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ROLE OF SHIELDED METAL ARC WELDING CONSUMABLES ON PIPE WELD JOINT

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***Abstract*— Major Pipelines across the world transport large quantities of crude oil, natural gas, and petroleum products. These pipelines play an important role in modern societies and are crucial in providing needed fuels for sustaining vital functions such as power generation, heating supply and transportation. If the pipeline carrying these chemicals burst/leaks it results huge loss of life, money, time and environmental disaster. Causes of these pipelines failure are internal weld discontinuities such as lack of penetration, lack of fusion, gas porosities, oxides, other inclusions and cracks etc. Pipeline girth welding under field conditions has always faced severe demands with regard to quality and cost. Consequently, the past years has seen the development of a number of methods such as various manual, as well as partly or fully mechanized processes or a combination of various welding processes. Intermixing of weld fluxes, change the chemical compositions of electrodes etc are applied for purpose of high weld quality, high productivity, strength and economy in pipeline welding field. Improvement in weld quality has been a challenge as new processes were introduced and existing processes were stretched to their limit. Competion in the field of welding is increasing day by day. Fabricators look for welding process which is cost effect and is able to give higher deposition rate better penetration and robust structures. The objective of the present study is to investigate the roll of intermixed weld metal of shielded metal arc welding consumable on weld properties**.

I. INTRODUCTION

Welding is widely used by metalworkers in the fabrication, maintenance, and repair of parts and structures. There are many methods for joining metals, welding is one of the most convenient and rapid method available for joining metals (Rozza, 2012). There are numerous advantages of welding process as compared to other fabrication techniques, such as excellent mechanical properties of the welded joints, air and water tightness and good joining efficiency.

However, welding creates various problems such as distortion, slag inclusions, undercuts, residual stresses, lack of penetration and misalignment etc. in welded structures, which reduce the fatigue crack propagation life of the structures (Alam, 2005). Welding is the process of joining two steel pieces together by heating them to the point in which molten filler material mixes with the base metal to form one continuous piece. The process of welding is quite complex and the strength of weldment is highly dependent on metallurgy, welding procedure and the skill of the welder (Quimby, 2009). Welding is used in different environments in air, underwater and space. It is also applicable in different areas such as construction, petroleum industries, aircraft industries, transportation, machine manufacturing, household manufacturing, repair and maintenance (Kah and Martikainen, 2012).

There are many arc welding processes like shielded metal arc welding, gas metal arc welding and submerged arc welding processes etc. which are used in welding field. However, shielded metal arc welding is one of the world's most popular welding processes. It dominates other welding processes in the maintenance and repair work and continues to be used extensively in the construction of steel structures and industrial fabrication due to its simplicity of welding equipment, its reliability, versatility and adaptability to indoor and outdoor uses (Moarrefzadeh, 2012). According to global statistics, in recent decades above 50% of whole metallic products are combined with one of the welding processes. These products vary from bridges, offshore facilities, pipelines, pressure vessels, ships, aircrafts, and many other applications in oil and gas, petrochemical and power generation equipments (Marefat et al., 2001).

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II. History of Shielded Metal Arc Welding Process (SMAW)

Welding is being used for more than one century in the world. In the early 19th century electricity was developed and at the same time, welding technology was remarkably changed by introduction of electric arc welding (Thwe et al., 2010). In 1810, Sir Humphrey Davy created a stable electric arc between two terminals, the basis for what is now known as arc welding. At 'The First World Electrical Exhibition' in Paris in 1881, the Russian, Nikolai Benardos, presented a method for arc welding, in which he stroked an arc between a carbon electrode and the work piece (Ball and Carter, 2001). In 1889 Russian, N. G Slavinoff and an American, C. L. Coffin replaced carbon electrode by metal electrode (Lincoln electric, 1994), around 1900, A.P. Strohmenger released a coated metal electrode in Britain, which gave a more arc stability in welding (Cary and Helzerl, 2005). In the 1950 manufacturers introduced iron powder into the flux coating to increase the welding speed. In 1938 K.K. Madsen described an automated variation of shielded metal arc welding process now known as gravity welding. It briefly gained popularity in the 1960s after receiving publicity for its use in Japanese shipyards, though today its applications are limited (Moarrefzadeh, 2012). As the 20th century progressed, arc welding has largely demand for industrial applications because development of metal coverings for the electrode that stabilize the arc and shield the base material from impurities continued to be developed. Later with covering electrode shielded metal arc welding process become popular, which has the wide application in the industrial work, structural work pipeline field, repair work, military equipment service due to its the simplicity of equipment involved, its portability, adaptability to indoor and outdoor uses (Kazakov,1985).

I. Shielded Metal Arc Welding Process (SMAW)

The shielded metal arc welding, also known as manual metal arc (MMA) welding, which uses a consumable electrode coated in flux to lay 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 metal to be joined. As the weld is laid the flux coating of the electrode disintegrates and providing shielding gas and a layer of slag to protect the weld area from atmospheric contamination (Moarrefzadeh, 2012).

The shielded metal arc welding process is one of the oldest and most widely used methods of joining metals by welding. In shielded metal arc welding currents typically used in range between 30 to 300 A and voltages from 15 to 45 V depending on the metals being welded, electrode types and length and depth of weld penetration required (Cronje, 2005). Fig.1.1 shows the shielded metal arc welding process.

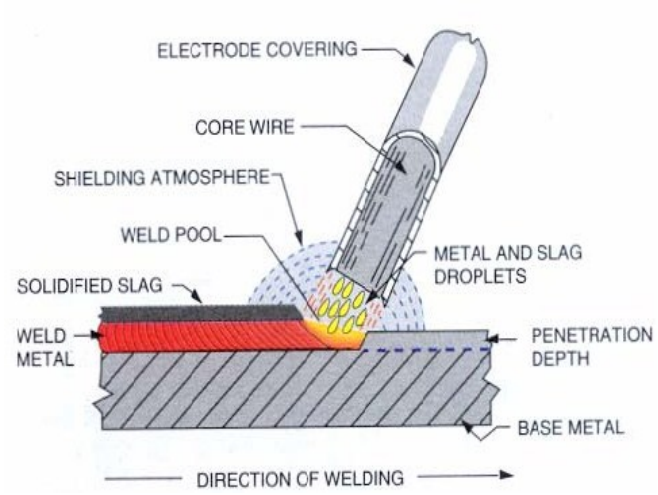

Fig.1.1 Shielded Metal Arc Welding Process (Genculu, 2011)

Equipment and Power Supply

The shielded metal arc welding equipment typically consists of a constant current welding power supply and an electrode with an electrode holder, a ground clamp, welding cables. The shielded metal arc welding process use different types of polarity which depends primarily upon the electrode being used and the desired properties of the weld. Direct current with a negatively charged electrode (DCEN) causes heat to build up on the electrode, increasing the electrode melting rate and decreasing the depth of the weld. Reversing the polarity so that the electrode is positively charged (DCEP) and the work piece is negatively charged increases the weld penetration. The shielded metal arc welding process consists of a step-down transformer to reduce the voltage and increase the current and for direct current models a rectifier used which converts alternating current into direct current (Jeffus , 1999).

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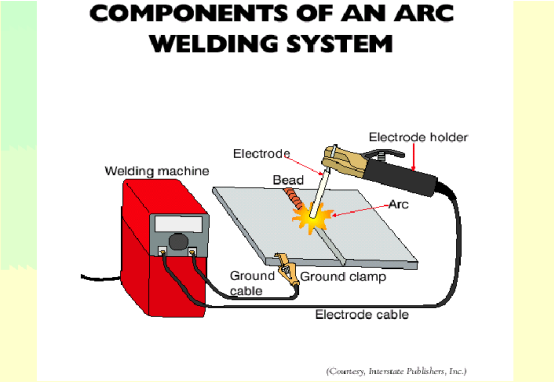

Fig.1.2 Set up Shielded Metal Arc Welding process

II. The Main characteristics of Shielded Metal Arc Welding Process (Rozza, 2012 and Halim, 2010)

- The equipment is simple, portable and inexpensive.
- Wide variety of metals, welding positions and electrodes are applicable.
- Suitable for indoor and outdoor applications.
- It can be used in area of limited access.
- The process is suitable for most of the commonly used alloys and metals.
- The process is less sensitive to draft and wind than gas shielded arc welding.
- The shielded metal arc welding electrodes provide a fast freeze weld slag that can assist in the control of the weld.
- In contrast to the alternate welding processes, the shielded metal arc welding process requires minimum weld process expertise.
- The electrode manufacturers can formulate the shielded metal arc welding electrode flux to meet specific chemistry and mechanical requirements.

III. Shielded Metal Arc Welding Electrodes

The shielded metal arc welding electrodes are coated metal in mixture of flux, which gives off gases as it decomposes to prevent weld contamination, introduces deoxidizers to purify the weld and provides slag layer to protect weld surface, improves the arc stability, and provides alloying elements to improve the weld quality (Jeffus, 1999). The types of welding electrodes used would decide the weld properties such as strength, ductility and corrosion resistance.

The type of electrodes to be used for a particular job depends upon the type of metal being welded, amount of material to be added, position of the work piece and desired weld properties (Sanths and Satish, 2010). The shielded metal arc uses a wide variety of coated electrodes that are classified by the strength level of the undiluted weld metal and types of coating. These different coatings vary the penetration of the electrode, welding positions and the amount of hydrogen in the gas shield (Wallace, 1979).

Basic electrodes

Basic electrodes also known as low hydrogen electrode consist the coating of limestone ($CaCo_3$), Fluorspar (CaF_2) and clay asbestos. Mechanical properties including ductility and notch toughness of these electrodes are superior to other type electrodes. Deposition of these electrodes has high resistance to hot and cold cracking, which is very good for welding higher strength steel. These electrodes give medium speed of deposition, moderate penetration and good bead appearance. Types of basic electrode are E7018, E7016, and E7028 etc (Radhakrishnan, 2007).

E7018 Electrodes

These electrodes have a smooth, low spatter, and medium arc penetration. These electrodes are all position use AC or DC polarity characterize and with addition of iron powder these electrodes gives better welding speed and recovery. Electrode E7018 is suitable for medium to thick base metals due to excellent crack resistance. Electrode E7018 is also required to weld have a minimum specified level of Charpy V notch impact energy and welds that require high toughness (Wallace, 1979).

E7016 Electrodes

These electrodes are chemically basic and low-hydrogen electrodes. These electrodes have a heavy, friable, and easy removable slag, arc immoderately penetrating and convex weld face. In addition to their use on mild steel, E7016 electrodes are also used for 490MPa high strength steel and suitable for medium to thick base metals due to superior crack resistibility (O'Con, 2000).

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Cellulosic Electrodes

These electrodes contain over 30 per cent organic material coverings such as alpha flock, wood flour or others cellulose. These electrodes develop a strong plasma jet which gives excellent penetration. These are all position electrode used with only direct current polarity (Radhakrishnan, 2007). Because of the organic material and moisture content, these electrodes have a very strong arc force but at the same time the weld metal freezes very quickly. This method of welding is fast and economical for pipelines which welded with the progression vertically downward. Impact toughness properties which are very good may be met with modern cellulosic electrodes (Lincoln Electric, 1999). Cellulosic coated shielded metal arc welding electrodes E6011, E6010 are traditionally used for deposition of pipeline girth weld and are capable of high deposition rates of welding (Ramirez and Johnson, 2010).

E6010 Electrodes

These electrodes suitable for low carbon steels because of their deep penetration characteristic, minimal slag production and give weld quality through rust, oil, paint or dirt. These electrodes are recommended for all welding positions, particularly with multiple pass applications in the vertical and overhead welding positions (Genculu, 2011)
Rutile coated electrodes

These electrodes contains 50 per cent titania as mineral rutile or limonite. These electrodes give good arc stability and low operating voltage and can readily be used with alternating current. Weld metal has good appearance, medium penetration, and high deposition rate, good mechanical and radiographic soundness. (Radhakrishnan, 2007). Rutile electrodes are good slag former and by varying amount of flux agent, viscosity and surface tension can be adjusted to give electrode of excellent welding characteristics in all positions (Khan, 2012).

E6013 electrodes

It is the best, all-round, rutile electrode, relatively insensitive to rust or other surface impurities. It deposits smooth and good finish weld beads in all positions, including vertical down, and the slag is easy to remove. The stable arc, even at low welding currents, makes the electrode very suitable for sheet metal welding (welding hand book, ESAB 8th Ed.).

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Shielded metal arc welding (SMAW) is the simplest, least expensive, and mostly widely used arc welding process (Figure 2). It is often referred to as â€˜stick weldingâ€™ or manual metal arc welding. This process produces coalescence of metals by heating them with an arc between a covered metal electrode and the base metal work piece.Â Welding involves striking an arc between the electrode and the workpiece, with the heat of the arc melting the electrode coating which forms a protective slag. The weld metal is produced both by the core electrode wire and iron powder in the coating. The layer of slag on top of the joint needs to be removed after welding. The equipment required is simple, as shown in Figure 9.1, which means that the method is straightforward to use. Three different consumables namely (i) austenitic stainless steel, (ii) low hydrogen ferritic steel, and (iii) high nickel steel have been used to fabricate the joints by shielded metal arc (SMAW) welding process. The joints fabricated using low hydrogen ferritic steel electrodes showed superior fatigue properties than other joints. Keywords. austenitic stainless steel fatigue properties high nickel steel low hydrogen ferritic steel quenched and tempered steel shielded metal arc welding process. This is a preview of subscription content, log in to check access. Notes.