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An Assessment over Underwater Welding Technique

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ABSTRACT

The underwater welding is developing technology of the present and the future. Many ships and offshore platforms need the underwater welding process during emergency. There are many research institutes in the world developing techniques for underwater welding. Welding in marine and offshore application is an area of research and understanding where still many unsolved problems are present. . This paper contains principles of underwater welding, types of underwater welding, advantages and disadvantages of underwater welding and recent trends in research works are taken to enhance welding technology and possessions of underwater welds. This paper also contains conventional and advanced underwater welding techniques.

Key words: Underwater welding; wet welding; dry (hyperbaric) welding; SMAW; FCAW; TIG FRW

1. INTRODUCTION

Welding processes have become progressively important in almost all manufacturing activities and for structural application. Even though, a large number of techniques are available for welding in atmosphere, many of them cannot be used in marine and offshore application where presence of water is of major anxiety.

The fact that electric arc could used for welding was known to us over a 100 years. The first ever underwater welding was performed by British Navy – Dockyard for sealing leakage in ship rivets below the water line. Underwater welding is ansignificant tool for underwater assembly works. In 1946, special waterproof electrodes were advanced in Holland by 'Van der Willingen'. In recent years the number of marine structures including pipeline, oil drilling rigs and platforms are being installed successfully. Some of these structures will experience letdowns of its essentials during normal usage and during unexpected occurrences like collisions, storms. Any reparation method will require the use of underwater welding.

2. GENERAL ASPECTS OF UNDERWATER WELDING

There are various methods in which underwater welding technique can be completed. In underwater welding technique, the main task is to create an environment for welding. These are discussed in the below in this paper.

One of the main benefits of this welding technique is the saving of time. For maintenance and repair works in marine applications, the tools/vessel need not be taken out to carry out the welding process. The main troubles in underwater welding are the presence of a higher pressure due to the water at working area, disturbing action of the water on the weld metal , the probability of producing the arc mixtures of oxygen and hydrogen in pockets, which might set up an blast, and the common threat persistent by divers, of having nitrogen diffused in the blood in dangerous proportions. Moreover, complete insulation of the welding route is annecessary requirement of underwater welding.

3. IMPORTANCE OF UNDERWATER WELDING IN MARINE APPLICATIONS:

In practice, the utilization of underwater wet welding for offshore maintenances has been limited primarily

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because of porosity and low durability in the resulting welds. With suitable design, however, it is possible to reduce porosity and to improve weld metal toughness through microstructural modification. Hence,welding in marine and offshore application is an important area of research and needs extensive attention and understanding where, many problems are present[1]. In the present review, a brief understanding of the problems in underwater welding will be discussed in form of existing welding techniques. Detailed explanation of a few advanced welding techniques has also been made. Finally, the scope of further research would be recommended.

3.1 CLASSIFICATION:

The underwater welding can be classified as:

1) Wet welding.
2) Dry (Hyperbaric) welding.

1. WET WELDING: Wet welding shows that welding is performed underwater, openly exposed to the wet surroundings. A special electrode is used and welding is performed manually just like open air welding. The improved freedom of movement makes wet welding the most operative, effectual and economical method. Welding power supply is situated on the surface with connection to the diver/welder via cables and hoses [2].

Power supply: DC (direct current)
Polarity : -ve (negative)

When DC is used with +ve polarity, electrolysis will take place and cause rapid deterioration of any metallic components in the electrode holder. For wet welding AC is not used on account of electrical safety and difficulty in maintaining an arc underwater [2].

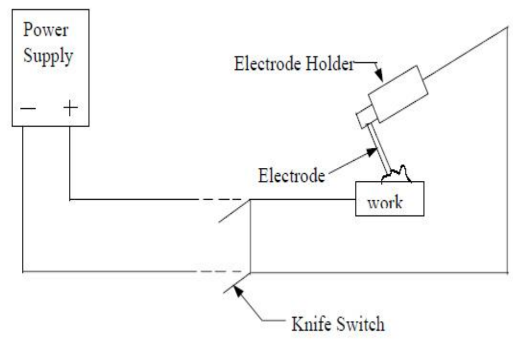

Fig.1 Wet welding (MMAW)

PRINCIPLE OF OPERATION OF WET WELDING:

The method of underwater wet welding takes in the following way:

The work to be welded is linked to one side of an electric circuit, and a metal electrode to the other side. These two chunks of the circuit are conveyed together, and then separated faintly. The electric current moves to the gap and causes a spark (arc), which melts the metal, forming a weld pool. At the same time, the tip of electrode melts, and metal drops are jumps into the weld pool. During this process, the flux casing the electrode melts to provide a shielding of gas, which is used to control the arc column and shield the metal transferred [3].

ADVANTAGES OF WET WELDING:

Wet underwater welding (MMAW) has used for many years in the maintenance of marine platforms[3,4]. The advantages of wet welding are: -

- The adaptability and low cost of wet welding makes this technique highly desired.
- Further benefits include the high speed of the operation that is carried out.
- The cost of this welding is less as compare to dry welding.
- In this type of welding a welder can be reached to the working area freely.
- In this type of welding there is no need to prepare a dry surrounding to the working area.

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DISADVANTAGES OF WET WELDING:

Even though wet welding is commonly used for underwater assembly works, it undergoes from the following downsides [3, 4]:

- Due to the wet environment in the welding area the properties of the metal can be changed due to the quenching of the metal, the contact of water to the metal increases the harness of the metal and decreases the ductility of the metal which reduces the toughness of the metal.
- Hydrogen Embrittlement- Huge amount of hydrogen is present in the weld area, causing from the detachment of the water vapor in the arc area. The Hydrogen dissolves in the Heat Affected Zone (HAZ) and the weld metal, which causes cracks, embrittlement and microscopic fractures. Cracks can raise and may result in catastrophic failure of the structure.
- Due to the poor visibility inside of water the proper welding is difficult.

2. DRY WELDING (HYPERBARIC WELDING): Dry (Hyperbaric) welding is performed in the dry chamber sealed around the structure to be welded. The chamber is filled with a gas (commonly helium having 0.5 bar of oxygen) at the normal pressure. This method results high-quality weld joints that fulfills X-ray and code necessities. The gas tungsten arc welding technique is used in this process. The area under the floor of the Habitat is open to water. Thus the welding is done in the dry but at the hydrostatic pressure of the sea water covering the Habitat [5].

PRINCIPLE OF OPERATION OF DRY WELDING:

Underwater welding in a dry surroundings is made possible by covering the area to be welded with a physical obstacle (weld chamber) that eliminates water. The weld compartment is custom madeand designed to accommodate braces and other structural supports whose centerlines may cross at or near the area that is tobe welded. The compartment is usually made of steel, rubberized canvas, plywood or any other proper material can be used. Size and shape of the compartmentare determined by geometry and dimension of the area that must be comprehended and the number of welders that will be working in the compartment at the same time [6,7].

ADVANTAGES OF DRY WELDING:

- **Welder Safety -** Welding is performed in a compartment with dry environment, So the welder is safe from electric shock.
- **Good Quality Welds –** In this method the welding is performed in the dry conditions, So there is no effect of water to change the properties of weld by quenching that's why the weld produced is of good quality [8].
- **Surface Monitoring -** Pipe alignment, joint preparation, NDT inspection, etc. are monitored visually [7].
- **Non-Destructive Testing (NDT) -** NDT is also allowed by the dry habitat environment.

DISADVANTAGES OF DRY WELDING:

- The wet welding requires big numbers of complex apparatus and much support equipment on the surface. The chamber is highly complex.
- Cost of dry welding is very high and increases with depth. Work depth has an effect on dry welding [9, 10].

4. CONVENTIONAL UNDERWATER WELDING TECHNIQUES:

1. SHIELDED METAL ARC WELDING (SMAW): The shielded Metal Arc Welding (SMAW) is the mostly used welding processes. During the process, the flux covered on the electrode melts during welding. This generates the gas and slag to shield the molten weld pool. The slag must be removed from the weld bead after welding.

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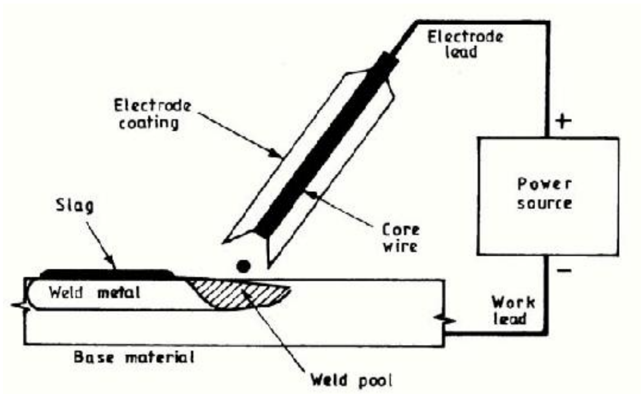

Fig. 2. Schematic of shielded metal arc welding process

The flux also offers a method of adding deoxidizers,scavengers and alloying elements to the weld metal. For underwater wet welding with SMAW technique direct current is used and generally polarity is straight. Electrodes are generally water proofed. Electrodes for SMAW are classified by AWS as E6013 and E7014 [7]. Simple set-up, versatility economy in process and finished product quality are main advantages of this technique. However, during welding all electrode holder, gloves, electrical leads, lighting gear etc., must be fully insulated and in good condition.

2. FLUX CORED ARC WELDING (FCAW): Flux Cored Arc Welding (FCAW) is a generally used high deposition rate welding process that adds the advantages of flux to the welding simplicity of MIG welding (Khanna, 2004). As in MIG welding wire is constantly fed from a spool. Figure 3 shows the schematic of FCAW process. FCAW is therefore stated as a semiautomatic welding method. Self-shielding FCAW wires are available or gas shielded welding wires may be used. However, the situation of the base metal can affect weld quality. Extreme contamination must be rejected. FCAW produces a flux that must be removed. FCAW has good weld look. Flexibility in process, good quality, higher deposition rate and low operator skill of the weld deposits are the main advantages of FCAW.Recent improvement of nickel based flux cored filler materials have provided better wet weldability and halogen free flux formulation specially designed for wet welding application (Oates, 1996).

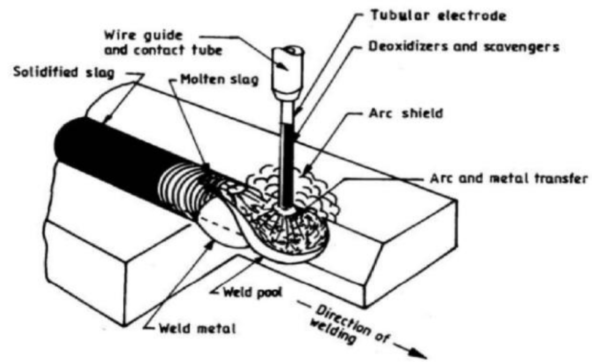

Figure 3: Schematic of Flux Cored Arc Welding

3. TUNGSTUN INNERT GAS WELDING:GTAW welding (Gas Tungsten Arc Welding) or TIG-welding (Tungsten Inert Gas) uses a permanent non melting electrode made up off tungsten (Khanna, 2004). Filler metal is added independently, which creates the method very flexible. TIG welding has got the benefit that it provides as table arc and less porous weld.

.The greatest used power source for TIG-welding creates alternating current (AC). Direct current can be used. ACTIG-welding generally uses argon as a shielding gas. The process is a multiuse process, which offers the user great litheness. By altering the diameter of the tungsten electrode, welding may be performed with a wide range of heat input at different depths. AC TIG welding is possible with thicknesses down to about 0,5mm.For larger thicknesses, > 5 mm, AC TIG-welding is less economical related to MIG-welding due to lower welding speed. DC TIG-welding with electrode negative is used for welding thicknesses above 4 mm. The negative electrode gives a poor oxide cleaning related to AC-TIG and MIG, and special cleaning of joint surfaces is essential. The procedure usually uses helium shielding gas. This gives a better penetration in thicker pieces.

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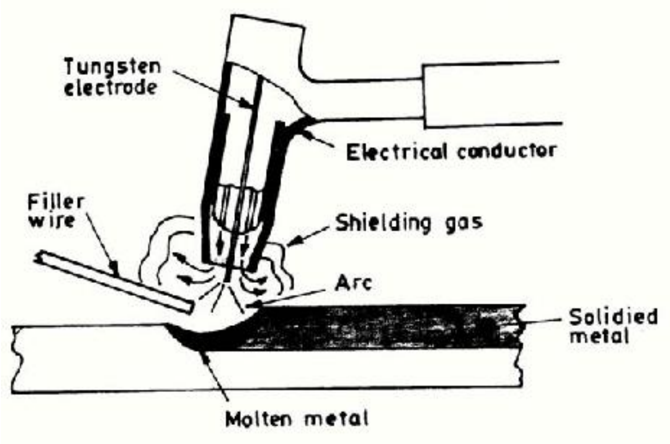

Fig. 4. Schematic of a Gas Tungsten Arc Welding Technique.

ADVANCED UNDERWATER WELDING TECHNIQUES:

1. FRICTION WELDING: Friction welding is a solid state welding procedure which produces coalescence of metal by the heat gained from mechanically-induced sliding motion between rubbing surfaces. The work pieces are held together in pressure. This process usually contains rotating of one part against another to produce frictional heat at the intersection. When a proper high temperature has been reached, rotational motion stops and extra pressure is applied and coalescence occurs. Fig. 5 shows the schematic of friction welding process [11, 4].

In the original procedure one part is held static and the other part is rotated by a motor which preserves abasically constant rotational speed. The two parts are taken in contact under pressure for a stated period with a particular pressure. Rotating power is disconnected from the rotating piece and the pressure is increased. When the revolving piece stops the weld is finalized. This operation can be correctly controlled when pressure, speed and time are closely controlled [11, 4].

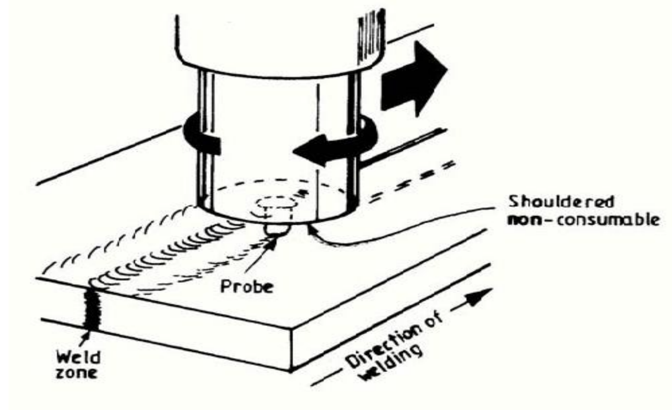

Fig. 5. Schematic of friction welding.

2. LASER WELDING: Laser as a source of monochromatic and coherent radiation, has a wide possibility of use in materials processing [10, 12]. Laser supportedwelding because of the sheer volume/proportion of work and development over the years, establishes the most important processes among the laser joining processes [13, 14].

The schematic of laser welding with a filler rod. Argon covering removes heat and avoids undue oxidation and displaces water. The comparative location of the laser focus determines the quality and structure of the weld. [15].

The attentive laser beam is made to irradiate the joint or work piece at the given level and speed. A shroud gas protects the weld pool from unnecessary oxidation and provides with the essential oxygen flow. Laser heating tempers the work piece or plate edges once the beam is withdrawn. In case of welding with filler, melting is principallyrestricted to the feeding wire tip while apart of the substrate being exposed melts to insure a smooth joint. In either case, the work piece rather than the beam travels at a rate conducive for welding and maintaining a least heat affected zone.

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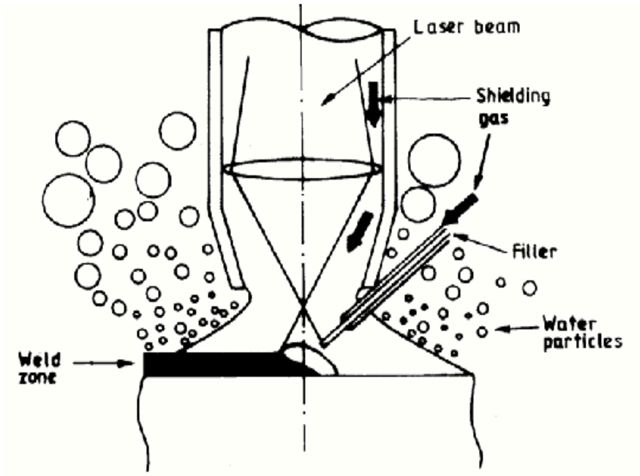

Fig. 6. Schematic of laser welding with a filler rod.

5. UNDERWATER WELDING FUTURE SCOPE:

Considerable research work has been made to improvethe performance and control plans for thevarious underwater welding methods over the last half century. However, there are still many limitations toovercome.

The main efforts on research and progress should be focused on the few topics:

1. Automation of the underwater welding and assessment of the welded structures.
2. Mechanized underwater welding for real usage of a very big floating arrangements.
3. Exploration of the probable of using a robot manipulator for underwater ultrasonic testing of welds in joints of complex structures.
4. Application of advanced welding technique likelaser welding, friction welding and understand the performance of metal after the welding and procedure optimization.
5. Development of new welding techniques and explore the chance of its application in underwater welding.
6. Generation of research data book on weld capacity of materials during underwater welding.
7. Wet MMAW is still being used for underwater maintenances, but the quality of wet welds is weak and are responsible for hydrogen cracking
8. Improvements of driverless Hyperbaric welding system is an even greater challenge calling for annexes improvementslike pipe preparation and aligning, automatic electrode and wire reel changing functions, using a robot arm installed. This is in testing stage in deep waters.
9. Friction and explosive welding are also to be tested in deep waters.

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