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Electro Slag Strip Cladding Process

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Abstract: *The Technological advancements have driven up temperature and pressure serviced in the petroleum, chemical, pulp, and environmental protection. Industries have increased the possibility of severe corrosion and wear in process pressure vessels. The industries must upgrade the corrosion and wear performance of these main important parts .Economic features as a rule will not allow fabricating components from solid high alloyed materials. As a result it is essential to surface non-alloyed or low alloy base materials with high-alloy cladding. The submerged arc welding(SAW) and electroslag welding (ESW) process are appropriate for applying welded deposits over large surface areas by means of strip electrodes .Both processes are using a granular flux material. A strip electrode, fed continuously, is liquefied and fused to the substrate. In contrast with other processes it is very effective in spite of the same equipments used but due to the wide strip used it procures a magnetic flow effect within to rectify it a magnetic steering device is exercised. After the welding to examine the defects NDT's are carried upon it.*
Keywords: *cladding, electro slag welding, weld overlay.*

I. Introduction

The Welding is "a material joining process used in making welds," and a weld is "localized coalescence of metals or non-metals produced either by heating the material to a suitable temperature with or without the application of pressure and with or without the use of filler metal. Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the workpieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the workpieces to form a bond between them, without melting the workpieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space. Welding is a potentially hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used for centuries to join iron and steel by heating and hammering. Arc welding and oxyfuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after. Welding technology advanced quickly during the early 20th century as World War I and World War II drove the demand for reliable and inexpensive joining methods. Following the wars, several modern welding techniques were developed, including manual methods like shielded metal arc welding, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as gas metal arc welding ,submerged arc welding, flux-cored arc welding and electroslag welding.

Electro slag strip cladding is an advancement of submerged arc strip cladding, which has speedily established itself as a reliable high deposition rate procedure. ESW is an arc less technique using Joules Effect to liquefy the strip material. The heating is an outcome of current flowing through the strip electrode and a relatively shallow layer of liquid electro conductive slag as shown in figure 1. The penetration is lesser for ESW than for SAW since the molten slag pool is used to liquefy the strip and some of the flux material rather than as an arc between the strip electrode and the flux material. As a rule of thumb, electro slag strip surfacing decreases dilution by up to 50% in contrast with submerged arc strip surfacing for the same heat input with a significantly higher deposition rate.

II. METHODOLOGY

2.1 Cladding

Cladding is the bonding together of dissimilar metals. In many cases, corrosion resistance is required only on the surface of the material and carbon or alloy steel can be clad with a more corrosion resistant alloy. Compared to carbon and alloy steels, all corrosion resistant alloys are expensive. Cladding can save up to 80% of the cost of using solid alloy. Cladding of carbon or low alloy steel can be accomplished in several ways including roll bonding, explosive bonding, weld overlaying and wallpapering. Clad materials are widely used in the chemical process, offshore oil production, oil refining and electric power generation industries. The use of clad steel is not new. Corrosion resistant alloy clad steel has been available for over 40 years. Almost any corrosion resistant stainless steel or nickel alloy can be bonded to steel. The steel can be clad on both sides or on one side only. Hence Strip cladding is a fusion welding technique used to:

- Deposit a strip of weld metal on to a component to achieve the desired dimensions or properties.
- Weld two dissimilar surfaces.
- Providing a wear or corrosion resistant surface.

Weld overlaying technique of cladding is commonly used to clad the surfaces of fabricated steel structures. The actual weld overlay process used depends on many factors including access, welding position, the alloy applied, and economics. In some alloy combinations, dilution of the weld overlay material by the steel requires that more than one weld pass is required. Post weld heat treating to temper the backing steel may be required in some cases. Strip cladding can be a very economical way to provide excellent corrosion resistance for steel structures. Both stainless steels and the more corrosion resistant nickel alloys can be economically applied to steel by Strip cladding . Strip cladding has also been widely used to line interiors of stacks and ducting for flue gas desulfurization units in fossil fuel power plants. One major benefit of weld overlaying is that they can be used to repair or modify existing steel structures.

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Applications of Strip Cladding:

- The process is usually confined to relatively large and thick components which need to be manipulated to enable welding to be carried out in the flat position.
- The technique finds its widest application in the oil, gas and fertilizer related industries and in the nuclear power generation field.
- Generally used for surfacing the internal surfaces of pressure vessels and large diameter pipe and in the reclamation of steel mill rolls.

2.2.1 Submerged arc Strip Cladding (SASC)

This well-known SAW method has been widely used with strip electrodes since the mid-1960s. There is no fundamental difference between submerged arc welding and cladding. The welding wire is merely replaced with the cladding strip. The equipment is the same, except the head must be adapted to guide the strip. The principle is the same: the energy to melt the strip and the base metal is supplied by the electric arc struck between them. On melting, the agglomerated flux protect the liquid metal and where applicable enriches it with alloying elements. In the SAW process the strip is feed down through the contact jaws at the same time as the flux is feed down on both sides of the strip. The strip generates an arc between itself and the base material, the arc is not uniform and static, it wanders along the width of the strip but is all time sub merged under the molten slag. . It uses a strip, normally with a thickness of 0.5 mm and the width normally varies from 30 to 120 mm, but other width´s are available for special applications.

2.2.2 Electro Slag Strip Cladding (ESSC)

The electro slag welding process was patented in USA in February 1940 and is a process that can weld material thicknesses from 25 up to 300 mm . It works in the vertical or very close to vertical position, it is in use for hull welding of ships, it is used for welding heavy wall thickness vessels of different kinds and many more applications. In the early 70’s the electro slag concept was adjusted to fit the cladding process with a metal strip. I can be said to be a development of SAW strip cladding which has quickly established itself as a reliable high deposition process.

- Technological developments have driven temperatures and pressures used in the petroleum, chemical, pulp, and paper, and environmental protection industries, and increased the likelihood of serve corrosion and wear in the process pressure vessels. The industries must improve the corrosion and wear performance of these major components.
- Economic factors as rule will not permit fabricating components from solid high alloyed material. As a consequence, it is necessary to surface non-alloyed or low alloy base material with high alloy cladding. The electro slag welding (ESSC)
- process is suitable for applying weld deposits over large surface areas using strip electrodes
  Both the processes use a granular flux material. A strip electrode, fed continuously, is melted and fused to the substrate.
- In width, which are melted by applying current of appropriate strength; while using an auxiliary magnetic field, which improves the geometry of the beed.

III. MANUFACTURING PROCESS

3.1 Characteristics of ESSC

- Electro slag strip cladding is the modified version of submerged arc strip cladding process.
- The heat generation in the case of ESSC is due to the current flowing through the electro conductive slag.
- Molten weld pool will be visible during welding.
- Radiation only in the visible and infrared spectrum. No ultraviolet radiation because of the absence of the arc.
- Flux fed from front side only.
- Automatic removal of the slag crust.
- Very regular, finely ripped bead, without any slag adherence.

3.2 Process Principle

- In electro slag strip cladding the heat required to melt the base metal and the strip electrode is not generated by an electric arc; the Joule effect is utilized instead.
- The current flows through the strip and into a layer of electrically conductive slag; the resistance of this material generates the heat and keeps the welding process going (slag temperature approximately 2300° C)
- In ESSC process, the arc must be extinguished once it has been ignited and the current flow through the slag. As a consequence, the following must apply:
  RA => infinity ; IA = 0
  Where RA is the resistance in the arc and IA is the current in the arc.
- If these conditions are to be satisfactory, the electrical resistance for the slag must be less than that for the arc.
- This presupposes that the electrical conductivity of the liquid slag created during the ignition process will rise with the rising temperature (or, the specific resistance is dependent on the temperature and is going down with rising temperature).
- If the process is to be stable, the thickness of the layer and the surface of the slag pool must be kept constant. This is effected by continuously melting flux, which is fed at one side only.
- To retard the interface resistance; it is important that the strip electrode has a sufficient depth in the slag pool.
- In ESSC process the resistance heating of the slag melts the fillet metal and the base material. Electroslag surfacing is thus classified as a resistance welding technique.

3.3 Welding Parameters

Attitude of the electrode: The electrode is usually located at right angles to the work piece (vertical) and at right angles to the axis of its movement (relative to the work piece). Rotating the electrode around its longitudinal axis is acceptable to a certain extent, but this will produce a narrower, thicker bead.

Spacing of current contact: The distance from the lower edge of the contact jaws to the surface to the work piece is generally about 30 mm. Flux depth: The depth of the flux determines the width of the slag layer obtained. If the flux is not deep enough, the slag pool will be too shallow, causing improved arcing of the strip. If the flux is too deep, the flux will liquefy only in the middle. The slag pool would be cooled by the flux lying on it, causing deterioration in electrical conductivity. At this point, again, the end result will be increased arcing. Normal depth should be 30 mm. Current density: Because of the absence of an arc, the penetration in the ESW procedure is very shallow; this represents that there will be slight mixing of the filler metal with the melted parent material. It is possible, in evaluation with the submerged arc welding (SAW), to use far higher power levels. For thin layers a normal current density of about 33 A/mm2 , 43 A/mm2 for thicker layers. For strip type electrodes calculating 60*0.5 mm this will cause 1000 or 1250 A, respectively. This increased current level will cause penetration, though the here is still at the lower limit of what would be predictable in SAW surfacing using a strip type electrode. Power levels exceeding about 1000 A for 60*0.5 mm strip electrode would require very high welding speed to attain thin layers (below 0.15 in - mm) and the strip electrode would break up either wholly or partially from the front edge of the liquid slag. This would outcome in the increased arcing. When using wider electrode strips -120*0.5 mm, for instance—current of > 2500 A may be necessary.

Welding voltage: The welding voltage influences the specific resistance of the liquid slag and will decide how far the strip electrode is to be submerged in the slag pool. Inadequate immersion in the weld pool will affect the process and turn out the process into unstable one. The welding voltage must be lowered as current ascends. A range of 24 to 26 V when operating at 1250 A, or 22 to 24 V for 2500 A, is normal. The precise value will depend on the properties of the flux and the dimensions of the strip. Arcing may be experienced if the voltage is too high and the electrode is not immersed far enough in the slag pool. The welding process will turn out to be unstable with increased arcing.

Welding travel sound: The travel speed will depend on the desired thickness of the surfacing layer. The greater current density which can be applied along the high melting rate that can be achieved, make it possible to attain higher welding speeds than would be achieved, make it possible to attain higher welding speeds than would be possible with SAW surfacing. A layer of 4mm, is often specified encountered in processing equipment, the welding speed will be between 16 and 20 cm/min. The extent to which the thickness of the cladding can be reduced by increasing the welding speed is limited since, at sped exceeding 20 cm/min, the strip electrode will tend to “run away from “the slag pool. For this reason, lower current densities are used to apply thin layers about 3.5 mm. Not only can the surfacing depth be regulated by adjusting the welding speed; the degree of dilution by the substrate material can also be influenced for two different current levels, in comparison with submerged arc welding.

Supplementary magnetic fields: With the auxiliary steering magnets switched on, the width of the bead will increase by1 to 2 mm; the depth is reduced accordingly since the filler material will be pulled toward the outer edges. With suitable adjustment of the magnetic fields at the north and south poles of the magnets will make it possible to affect the shape of the bead. The South Pole is always place at the left side in the welding direction. Using additional magnetic fields for steering purposes are not required for 60*0.5 mm electrodes. The geometry of the bead may be unfavorably influenced by welding near the ground connection. The two yokes of the magnet are placed 15 mm to the sides of the electrode strip and 1.5 mm above the surface of the base material. A strong magnetic field at the South Pole (3A: 1A) will pull the liquid filler material against the natural magnetic blow direction, which would be to the left when looking at the rear of the electrode. A strong magnetic field at the North Pole (2 A: 1A) would pull in the opposite direction. This is how we can neutralize the natural magnetic blow effect by accurate correction of the two auxiliary magnetic fields.

IV. ADVANTAGES & APPLICATION

4.1 Advantages of ESSC

Conventional welding procedure being used for overlay such as SMAW, FCAW, SAW, and SASC are all arc welding procedures. This procedure results in high dilution because of concentrated arc forces, which tend to produce a digging action on the parent metal, which is in molten form. This eventually affects the chemistry of the overlay, making it making to deposit more number of layers to attain the desired chemistry's. This problem is not found in ESSC welding procedure. By controlling various interaction parameters of ESSC, dilution can be limited to 7-10%. This gives ESSC a huge advantage over the other overlay procedure in productivity. The further main advantages of ESSC are:

- Lower penetration level (about 0.5mm)
- Lower defect and rework possibilities.
- Better bead characteristics.
- Problem free operation.
- Higher Overall Productivity.
- Simple equipment (similar to SAW equipment)
- Lesser number of layers to attain desired chemistry.

4.2 Applications of ESSC

The process is usually confined to relatively large and thick components which need to be manipulated to enable welding to be carried out in the flat position. The technique finds its widest application in the oil, gas and fertilizer related industries and in the nuclear power generation field. Generally used for surfacing the internal surfaces of pressure vessels and large diameter pipe and in the reclamation of steel mill rolls. Heavy plates, forgings and castings can be butt welded.

Where plates or castings of consistent width are involved or if they taper at a consistent rate, electroslag welding has virtually replaced thermit welding, being much simpler.

Subsequent alloys can be welded:

- Low carbon and medium carbon steels.
- High strength structural steels
- High strength alloy steels such as stainless steel and nickel alloys.
- Longitudinal stiffeners of the upper deck of ships.
- Longitudinal welds in cylindrical pressure vessels.
- Shells for blast furnaces and basic oxygen furnaces.

V. Conclusion

Electro slag strip cladding is the most widely used welding procedure in the industry. Electro slag strip cladding is an advancement of submerged arc strip cladding, which has rapidly established itself as a reliable high deposition rate procedure. In ESSC for each application, the efficiency and quality of weld can be controlled by controlling the process variables: attitude of electrode, spacing of current contact, flux depth, current density, welding voltage, welding travel sound, supplementary magnetic fields. There are certain safety measures which are to be taken care of before and during welding. Auto step over technique saves 10 hours of time equivalent to one working shift. It also enhances superior weld quality and very less amount of surface grinding. Thus increasing the productivity of overall activity with better efficiency.

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