WELDING TECHNOLOGIES IN SHIPBUILDING INDUSTRY

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Abstract: Welding is very important in shipbuilding industry. In order to protect the ship structure, this process should be performed by the qualified welders and controlled efficiently by the quality control engineers and Classification Societies. All welders should have a certificate and the procedures should be prepared in the shipyards.

There are several kinds of welding methods. In shipbuilding, the most common technique is electrical arc welding. With the developed technology in all areas, welding technology is improving with each passing day. Today, ceramic welding is much started to be used especially on the shell platings and block connections. This provides easiness for the welders and shortens the production period.

The shipyards that intend to construct bigger vessels, build up production lines and use robots for welding in these lines. This increases quality, production capacity and decreases the planning times and production periods.

In the scope of new technologies on welding, the importance of welding and the benefits of new techniques to the ship building are investigated, evaluated and some suggestions are put forward.

Key words: Welding, Shipbuilding, Technology, Ships

INTRODUCTION

Welding is defined as "a jumping process that produces coalescence of materials by heating them to the welding temperature, with or without the application of pressure alone, and with or without the use of filler metal. In less technical language, a weld is made when separate pieces of material to be joined combine and form one piece when heated to a temperature high enough to cause softening or melting and flow together. Filler material is added when needed to form a completed weld in the joint.

Modern welding techniques are employed in the construction of numerous products. Ships, buildings, bridges are fabricated by welding processes. Welding is also used extensively in the manufacture of automobiles, farm equipment, home appliances, computer components, mining equipment and earth moving. Hundreds of products we use in our daily life are also joined together by some type of welding processes.

Before welding, ships were being constructed by using clinches. Nowadays, due to welding is more water resistant comparing to clinch system, ships are being constructed by welding. There are several types of welding processes grown in recent years. These processes differ greatly in the manner in which heat, pressure, or both heat and pressure are applied and in the type of equipment used.

TYPES OF WELDING USED IN SHIPBUILDING INDUSTRY

The most popular welding processes in shipbuilding industry are

- Shielded metal arc welding (SMAW), often called stick welding
- Submerged Arc Welding
- Gas metal arc welding (GMAW)
- Gas tungsten arc welding (GTAW)
- Oxyacetylene Welding (OAW)

Shielded Metal Arc Welding (SMAW)

This method is also known as Manual Metal Arc Welding or Stick Welding. An arc welding process in which coalescence of metals is produced by heat. The heat comes from an electric arc that is maintained between the tip of a covered electrode and the surface of the base metal in the joint being welded.
In the SMAW process, welding is done by setting up an electrical circuit using a welding machine to produce the electricity, a welding cable with an electrode holder to hold the electrode and a ground cable with a clamp to fasten to the work-piece to complete the circuit. The weld is made by touching the electrode to the work-piece closing the electrical circuit and causing the electrode to melt and form the weld.
The consumable electrode provides:
1) Gas protection to shield the arc and prevent atmospheric contamination of the molten filler metal.
2) Adding elements to change the mechanical properties and prevents excessive grain growth in the welded metal.
3) Enhance the mechanical properties and surface cleanliness of the weld metal.

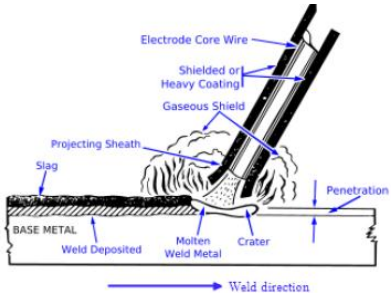


Fig. 1: Shielded Metal Arc Welding

This welding method is used for maintenance and repair industries, naval industry, pipelines, offshore platforms, construction of steel structures, weld carbon steel, low and high alloy steel, stainless steels, cast iron, aluminum, nickel and cooper alloys.

The advantages of this method are as follows;

- High quality welds can be made rapidly and with excellent uniformity.
- A variety of metal types and metal thicknesses can be joined with one machine.
- The equipment is cheap, versatile, simple and portable and welds can be done in any position.
- Suitable for out-of-position welding
- Adaptable to confined spaces and remote locations

The disadvantages of this method are as follows;

- Smokes prejudicial to health;
- Electrode type choice is crucial;
- Hydroscopic electrodes;
- Need to remove slag immediately due inclusions problems;
- Quality depends welder skill.

Submerged Arc Welding

Submerged arc welding is a method in which the heat required to fuse the metal is generated by an arc formed by an electric current passing between the welding wire and the workpiece. The tip of the welding wire, the arc, and the workpiece are covered by a layer of granulated mineral material known as submerged arc welding flux. There is no visible arc and no sparks, spatter or smoke.
An arc is maintained between the end of a bare wire electrode and the work. As the electrode is melted, it is fed into the arc by a set of rolls, driven by a governed motor. Wire feed speed is automatically controlled to equal the rate at which the electrode is melted, thus arc length is constant (similar to MIG/MAG - constant voltage). The arc operates under a layer of granular flux, hence submerged arc. Some of the flux melts to provide a protective blanket over the weld pool. The remainder of the flux is unaffected and can be recovered and re-used, provided it is dry and not contaminated. A semi-automatic version is available in which the operator has control of a welding gun that carries a small quantity of flux in a hopper.

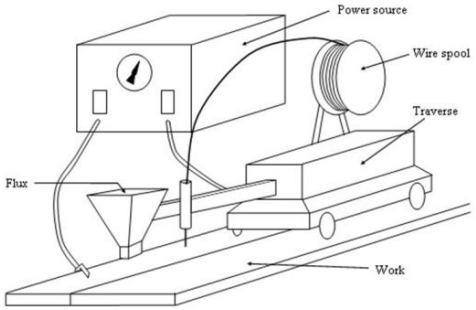


Fig. 2: Submerged Arc Welding

The advantages of this method are as follows;

- Lends itself to the production of consistently high quality welds with minimum operator skills.
- Minimum of welding fume and of arc visibility (radiation).
- Well suited to welding thick sections.
- Suitable for welding carbon, low alloy and alloy steels.
- Relatively high metal deposition rates

The disadvantages of this method are as follows;

- Flat or horizontal position welding only
- Care required to preserve correct electrode alignment, as electrode
- Tip and weld pool are underneath solid flux cover

This welding method is mainly used for welding of thick steel plates in heavy industry such as shipbuilding, large diameter pipes manufacturing, boilers manufacturing.

Gas Metal Arc Welding (GMAW)

Gas Metal Arc Welding (GMAW), by definition, is an arc welding process which produces the coalescence of metals by heating them with an arc between a continuously fed filler metal electrode and the work. The process uses shielding from an externally supplied gas to protect the molten weld pool.
Gas metal arc welding (GMAW), sometimes referred to by its subtypes metal inert gas (MIG) welding or metal active gas (MAG) welding, is a semi-automatic or automatic arc welding process in which a continuous and consumable wire electrode and a shielding gas are fed through a welding gun. Nowadays,with the development of electronic controlled welding machines, the process of welding cause has become very common.

GMAW can be done in three different ways:

- Semiautomatic Welding:Equipment controls only the electrode wire feeding. Movement of welding gun is controlled
  by hand. This may be called hand-held welding.
- Machine Welding: This method uses a gun that is connected to a manipulator of some kind (not hand-held). An operator has to constantly set and adjust controls that move the manipulator.
- Automatic Welding: This method uses equipment which welds without the constant adjusting of controls by a welder or operator.

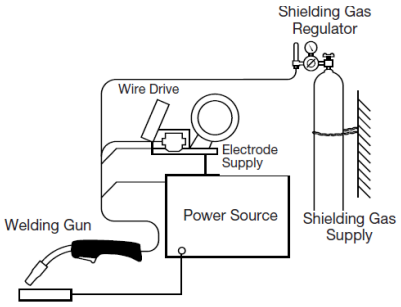


Fig. 3: Gas Metal Arc Welding

The advantages of GMAW are as follows;

- Welding can be done in all positions.
- No slag removal required.
- High weld metal deposition rate.
- Overall times for weld completion about 1/2 that of covered electrode.
- High welding speeds. Less distortion of the workpiece.
- High weld quality.
- Large gaps filled or bridged easily, making certain kinds of repair welding more efficient.
- No stub loss as with covered electrode

The disadvantages of GMAW are as follows;

- Expensive and complex equipment
- Setting up equipment can be time consuming and trick.

Gas tungsten arc welding (GTAW)

Gas Tungsten Arc Welding (GTAW), also known as tungsten inert gas (TIG) welding is a process that produces an electric arc maintained between a nonconsumable tungsten electrode and the part to be welded. The heat-affected zone, the molten metal and the tungsten electrode are all shielded from atmospheric contamination by a blanket of inert gas fed through the GTAW torch. Inert gas (usually Argon) is inactive or deficient in active chemical properties.

The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. Inert gases such as Argon and Helium do not chemically react or combine with other gases. They pose no odor and are transparent, permitting the the welder maximum visibility of the arc. In some instances Hydrogen gas may be added to enhance travel speeds.

GTAW is used to weld stainless steel, nickel alloys such as MonelR and InconelR, titanium, aluminum, magnesium, copper, brass, bronze and even gold. GTAW can also weld dissimilar metals to one another such as copper to brass and stainless to mild steel.

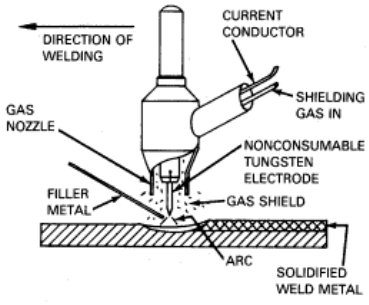


Fig. 4: Gas Tungsten Arc Welding

The advantages of GTAW are as follows;

- Applicable to a very wide range of materials.
- Especially good for welding thin sections and delicate workpieces
- Capable of producing welds of high quality and appearance
- No Slag - No requirement for flux with this process; therefore no slag to obscure the welder's vision of the molten
- weld pool
- No Sparks or Spatter - No transfer of metal across the arc. No molten globules of spatter to contend with and no
- sparks produced if material being welded is free of contaminants
- Few fumes are produced. However, the base metals being welded may contain coatings or elements such as lead, zinc, copper,nickel, etc. that may produce hazardous fumes.
- Good for welding thin material

The disadvantages of GTAW are as follows;

- Generally restricted to flat or horizontal welding
- Hand-eye coordination is a required skill
- Brighter UV rays than other processes
- Equipment costs can be higher than other processes

Oxyacetylene Welding (OAW)

The oxyacetylene welding process uses a combination of oxygen and acetylene gas to provide a high temperature flame.
When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3,200 deg.C. The chemical action of the oxyacetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene. Oxygen and Acetylene are stored under pressure in steel cylinders

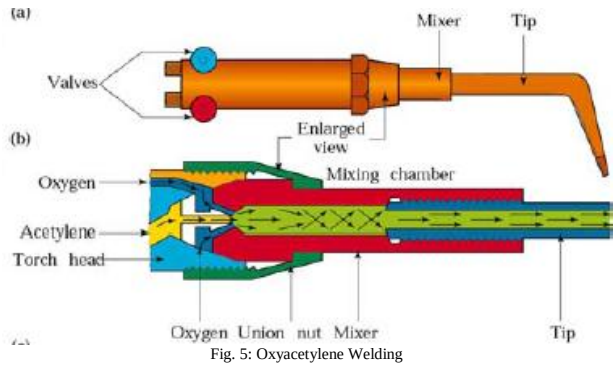


Fig. 5: Oxyacetylene Welding

The advantages of OAW are as follows;

- It's easy to learn.
- The equipment is cheaper than most other types of welding rigs
- The equipment is more portable than most other types of welding rigs
- OA equipment can also be used to "flame-cut" large pieces of material.

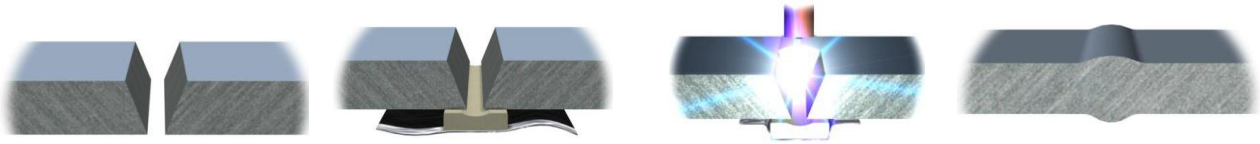
The disadvantages of OAW are as follows;

- OA weld lines are much rougher in appearance than other kinds of welds, and require more finishing if neatness is required.
- OA welds have large heat affected zones (areas around the weld line that have had their mechanical properties adversely affected by the welding process)
- OAW is a manual process in which the welder must personally control the the torch movement and filler rod application

NEW WELDING TECHNOLOGIES IN SHIPBUILDING INDUSTRY

Ceramic Welding

In recent years, especially for the shell plate of the vessels, ceramic welding is being started to be used as a welding technique. The welding is being done by using **c**eramic weld backings. X-ray quality, full penetration welds from one side and in a single pass can be achieved with this method. On the other hand, finished high quality weld and savings of labor, materials and time are also been achieved. Weld backings can be used to compensate for poor fit-ups, and is valuable when welding conditions are not ideal or where the back side of a weld joint is inaccessable. In ceramic welding firstly welder should do root opening. Then backing is applied on the material and welding starts. After finishing welding process, ceramic backing should be removed.



(1)Root opening (2)Application of Ceramic Backing (3)Welding (4)Finishing

Fig. 6: Stages of Ceramic Welding

This method is applied for welding of the shell plates of the ships. High quality, full penetration, time and economical savings can be achieved with this method. Therefore the delivery times of the projects are being shortened.

Robotic Welding

Robots are used in a wide range of industrial applications. The earliest applications were in materials handling, spot welding, and spray painting. Although the automotive industry is the major user of robotic welding, the usage of robotic welding is also improving in the shipbuilding industry day by day. The two basic welding types in shipbuilding are spot welding and arc welding.

Arc welding robot is one of the most common functions in industry today. During this process, electricity jumps from an electrode guided through the seam, to the metal product. This electric arc generates intense heat, enough to melt the metal at the joint. For robotic arc welding system, a much more controller is also required.

Automated welding has begun improving upon manual welding in the industry due to increasing speed, quality and throughput. The shipbuilding industry is suitable for robotic welding (Karagoz, 2001). Robot welding automation is much safer and more cost-effective. Welding can be done completely at the unreachable areas. Due to it is an automation, the faults regarding human factors willnot be come across with this method.

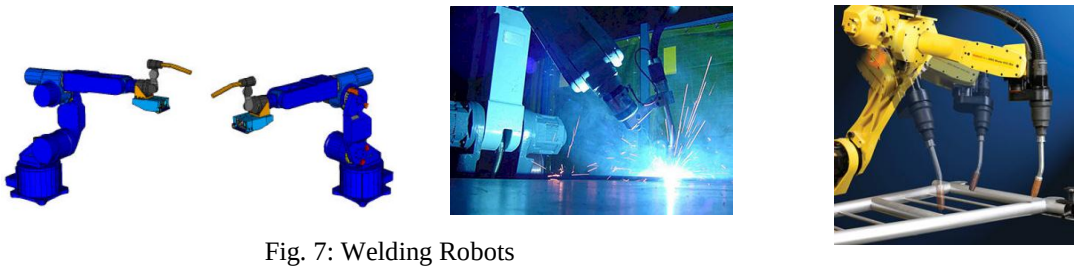


Fig. 7: Welding Robots

CONCLUSION

The shipbuilding industry has begun to see changes in demand for its expertise. One of the important factors was the new legislation regarding "double hull" standards for safety against spillage in the event of

a collision. This prohibits port entry for crude oil carrying vessels which do not comply to the double hull standards. Many older vessels still have a single thickness of steel between the sea and the oil storage. The new legislation has forced ship owners to invest in the new double hull technology. Another reason for the rise in shipyard activity is that much of the world's ageing shipping fleet is reaching the point where vessels can no longer be practically or economically maintained as sea-worthy. A relative stagnation in demand for new ships is being revived by the requirement for replacement vessels (Sorenti, 1997).

Competition for this increased business is global and there is a demand for suppliers to deliver high-quality products, made quickly and at the lowest possible cost. Typical of the solution to these demands is to introduce automation. Robotic technology meets quality, cost and delivery requirements and also offers flexibility in welding. Robot technology gives the means by which a shipyard can produce vessels for its customers that meet their specific needs in a cost-effective manner (i.e. profitable) and more quickly (Sorenti, 1997). The delivery times of the vessels are also shortened by this technique.

Potential safety hazards associated with arc welding include arc radiation, air contamination, electrical shock, fire and explosion, compressed gases, and other hazards. Robots were originally designed to perform the job functions of a human. Robots can replace humans in the performance of dangerous jobs and are considered beneficial for preventing industrial accidents. Ceramic welding is also important due to it lets one side welding and shortens the production period.

The stability of the welding process is very sensitive to the main welding parameters such as current, voltage, welding speed, shielding gas and arc length. A small change in the distance between the welding torch and the component being welded or a fault of a welder may produce a considerable variation in the current and in the voltage. However, in robotic welding, the welding defects sourced by the welder can be prevented.

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