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STUDY AND ANALYSIS OF MICROSTRUCTURE AND MECHANICAL PROPERTIES OF WELD DURING UNDERWATER WET SMAW

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Abstract

SMAW experiments were conducted under the water and in the air with PVA-alumina coated electrode. Influences of surrounding water on the weld geometry, weld microstructure and mechanical properties were studied. Results shown that formation of fine granular pearlite and ferrite in the wet weld. High amount of acicular ferrite (AF) in HAZ of wet weld and this amount is decreased by increasing the heat input, more ferrite content in the air weld. Two types of metal transfer mode has been observed, i.e. globular transfer mode and combined surface tension and repelled globular transfer mode. Second one is the reason for poor weld bead appearances in wet weld. Mechanical properties like toughness and hardness has been studied. Results shows improved mechanical properties at reduced cooling rate by increasing the heat flux.

Keywords: Underwater welding, Polymer based coated aluminium, Microstructure and metal transfer mode.

1. INTRODUCTION

The desire to repair damaged offshore structures as a result of corrosive defects, material fatigue, accident during assembly, construction errors, and excessive operational loads has brought the underwater welding. The first under water welding was done by British admiralty dockyard for the repair of leaking ship rivets. Most recently a lot of underwater welding activities have been going on for example the platform installation, pipeline welding, watercraft welding, seashore components and offshore structure welding. Offshore development has accelerated in recent years owing to the fact that more than 60% of undeveloped petroleum deposits are located under the ocean .In the offshore industry and In oil and gas pipelines already a routine activity, the demand for under welding can produce the quality wet welding at greater depths, and on variety of materials will continue to increase. Characterized by low cost, good adoptability, simple equipment the underwater wet welding is widely used .the most commonly used one is shielded metal arc welding (SMAW). There are two types of underwater welding wet welding and dry welding. wet welding occurs directly in aqueous environments with no mechanical barriers between the water and welding arc.it was established that significant low cost and simplicity of the process The desired qualities of sound underwater are flexibility of operation in all positions, minimum electrical hazard ,good visibility, reliable welds, less porosity of welds. However the increase in the carbon and oxygen content leads the tendency of cracking.so the steel having higher carbon equivalent greater than 0.4% shows the poor weld ability and also the aqueous environment produce lots of dis advantages like loss of alloying metal and considerable amount of diffusion of hydrogen and the cooling rate is high from 800°c to 500°c is in the range of 63°c to 425°c/sec and $t_{8/5}$ also very less in the range of 1 to 6 sec. which causes the hydrogen induced cold cracking in HAZ.So in our project we chosen the low carbon steel having less carbon equivalent about 0.32 and dealing with extending of the $t_{8/5.}$

2. MATERIALS AND METHODS

C	Mg	P	S	Si	Cr	Ni	Mo	V
0.2	0.4	0.035	0.035	0.1	0.4	0.4	0.15	0.08

Table: 1 Base material composition

2.1 Filler Rod

E6013 welding electrode has been chosen. In this electrode filler rod is mild steel. The composition of filler rod shown in table below

CONTENT	WEIGHT PERCENTAGE
Silicon	0.18
Magnesium	0.45
Phosphorus	0.014
Carbon	0.08
Sulphur	0.012

Table: 2 Filler Rod composition

2.2 *Water Proofing Electrode*

Commercial rutile electrode (E6013) has been coated in dip coating method with poly vinyl alcohol and alumina mixture. For water proofing of electrode.

A small amount of poly vinyl alcohol salt is poured in a beaker containing 100 ml of water. The solution heated and mechanically stirred with help of glass rod for 5 minutes. After 5 minutes another small amount of poly vinyl alcohol added and stirred for 5 minutes. This process continues till gel like adhesive polymer solution. After the gel like structure formed the solution allowed to cool to the room temperature. Then Nano alumina powder is poured into the solution and stirred for 30 minutes for better dispersion of Nano particles into the polymer matrix.

Now the electrode is dipped into the solution and removed slowly. After that electrode is placed in the oven for 15 minutes for drying. The electrode from oven having thin layer PVA-alumina. The coating from the bottom of the electrode is removed by rubbing in the abrasive sheet for arc initiation purpose.

Figure: 1 Electrode dipped in solution

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Figure: 2 PVA-alumina mixture

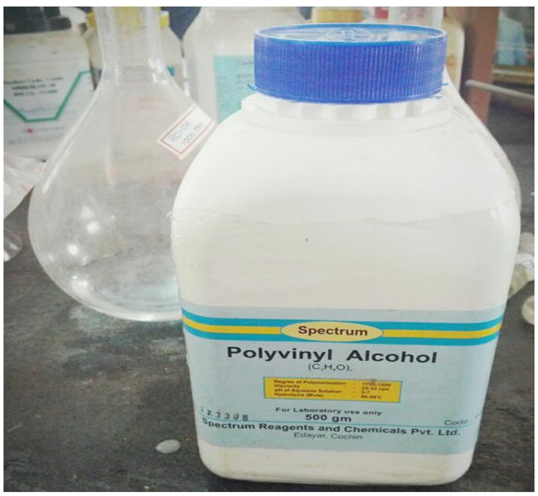

Figure: 3 Polyvinyl alcohol

Parameters	Air	Water 1	Water 2
Current	120A	150A	180A
Voltage	35V	33V	31V
Speed	$1.6x10^{-3}$ m/s	$1.42x10^{-3}$ m/s	$1.48x10^{-3}$ m/s

Table: 3 Welding parameters

Phase	Power(W)	Heat input (KJ/m)
Air	4200	2100
Water 1	4950	2021
Water 2	5580	2186

Table: 4 Heat input conditions

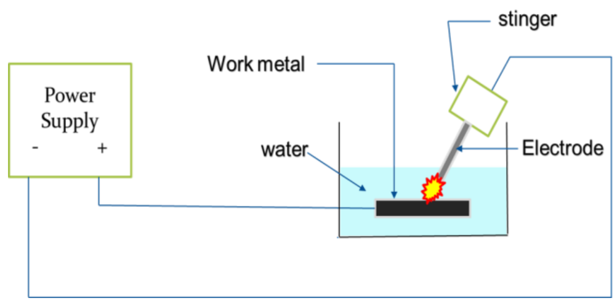

Figure: 4 Underwater welding

3. WELD CHARACTERISTICS

3.1 Weld Bead Appearance

The weld bead appearance was good in the air welding and it is poor in water welding, the poor bead appearance takes place in the underwater weld due to the metal transfer affected by surface tension.

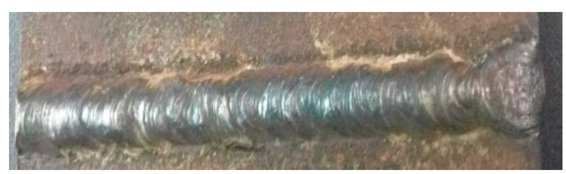

Figure: 5 Air welding bead appearance

Figure: 6 wet welding bead appearance

In the air welding the globular mode of metal transfer has taken place. In this mode small droplet is hanging on electrode dip due to surface tension between electrode tip and molten metal and the droplet becomes bigger, the droplet falls to the weld pool when gravitational force acting on the droplet exceeds the surface tension.

In the underwater welding the molten metal is surrounded by the water, so the surface tension acts between the water and droplet which changes the shape of the droplet and distributed without uniformity to the weld pool, this causes the spattering of molten metal here and there. That's why its bead appearance was poor

3.2 Joint Preparation

Initially the underwater welding were tried with the square butt joints results in lower penetration and lack if fusion of faying surface

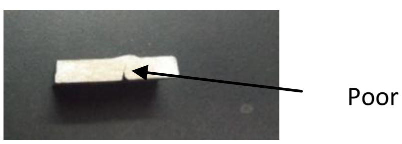

Figure: 7 Square butt joint

So V groove at an angle of 30^o to the depth of 4mm was made in the work piece for more penetration. Multi pass welding done. Two pass was done during welding. After completion of the first pass slag is removed. Before continuing to the next pass.

Figure: 8 Cross section of V weld joint

4. MICROSTRUCTURE ANALYSIS

4.1 Microscopic Examination

Microscopic viewing done utilizing a stereomicroscope, which reveals a three-dimensional scanning of the specimen surface. The specimen is placed on the stage of the microscope so that its surface is perpendicular to the optical axis. Detailed viewing is done with a Metallurgical Microscope. A metallurgical microscope has a system of lenses (objectives and eyepiece) so that different magnifications (25X to 1000X) can be achieved.

4.2 Microstructures of Specimen

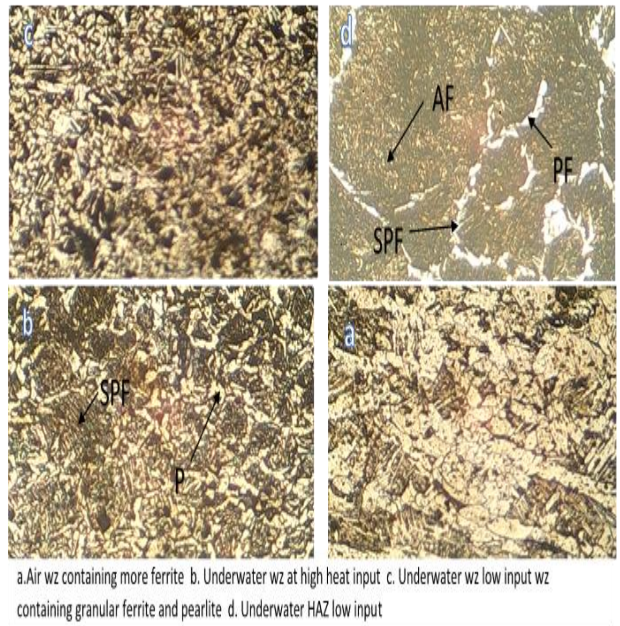

Figure: 9 Microstructure of specimens

The air weld having more ferrite and less pearlite content in weld zone shown in the figure a. Fine granular ferrite and pearlite structure were obtained in wet welding of lower heat input showed in the figure c. this is due to cooling rate was high which in turn increases the solidification rate of weld metal. There is no sufficient time provide to grains to grow. This grain size is increased at higher input due to reduced cooling rate. The higher amount of acicular ferrite were obtained in the heat affected zone of underwater wet at low heat input shown in the figure d. The amount of acicular ferrite reduced and pro-eutectoid ferrite increased at increased heat input specimen shown in figure b.

5. MECHANCIAL TESTING

5.1 Rockwell Hardness Test

The Hardness of the specimen were found in Rockwell hardness testing Machine.

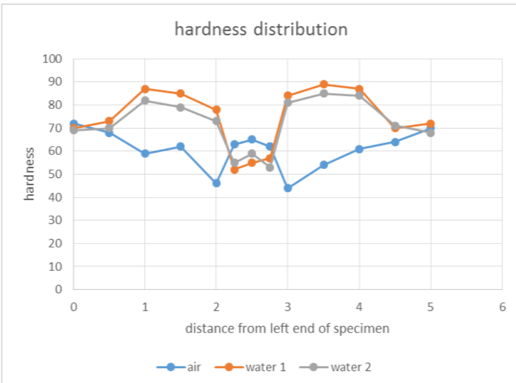

Figure: 10 Hardness Distribution

Hardness distribution shown above the water 1 low input specimen having less hardness due to the formation of fine grains. Also heat affected zone having higher hardness because of it's having higher amount of acicular ferrite shown in figure. The hardness values are reduced considerably in water 2 at increased heat input.

5.2 *Impact Test*

Impact tests were conducted in CHARPY V NOTCH TESTING MACHINE. The V Notched specimen of Dimensions 5X10X55 mm as per ASTM A370 Standard used.

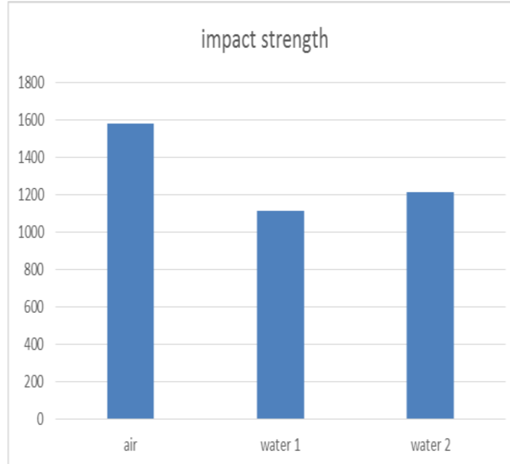

Figure: 11 Impact strength at various condition

6. CONCLUSION

Shielded metal arc welding were formed under the water at different heat input. The surrounding water effects on the microstructure and mechanical properties studied and the following conclusions were made. The cooling rate is main factor that affecting properties of varies zones in the weld joint. This cooling rate can be reduced by increasing the heat flux and better properties can be obtained. Fine granular structure Produced in weld zone of underwater welding at low input. The size of granular structure are also increased at higher heat input as result of reduced cooling rate. Higher amount of acicular ferrite were absorbed in the heat affected zone of underwater welding. The amount of acicular ferrite content reduced by increasing the heat input. We are planning for further researches with insulated work piece to reduce cooling rate by reducing heat transfer between the water and work piece.

References

[1] Cui, L., Yang, X., Wang, D., Hou, X., Cao, J., Xu, W., 2014. Friction taper plug welding for S355 steel in underwater wet conditions: welding performance, microstructures and mechanical properties. Mater. Sci. Eng. A 611, 15–28.

[2] Yin, Y., Yang, X., Cui, L., Wang, F., Li, S., 2015. Material flow influence on the weld formation and mechanical performance in underwater friction taper plug welds for pipeline steel. Mat. Des. 88, 990–998.

[3] Di, X., Ji, S., Cheng, F., Wang, D., Cao, J., 2015. Effect of cooling rate on microstructure, inclusions and mechanical properties of weld metal in simulated local dry underwater welding. Mater. Des. 88, 505–513.

[4] Gao, W., Wang, D., Cheng, F., Deng, C., Liu, Y., Xu, W., 2015a. Enhancement of the fatigue strength of underwater wet welds by grinding and ultrasonic impact treatment. J. Mater. Process. Technol. 223, 305–312.

[5] Guo, N., Guo, W., Du, Y., Fu, Y.L., Feng, J., 2015a. Effect of boric acid on metal transfer mode of underwater flux-cored wire wet welding. J. Mater. Process. Technol. 223, 124–128.

[6] Guo, N., Liu, D., Guo, W., Li, H., Feng, J., 2015b. Effect of Ni on microstructure and mechanical properties of underwater wet welding joint. Mater. Des. 77, 25–31.

[7] Guo, N., Xu, C., Du, Y., Wang, M., Feng, J., Deng, Z., Tang, D., 2016. Effect of boric acid concentration on the arc stability in underwater wet welding. J. Mater. Process. Technol. 229, 244–252.