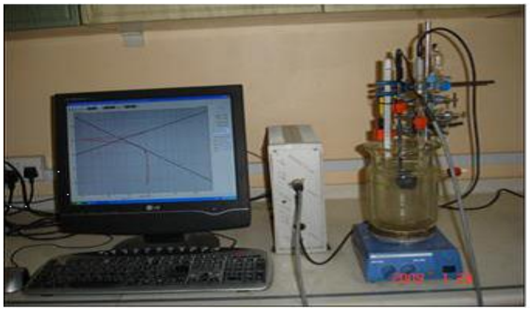

Figure 5a. Electrochemical corrosion device.

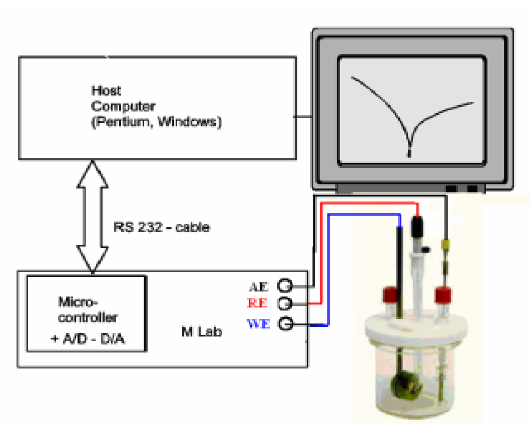

Figure 5b. The unit used for electrochemical

Table 4. Result of corrosion test.

Symbol	Icor.mA	E Potential mV	Corrosion Rate m.p.y
A	66.37	-420	29.2
B	77.17	-513.8	33,29
C	61.17	-562.5	26.9
D	30.21	-575.2	13.29

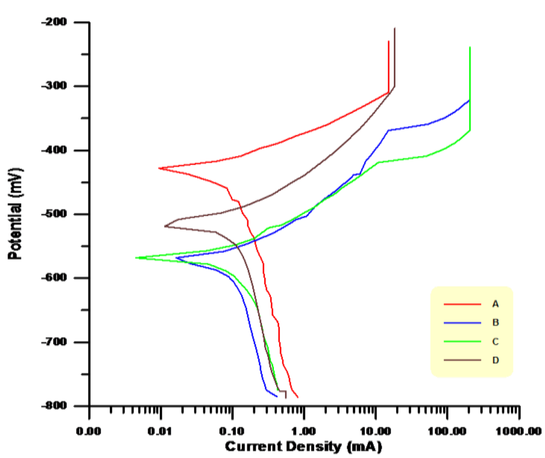

Figure 6. Polarization of cathode and anodic Curve for all specimens.

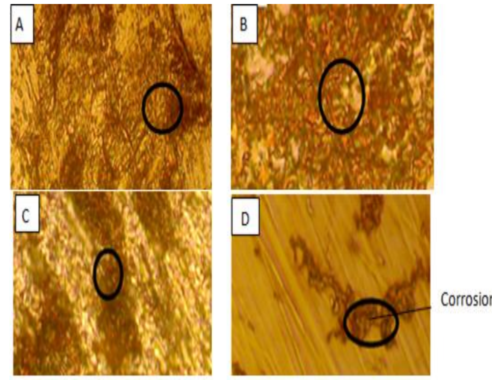

Figure 7. Corrosion photograph show corrosion shape after test.

3. Discussion

The microstructure which was taken by Optical microscope of the diverse areas from the origin metal and its welds joints for low carbon steel 1020 AISI are shown in "Fig. 4a & b" observed that the microstructure base metal "Fig . 4a" contains of ferrite and pearlite but in "Fig .4b" which represented the microstructure of GTAW areas for all welded joint(B,C,D) areas it's found that ferrite phases in different grain shape and size also was the main control due to the filler metal ER70S-3 which also made from low carbon steel and during welding the heat quantity which was calculated and listed in "Table 2", it was rely on input parameters as current ,voltage and wire speed . Increasing of heat quantity contributes at growth of granules volume with high ductility due to slow cooling of the metal during welding therefore, it is preferred that the welding angle be 45^{o} for homogenous heat distribution to it."Fig. 4b" shows the variance of the particles of the weld region for the different in current which used in welding I t is evidenced from the figure that the microstructure becomes finer with the change of current for each pass Weld ability differs from one metal or alloy to another. Linear polarization of base metal and weldments observed in "Table 4" and "Fig. 6" in that order .Which observed the cathodic and anodic conduct of all specimens, the cathodic interplay typify the decrease of oxygen agreeing to the next interplay:

$O_2 + 4e + 2H_2O \rightarrow 4OH^-$

Even though the oxidation of iron typify the anodic
Interplay:

$Fe \rightarrow Fe_2+ + 2e$

Also polarization data were clear in "Table 4" these data show that the corrosion potentials (Ecorr) values for weldments change in the direction of active analogy with unwelded low carbon steel, corrosion rate from result in "Table 4" and "Fig.7" show increase in corrosion rate in weld joint specimens (B) comparing with un welded metal specimens (A) due to heat input quantity was un stable when decrease DC current for each welded pass also specimens (B) also have high corrosion rate for the same reason above but specimens (D)give the best corrosion when increase DC current for weld pass due to homogeneity in heat input quantity which contributed in homogeneity in microstructure .

4. Conclusions

1. TIG weld joints get low corrosion rate when increasing DC current for each pass of weld.
2. Improving corrosion behavior by using filler metal from the same group of metal.
3. The efficiency of protective weld zones from oxidation is increased by tungsten arc welding argon gas for weld low carbon steel.

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