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MICROSTRUCTURE ANALYSIS OF SHIELDED METAL ARC WELDING USING DIFFERENT ELECTRODE COMBINATION

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Abstract - **Shielded metal Arc Welding process is one of the oldest and most widely used methods of joining metals by welding. It is generally used in heavy industry such as ship construction, ship repair sites, hydro power plant and cargo ship. It consist of a metallic electrode covered with flux, which conducts electricity, and flux giving off vapour that act as a shielding gas during welding process and providing a layer of slag around the weld area to protect from atmospheric contamination. The present paper represents the microstructure analysis of the base metal, weld metal and heat affected zone using different electrode combination during Shielded metal Arc Welding.**

Keywords – Shielded metal arc welding (SMAW), Heat affected zone (HAZ), Pearlite, Ferrite.

1. INTRODUCTION

SMAW process has wide application in the industrial work, structural work pipeline field, repair work, military equipment service due to the simplicity, portability and adaptability of equipment to indoor and outdoor uses [Kazakov, 1985]. SMAW is widely used in the construction of steel structures and industrial manufacturing. The process is basically used to weld steels and iron (including stainless steel). Aluminium, nickel and copper alloys can also be welded with SMAW [Cary and Helzer, 2005].The shielded metal-arc welding equipment consist of a metallic electrode, which conducts electricity, is covered with flux and connected to electric current source. The metal to be welded is connected to the other end of the same source of current. By touching the electrode tip to the metal for fraction of second and then take it away, an electric arc is created. The extreme heat of the arc melts the parts to be welded and the tip of the metal electrode, which supplies filler metal for the weld. An electric current in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapours that act as a shielding gas that protect the weld area from atmospheric contamination [Houldcrof, 1973]. Figure 1 show the Shielded metal arc welding process. The highest hardness measurement was recorded when welding was performed using the DC- polarity and lowest hardness when the welding was performed using the AC polarity [Hamza et al., 2005].

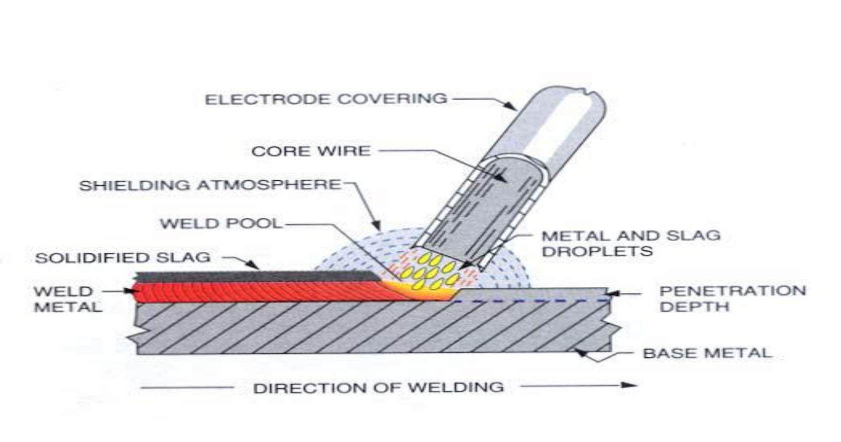

Figure 1: SMAW Process (Cary and Helzer, 2005).

Alloying elements are given special care to obtain a mixture of ferrite and pearlite in the matrix microstructure after SMAW. Well known alloying elements are chromium, copper, phosphorus, manganese, and nickel [Gonzaga et al., 2009]. To diminish the probability of hot cracking, also known as solidification and cracking at fusion zone of a weld, a proper filler material should be utilized [Bull and Steve, 2000]. The three main absorbed gases within weld metals are oxygen, nitrogen and hydrogen. Oxygen reduces the both strength and toughness. Oxides can be in the form of iron-manganese oxide in neutral and acidic weld metal with the latter containing some iron-manganese-silicate oxides while the basic type weld metal almost only contain iron-manganese-silicate oxides [Noren and Pfeifer, 1994]. Nitrogen raises the strength but reduces the toughness. Nitrogen is normally present in ppm concentration but may still have a large effect on the mechanical properties. Too long arc may lead to excess nitrogen pick up [L.-E. Svensson, 1994]. Filler metal significantly affects the microstructure of the weld metal and HAZ durin SMAW process [N.Bajic et al, 2011]. Tensile ductility relatively decreased to some extent after the SMAW process [Quintana et al, 1997].

2. MATERIALS USED

2.1 Base metal material

Low carbon pipeline steel (IS 3589 GR 330 Class A91A) has been used as base metal material. The test plates of 120 × 80 mm and 6 mm thickness were prepared from 6 mm thickness pipe. A single groove angles of 35 degree were cut in the plates with 1 mm root faces and 2 mm root distance for a total of 70 degree inclined angle between two plates.

2.2 Electrode material

E 6010 is used as electrode material. It suitable for low carbon steels because of their deep penetration characteristic, minimal slag production and give weld quality through rust, oil, paint and dirt. The coverings of these electrodes are high in cellulose content, usually exceeding 30% by weight. Table 1 show the chemical composition of E 6010.

Table 2: Chemical composition of E6010

Material	C	Mn	P	S	Si
%	0.10	0.51	0.13	0.12	0.30

E7016 is used as electrode material. These electrodes are also known as low-hydrogen type electrodes. The slag of electrodes is chemically basic and heavy, friable, and easy to remove. The arc immoderately penetrating and weld face is convex. E7016 electrodes are used for welding of mild steel and high strength steel. Table 2 shows the chemical composition of E 7016[SMAW].

Table 2: Chemical composition of E7016

Material	C	Mn	P	S	Si
%	0.15	1.60	0.035	0.035	0.75

3. ADOPTED METHODOLOGY

The initial Butt joint sample was fabricated using SMAW. The joint geometry and pass sequence was selected to ensure sample weld metal in a manner consistent with typical AWS conformance testing. Samples were named as A and B and welded joints are prepared using combinations of electrodes as given in Table 3. Samples were cut from the weldment and subjected to standard metallographic preparation and etched with a Natal 2% (nitric acid in ethanol) etchant. Microstructure examination of weld samples was carried out using a light optical microscope (Meji, Japan; model MIL-7100) incorporating image analyzing software (Metal vision). Hardness testing of welds was performed on ground, polished and etched cross-section of the joint area. Vickers hardness test were performed on the various zones.

Table 3: Combination of electrodes

Sample	Root Electrode	Filler electrode

A	E6010	E6010
B	E6010	E7016

4. RESULTS AND DISCUSSION

4.1 Analysis of Microstructure of weld zone, HAZ and Base Metal Sample A

The Microstructure Analysis of weld metal, HAZ and Base Metal are shown in Figure 2(a), 2(b) and 2(c) espectively. Analysis of weld zone shown the formation of self cooled structure containing pearlite and Ferrite structure and the Grain flow in direction of cooling, which shows homogeneity with the base metal. The structure containing mixture of pearlite and ferrite have adequate value of hardness 159.2. Which is in accordance with value of microhardness 160 and adequate ductility since pearlite contribute to hardness and ferrite imparts ductility (Gonzaga et al 2009) to the weld metal. The result of HAZ shows that there is formation of Coarse grains of pearlite-ferrite structure which has less hardness value of 150 as compared to weld metal zone. Coarse grains are lesser harder than fine grains (Leinonen et al 2004).

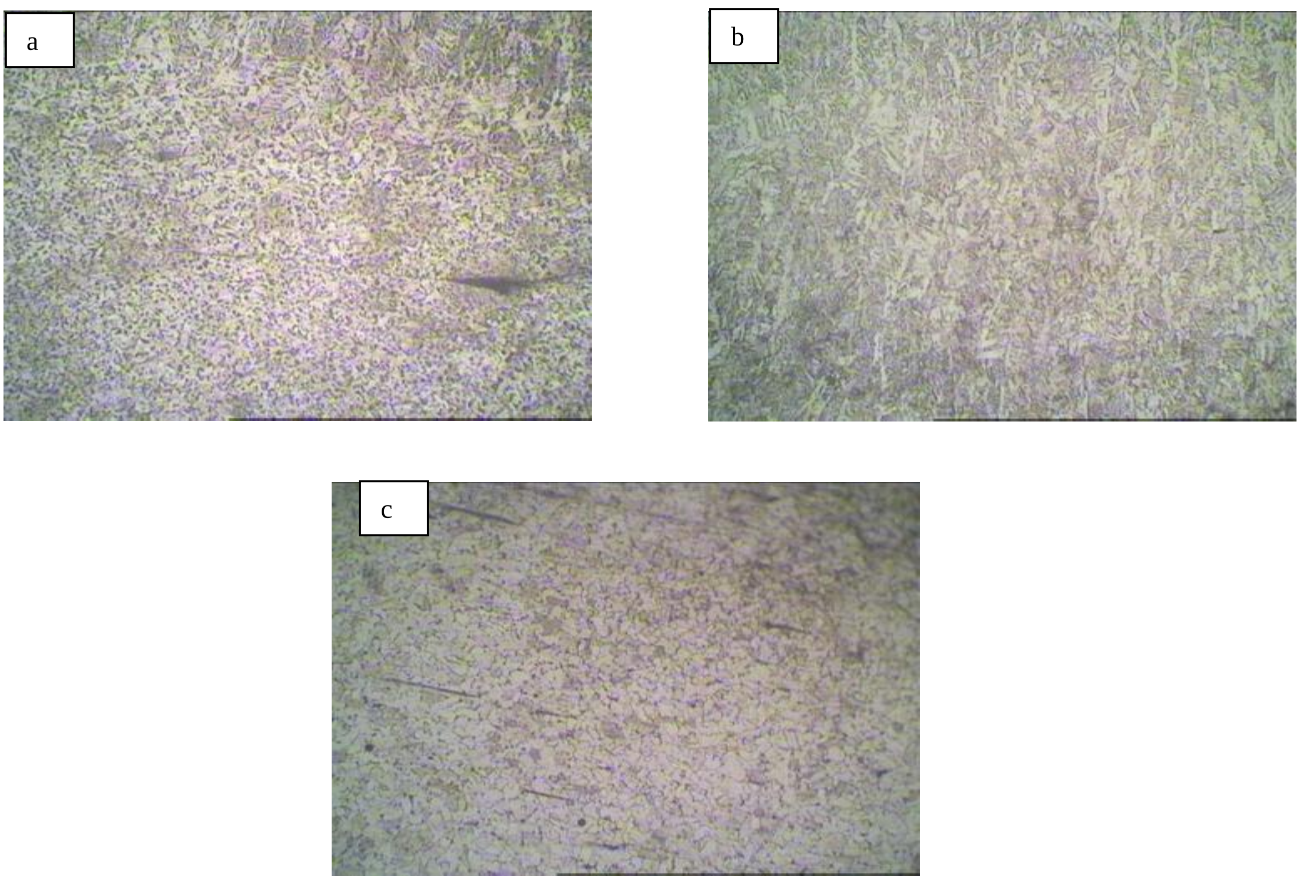

Figure 2: (a) Microstructure of weld zone (b) Microstructure of HAZ (c) Microstructure of base metal

Analysis of Base metal shows that base metal having pearlite ferrite grain structure (grain size (7.5 ASTM). The experimental value of micro hardness of this zone is 160.

4.2 Analysis of Microstructure and Micro hardness of weld zone, HAZ and Base Metal of Sample B

The Microstructure Analysis of weld metal, HAZ and Base Metal are shown in 3(a), 3(b) and 3(c) respectively. The Analysis of the weld zone shows that very coarse pearlite grain structure is formed in direction of flow of heat with patchy ferrite. This is due to lesser cooling rate since grains are formed in direction of heat instead of direction of cooling which leads to formation of coarse pearlite structure (Cepus et al 1994). The experimental value of hardness is 156.75 of the weld metal zone where as of base metal value is 174.25. Coarse pearlite imparts less hardness (Leinonen, 2004). Even formation of some patches of ferrite in the structure responsible for fast crack initiation at the surface.

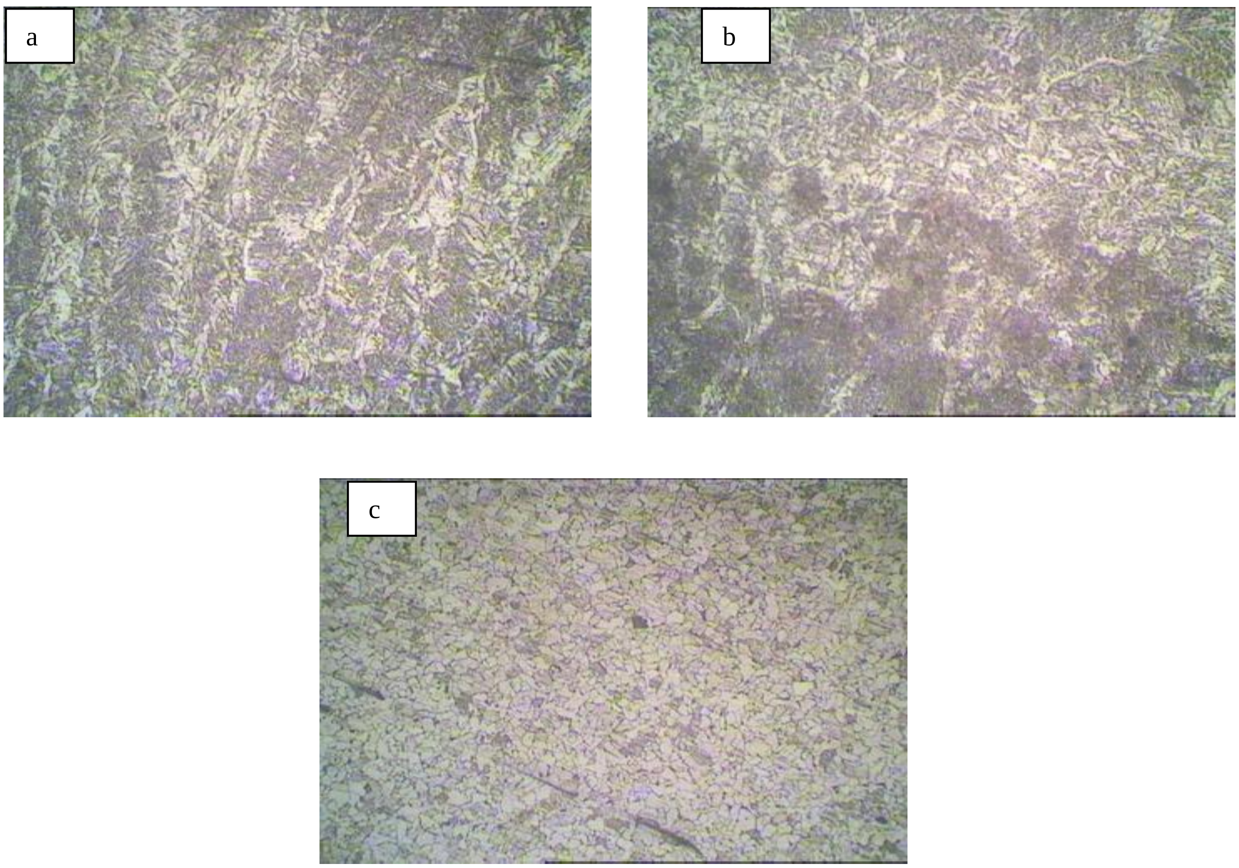

Figure 3: (a) Microstructure of weld zone (b) Microstructure of HAZ (c) Microstructure of Base metal

In the Heat affected zone microstructure shows that uneven pearlite grain structure with ferrite at grain boundaries ,so there is tendency to form crack initiation from the grain boundaries which will propagate from the boundaries to inward direction So there is chance of crack initiation at boundaries itself. The experimental value of micro hardness in this zone is 148. Microstructure analysis of Base metal result reveals that the base metal having pearlite ferrite grain structure with grain size (7.5 ASTM) with and hardness value of 174.25 are present.

5. CONCLUSIONS

Combination 6010-6010 microstructure is in accordance with the base metal and have fine grains as compared to combinations 6010-7016(those are having coarse pearlite structure) which will impart good hardness and adequate toughness properties to the weld metal. Microstructure of HAZ of Combination 6010-6010 is better as compared to combinations 6010-7016 which produce uneven pearlite grain structure with ferrite at grain boundaries, so there is tendency to form crack initiation from the grain boundaries.

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REFERENCES

[1] Bull and Steve.(2000) . Factors promoting hot cracking, University of Newcastle upon Tyne, archived from the original on 2009-12-06.

[2] Cary, Howard B., Scott C., Helzer. (2005). Modern Welding Technology. Upper Saddle River, New Jersey: Pearson Education. ISBN 0-13-113029-3.

[3] Cepus.E, Liu.C.D and M.N. Bassim.(1994, September). The effect of Microstructure on the mechanical properties and adiabatic shear band formation in a medium carbon steel. Journal De Physique. Gonzaga.R.A, Martinez .P Landa,A. .Perez.P, Villanueva.(2009) Mechanical properties dependency of the pearlite content of ductile irons. Journal of achievements in Materials and Manufacturing Engineering – Volume 33 Issue 2 April pp-150-158

[4] Gonzaga.R.A, Martinez .P Landa,A. .Perez.P, Villanueva.(2009,April) Mechanical properties dependency of the pearlite content of ductile irons. Journal of achievements in Materials and Manufacturing Engineering (Vol.33 Issue 2).(pp-150-158).

[5] Hamza R M A., Aloraier A K., Faraj E A.(2005). Investigation effect of welding polarity in joint bead geometry and mechanical properties of SMAW process.Journal of Engineering and Technology.(PP-100-111).

[6] Houldcroft P T., (1973).Chapter 3: Flux-Shielded Arc Welding. Welding Processes. Cambridge University Press. ISBN 0-521-05341-2.

[7] J.L. leinonen. (2004, March). Superior properties of ultra-fine-grained steels Acta polytechical- Vol.44.

[8] Bajic.N, Sijacki.V-Zeravcic,B.Bobic,Cikara.D,and Arsic.M. (April 2011).Filler metal influence on weld metal structure of micro alloyed steel. Supplement to the welding journal.Sponsored by the Americans welding society and the welding research council

[9] Quintana M A., Johnson M Q. (April , 1997). Effect of intermixing welds metal on mechanical property part-1. Paper presented at the AWS Annual Meeting, , Los Angeles

[10] Kazakov N F. (1985). Diffusion Bonding of Materials. University of Cambridge.

[11] L.-E. Svensson.(1994). Control of microstructure and properties in steel arc welds, CRC Press Inc.

[12] Narasaiah.N, Ray.K.K..((2005). Small crack formation in a low carbon steel with banded ferrite-pearlite structure. Materials Science and Engineering. (pp. 269-277)

[13] T.M. Noren and C. Pfeifer, Applied steel welding and metallurgy. ESAB. Gothenburg, Sweden.