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Investigation of Mechanical and Microstructural Properties of E250BR material

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Abstract: Welding is a most momentous part of manufacturing industry. The Mild steel (M.S) grade of E250BR material has wide-ranging application in today's manufacturing world. In the present exploration, the plate of E250BR with thickness of 16 mm is welded by using three different welding processes such as Shielded Metal Arc Welding (SMAW), Metal Inert Gas (MIG) welding and Submerged Arc Welding (SAW) for the study of the mechanical and microstructural properties as per the American Welding Society (AWS) standards. The purpose of this paper is to observe the mechanical properties and microstructure of diverse welding processes for the engineering application and explore the best welding process among them. The Mechanical property such as hardness test, tensile test, bending test, spectrographic test, and microstructure analysis is performed at heat affected Zone (HAZ), Welded Zone (WZ) and Parent Material (PM) with three different specimens. The conclusion is beimperilled to the mechanical and microstructural properties. The MIG welding gives superior result as compared to other two welding processes.

Keywords: E250BR, SMAW, MIG Welding, SAW, Mechanical & Microstructural Properties

1. Introduction

Welding is an essential manufacturing process which can join like or unlike metal of diverse shapes and sizes. The Stainless-Steel Grade of SS304 was welded by using the Gas Metal Arc Welding (GMAW) by examining the heat input (Low Heat, Medium Heat and High heat input) by varying the welding current, welding voltage, welding speed, the low heat input gives the better result in term of tensile strength, hardness and microstructure [1]. The Mild Steel (M.S) material was welded by using the Metal Inert Gas (MIG) by varying the input parameters like current, voltage, welding speed, and root gap to achieve the best and optimal reliability for depth of penetration (DoP), Bead Width (BW) by suing the RSM & ANOVA method. The optimal result achieved were 87.86 ampere of current, Voltage of 15 Volt, Welding speed of 59.02mm/min having root gap of 2mm [2]. The SS plate of 3Cr12 Steel material was welded by GMAW by changing the voltage, Wire feed rate (WFR), Welding speed (WS), and gas flow rate (GFR) to analyse the Bead Height (BH), Bead Width (BW) and depth of penetration (DoP) and thermal properties were analyzed [3]. The Titanium sheet Ti6Al4V were welded by CO2 laser welding by using L9 Taguchi approach and optimized by VIKOR multi objective optimization technique to achieve DoP, BW, BH by varying Welding speed, Laser power, GFR [4]. The Al5083 Alloys were used to weld by CMT welding by using L9 OA array by varying the input parameters welding current, welding speed, weld frequency to acquire the Welding Bead Geometry (WBG), DoP, BW, BH. The welding current 70 Ampere, WFR 225mm/min, 0.5Hz of Frequency was give the best result [5]. The 308L Stainless Steel (SS) was welded by GMAW based on additive manufacturing by using the parameters of current, 20Volt with travel speed and by using 99.9% Argon as Shielding gas. The microstructure analysis, micro hardness, Tensile strength was analyzed [6]. The double sided arc welding by MIG& TIG on 1060 Pure Aluminum and 304L Stainless Steel (SS)[7]. The welding of ductile iron (DI) was done by using Shielded Metal Arc Welding (SMAW) & Oxy Acetylene Welding (OAW) by two different electrodes. The preheating gives the healthier result with the Ni electrodes for the motive that the lack of carbide and ductility of joints.[8]. The welding of ductile cast iron (DCI) was analysed by the mechanical properties by varying the preheat temperature I n range of 200-400 0C. The 200-300 0C must be avoided because of formation of martensite in the Heat Affected Zone (HAZ) and reduction of fusion size to attain the best mechanical properties [9]. The study of pearlite ductile cast iron (DCI) by using the 5 different types of electrodes were examined the mechanical properties & non-destructive testing with preheating. The preheating of 300 0C gives the best result [10]. The SS plate was welded by using the SMAW to get the maximum depth of penetration to achieve the input parameters like current, Torch angle & polarity [11]. The High nitrogen SS plate was welded by SMAW with Cromang-N electrode of attains the best suited properties. The maximum drop delta ferrite and coarse austenite grains due to the lessening in active sites of the austenite/delta ferrite edge [12]. The Mild Steel (MS) Plate was welded by Gas Metal Arc Welding (GMAW) with 1.2mm copper coated plate to acquire the mechanical properties, weld bead geometry (WBG) with different input parameters like current, gas flow rate (GFR)and travel speed (TS) by using RSM & ANOVA [13]. The Mild Steel (MS) was welded by Gas Metal Arc Welding (GMAW) by using different input parameters like current, Voltage & welding speed with output parameters as mechanical properties & depth of penetration (DoP) [14]. The C-45 material was welded by SMAW and GMAW to get the weldability of the specified material under the define process standards as per AWS and ASME [15]. The research gap obtained from the present literature review can concluded as, very few research work were reported on welding of E250BR Mild Steel of 16 mm plate by various researchers. Whereas it has numerous applications in the field of railway, food processing, and oil industries. Mild Steel contains lower carbon percentage (less than 0.25%) which make it favourable to welding processes such as SMAW, SAW, and MIG. Thus, the objectives of this paper were to determine and analyse the different welding process under the mechanical property and microstructure on a same material E250BR.

2. Materials and Method

The material used in this experiment is Mild Steel of grade E250 BR. As per the IS2062:2011 (E250BR) the chemical composition was given in table.6 samples is prepared by cutting the long 16 mm thick sheet into 150 mm × 150 mm area. Each sample is chamfered from one side at an angle of 30 degree such that after joining two respective samples the V groove of 60 degree and root clearance of 2.5 mm is obtained as per ASME standards. The SMAW, MIG Welding & SAW was utilized.

Table 1. Chemical Composition of Baseplate of E250BR Mild Steel Plate

S.No.	Sample	Baseplate
1	Carbon (C)	0.22%
2	Manganese (Mn)	1.50%
3	Phosphor (Ph)	0.045%
4	Sulphur (S)	0.045%
5	Silicon (Si)	0.40%
6	Iron (Fe)	97.8%

3. Result and Discussion

3.1 Spectrography

This test is used to find out the chemical composition of the material, this helps us to understand chemical composite of the element region at Welded Zone. The decrease in the carbon % varies from 0.088, 0.098, 0.075 % in case of MIG, SMAW, SAW which indicates that decreasing the hardness and strength of material at Welded Zone on other hand decreases the brittleness, which gives the good result. The silicon percentage is increased on the MIG & SAW, decreased at SMAW which indicated that there was better strength and hardness in MIG & SAW as compared to SMAW. The Manganese result shows the better hardenability and tensile strength was achieved in MIG welding as compared to SMAW & SAW. The phosphor percentage at WZ gives the result that MIG Welding is more preferable than that of SAW & SMAW because increase of phosphor was result of increase in strength & increase on cost of ductility and impact to toughness. In term of Sulphur the MIG gives the best suited result in term of welding as compare to SAW & SMAW.

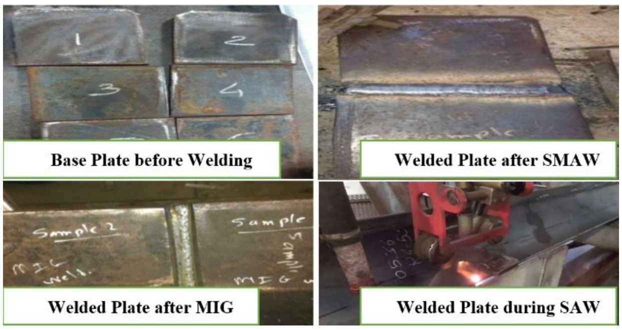

Fig.1.E250BR Plate before welding and after SMAW, MIG & SAW process

Table 2. Different input parameters for MIG, SMAW & SAW

Input Parameters	MIG	SMAW	SAW
Current (Ampere)	80-90	150-200	350-400
Voltage (Volts)	18-20	27	25-30
Travel Speed(mm/ min)	225	180	600
Polarity	DCEN	DCEN	DCEN
Electrode Type	Copper Coated MS (AWS-A5.1E6 013)	Copper Coated MS (AWS-A5. 18 ER70S6)	Copper Coated MS (EM12K)

Electrode Size (mm)	0.8	3.5	3.15
Nos. Of Passes	Multipasses	Multipasses	Multipasses

Table 3. Spectrography of MIG, SMAW& SAW

Sample	MIG	SMAW	SAW
C	0.088	0.098	0.075
Si	0.64	0.27	0.85
Mn	1.152	0.432	1.013
P	0.02	0.025	0.05
S	0.014	0.024	0.025
Cr	0.08	0.01	0.014
Ni	0.04	0.005	<0.001
Mo	<0.001	0.006	0.019
Al	0.007	0.008	0.071
Cu	0.13	0.014	0.021
V	0.004	0.015	0.004
Nb	<0.001	0.004	0.005
Ti	0.01	0.013	0.035

3.2 Hardness

The hardness of Base Metal (BM) observed as 138 BHN and the diameter of penetrated ball on base plate of 1.4mm, the hardness observed as 185 BHN on welded plate by using the MIG, SMAW & SAW and the diameter of penetrated ball on base plate of 1. 5mm.The hardness of all the welding were same.

3.3 Tensile Test

The tensile strength of BM calculated as 405 N/mm2, the ultimate load as 105 KN. The MIG welded plate give the ultimate tensile stress (UTS) 470.04 N/mm2, the ultimate load as 126 KN with cross sectional area of 268.19 mm2, the plate was broken at base metal (BM). The SMAW plate give the UTS 455.90 N/mm2, the ultimate load as 117 KN with cross sectional area of 257.52 mm^2, the plate was broken at weld metal (WM). The SAW welded plate give the UTS 455.90 N/mm2, the ultimate load as 125.6 KN with cross sectional area of 274.51 mm^2, the plate was broken at weld metal (WM). The best result in terms Ultimate Load, UTS & cross-sectional area was given by MIG welding as compared to SMAW & SAW process.

3.4 Bending Test

The bending test (Side Bend & Root Bend) was also done on MIG, SMAW, and SAW. The SMAW welded plated were cracked at welded metal other welding report shows the satisfactory result. The MIG welding gives the satisfactory result in terms of bend test and crack during the bending as related to SAW & SMAW.

3.5 Microstructure

The bending test (Side Bend & Root Bend) was also done on MIG, SMAW, and SAW. The SMAW welded plated were cracked at welded metal other welding report shows the satisfactory result. The MIG welding gives the satisfactory result in terms of bend test and crack during the bending as related to SAW & SMAW.

The microstructure was carried out on the Parent Metal (PM), Heat Affected Zone (HAZ) and Welding Zone (WZ). The MIG gives the result as 10% Pearlite with 7 Grainsized at Parent metal, 9.5 Grainsized HAZ is 1.2mm Circular Ferrite & Pearlite at (WZ). The SMAW plate gives the result as 10% Pearlite with 7 Grainsized at Parent metal, 8.5 Grainsized HAZ is 3.8 mm, Circular Ferrite & Pearlite with spheroidal carbide at (WZ). The MIG gives the result as 10% Pearlite with 7 Grainsized at Parent metal, 9 Grainsized HAZ is 4.2mm, Circular Ferrite & Pearlite with spheroidal carbide at Welded Zone (WZ). The light area r is ferrite and dark area is pearlite in 200X. It's shown with black colored (Pearlite) & orange colored arrow (Ferrite).

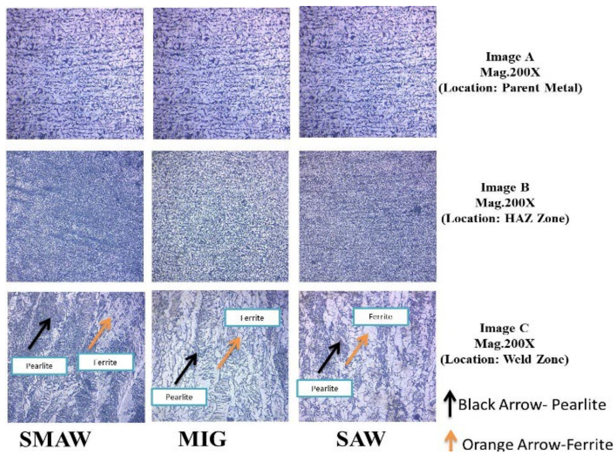

Figure 2. Microstructure of PM, HAZ & WZ at 200X on SMAW, MIG & SAW.

Table 4. Overall Testing parameters of MIG, SMAW& SAW Welded plate.

Sr.No.	Testing Name	MIG	SMAW	SAW
1	Hardness (BHN)	185	185	185

2	Ultimate Load (KN)	126	117	125.6
3	Cross Sectional Area (mm2)	268.19	257.52	274.51
4	Ultimate Tensile Stress (N/mm2)	470.04	455.90	455.90
5	Tensile (Broken at)	Base Metal (BM)	Weld Metal (WM)	Weld Metal (WM)
6	Bending (Side T)	Base Metal (BM)	Weld Metal (WM)	Weld Metal (WM)
7	Bending (Root R)	Satisfactory	Cracked	Satisfactory
8	Power (Watts)	1615	4725	10500
9	Heat Input (KJ/mm)	0.436	1.801	1.010
8	Microstructure	a) PM- 10% Pearlite with 7 Grainsize b) HAZ- 9.5 Grainsize HAZ is 1.2mm c) WZ- Circular Ferrite & Pearlite	a) PM- 10% Pearlite with 7 Grainsize b) HAZ- 8.5 Grainsize HAZ is 3.8mm c) WZ- Circular Ferrite & Pearlite with spheroidal carbide	a) PM- 10% Pearlite with 7 Grainsize b) HAZ- 9 Grainsize HAZ is 4.2mm c) WZ- - Circular Ferrite & Pearlite with spheroidal carbide
9	Operating Time (Second)	440	520	75
10	Electrode Consumption (Kg)	0.2136	0.213	0.1063

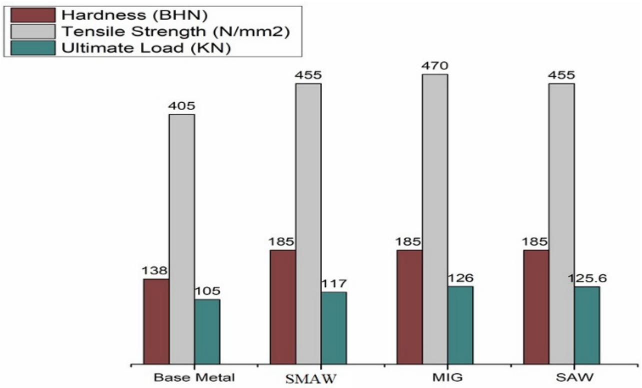

Figure 3. Output testing report on welded plates of SMAW, MIG, SAW

4. Conclusion

- The MIG welding gives better result as compared to other two welding processes viz SMAW & SAW with reference to tensile strength, hardness, bending, spectro analysis, and microstructure.
- The Ultimate load carrying & ultimate tensile stress was maximum at MIG Welding- 126 KN and 470.04 N/mm2 as compared to 117 KN, 125 KN & 455.90 N/mm2.
- The spectrograph clearly showing the better results in MIG as re-late to two other welding Processes.
- The microstructure also shown the clear indication that the MIG gives best suited consequence as compared to other welding, be-cause of - Circular Ferrite & Pearlite Structure at WZ and 9.5 Grain sizes HAZ is 1.2 mm.
- The heat input of MIG was 0.436 KJ/mm which gives the better result in terms of tensile, bending and microstructure properties as compared to SAW (1.010 KJ/mm) and SMAW (1.801 KJ/mm), operating time and power consumed were consumed less in MIG as compared to other welding process.
- The MIG welding gives the best suited result for welding of E250BR M.S material in terms of mechanical and microstructural properties. The future scope of this work will be carried by varying the consumables and input parameters of different welding processes.

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