Flange Internal Surface Weld Overlay Automation

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Abstract - *The project is directed towards enhancement in the manufacturing process and approaches towards efficient ways of production in process equipment required for highly corrosive environment application. Many industrial processes cause damage to inner surface of piping, vessels and fittings by the continuous assault of corrosive and abrasive media. Components get corroded due to contact with aggressive substances and friction generated. These phenomenon is often boosted by elevated process temperature and pressure. Hence, in order to maximize the operational availability & performance by avoiding these surface deteriorations, pressure vessels and high pressure heat exchangers used for chemical, petrochemical and refineries are generally fabricated from resistant low alloy steel .. To tackle such type of issues internal surfaces of these equipments are given a surface treatment(cladding) using austenitic stainless steel or exotic materials in order to prevent the parent material from aggressive corrosion effects of the process fluids. Vessel internal surfaces, process nozzles and other components are normally cladded, bonded or weld overlaid using various processes like flux cored arc welding process, Explosion bonding, Strip cladding etc.*

For nozzle flange internal surface, weld overlay process is used. This process of weld overlay is carried out manually by hand, which requires highly skilled manpower. Also the process being very time consuming demands excessive man hours and cost. Being manual operations, quality related issues are more likely to occur. Hence, we believe & aim to design, fabricate & engineer an automated PLC programmed mechanism, which would be a more user friendly and helpful for fabricator. The project aims to design an automated mechanism to create sound weld which will help customer in increasing the durability & life of the product in the service. FCAW being one of the best techniques prevailing, it has better controllability, higher deposition rates and lot of material flexibility than most of the other techniques. Moreover it is the best available method in terms of budget & application. The mechanism would be designed, manufactured and tested to serve its purpose completely.

Key Words: FCAW: Flux core arc welding, PLC: Programmable Logic Controller, PTA: Plasma Transferred Arc, GMAW: Gas metal arc welding, MCB: Miniature circuit boards.

1. INTRODUCTION

The welding process where one or more metals with specific characteristics is applied to a base metal to enhance desirable properties is called Weld overlay. It is performed to protect the base material from wear or corrosive environments. The weld overlay layer is added as a cost-effective means to increase the base material's corrosion-resistance or mechanical properties. Welding automation is very precise, move smoothly and at considerable speed through a programmed path. Being computer-based, it can be programmed and have sensors to follow the seam and to apply corrections to the welding parameters. Successful application of mechanized /automated systems can offer a number of advantages. Increased productivity, coherent weld quality, better welding production rates, reduced variable welding costs and lower costs. Constraints include higher capital investment than for manual welding components, accurate part location and more sophisticated arc movement and control devices.

1.1 Objectives

Currently the flange internal surface weld overlay is done manually. This method includes requirement of high level of welder skills and dependability on welder also. Since process is manual weld overlay quality also gets impacted and rework increases. Time required for manual welding is also high. To overcome this problem, automation should be used for this process. Automation in this process can improve the quality of welding, reduce rework, reduce the dependability on skills of welder, reduce time and improve productivity. The objective of the project is to design and manufacture the Automated Flange Internal Surface Weld Overlay Mechanism. It aims at developing an automation which will ensure higher productivity rates and increased overall efficiency, reduced labor fatigue, rework and costs. This can be developed by the use of PLC logic controller, positioners and chucks, Welding machine, lateral displacement mechanism etc.

The project aims at achieving increased levels of productivity along with minimum waste generation (through optimum weld deposition rates) by automation of the flange internal surface weld overlay. Lastly, the project aims to bring out defect-proof weld overlay unit.

1.2 Methodology

The approach towards the attainment of the project objective is planned as follows:

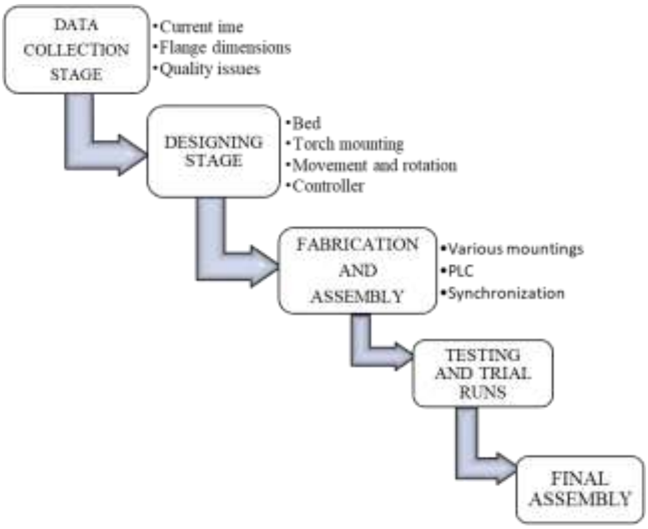

Fig -1: Methodology of Flange Internal Weld Overlay Process

1.3 Effect of Process Parameters

1.3.1 Effect of wire feed rate**-** it was ascertained that with increase in wire feed rate, depth of penetration, height of reinforcement, and weld bead dimension also increases. With increase in wire feed rate welding current additionally will increase leading to an enhanced power per unit length of the weld bead and better current density, resulting in larger volume of the base metal to melt that causes deeper penetration

1.3.2 Effect of welding speed**-** In stainless steel cladding by GMAW, height of reinforcement and weld bead width decrease with increase in welding speed. Heat Input per unit length of weld bead reduces with increase in welding speed, and less filler metal is applied per unit length of the weld. Welding speed, if increased, also decreases penetration of weld metal. In weld cladding by plasma transferred arc (PTA) process, effect of increase in welding speed was found the same as it was for cladding by GMAW. In PTA process, with the increase in speed, it was observed that reinforcement increases to some optimal value, and then decreases with further increase in speed, because, with high welding speed, quantity of powder deposited per unit length of bead decreases.

1.3.3 Influence of welding gun angle- Experimental results depicted that in forehand welding (i.e., gun angle>90°), depth of penetration, height of reinforcement, and weld bead width decrease gradually with increase in welding gun angle from its center point (90°) to the upper limit (110°). Same effects are also observed for backhand welding (i.e., gun angle<90°) when gun angle decreases from its center point (90°) to the lower limit (70°).

1.3.4 Nozzle-tip distance and its effect- It was observed that with increase in nozzle-tip-distance, depth of penetration increase at first, and then sharply decreases. On the other hand, it was found out that with increase in nozzle-to-plate distance, weld bead width and height of reinforcement increases. This is because circuit resistance increase with increase in nozzle-to-plate distance which reduces the welding current, and hence, lowers the heat input per unit length of the weld resulting in reduction in fusion area. Ultimately, depth of penetration decreases. It was also observed that arc length increases with increase in nozzle-to-plate distance and hence, the bead width increases due to wider arc area at the weld surface.

1.3.5 Effect of welding current**-** It was observed that with increase in welding current, penetration increases significantly. This happens because with increase in welding current heat input to the base metal increases to a large extent resulting in gradual increase in dilution, weld width and total area.

2. PROCESS STAGES

2.1 Procurement of raw materials:

Production-related procurement is the one that encompasses all items that are part of finished products, such as raw material, components and elements. Raw materials are parts or materials used in the manufacturing or in the primary production of goods which are often altered for use in various processes prior to being used in the manufacturing process. The production process of manufacturing firms is directly affected by the raw materials they use and is often termed as direct procurement.

2.2 Manufacturing Procedure

Manufacturing is the actual beginning of production of the required system or product using various set of tools and equipment to meet the requirements and needs of the user. Manufacturing can be defined as the steps in which raw material takes the shape of the final product. Usually manufacturing is carried out after the initial validation and prototypes have passed the needs for the user. Depending on the product or system to be manufactured, the system for manufacturing can be small scale or large scale to fully automate to semi-automated to hand-made.

2.3 Electric Installations

Electrical wiring is an installation of cables and linked devices such as switches, distribution boards, sockets, and light fittings, Circuit protection, control and distribution devices within a machine and its cabling system are subject to voltage, current and functional specification. In this electric panel, connections interrelated with VFD, PLC, SMP, Relays and MCB, PLC automation panels are used. PLC based Control Panels have ensured ease in modification of logic, decreased size and hence has dominated over conventional relay based systems.

2.4 Welding, Painting and fabrication

Flux core arc welding is used for flange internal weld overlay process. It is used because of its good controllability and comparatively low costs. Spray painting is done to enhance the machine outlook and also keep it away from getting corroded. Spray guns are used and the machine is painted.

2.5 Inspection

Inspection is mostly considered to be an organized examination or a form of evaluation exercise which determines the manufactured product to be put through certain measurements, tests and gauges to make sure they adhere to certain standards. An inspection determines if the material or the process is in proper quantity and condition.

3. DESIGN AND CALCULATIONS

3.1 Chuck and Positioner assembly

A solid cast iron bed forms the base of the chuck and positioner assembly. The 3 jaw chuck is guided by the positioner with a shaft connecting the two. Below is a driving motor of 5 HP which is further attached to a gearbox with reduction ratio 20:1. The pulleys of motor and gearbox are linked with use of belt drive.

Further, the motion is transferred to the positioner above using another V-belt linking the gearbox and positioner. Variable frequency drive 3 is in connection with the motor which helps in obtaining desired speed levels of chuck.

Product Specifications: Brand-Shanthi 40 W, 1440 rpm, 230 VAC.

Gear ratio: The ratio of the number of turns the output shaft makes when the input shaft turns once is called the gear ratio. This means that the number of teeth on driven gear are 20 times more than that of driver gear. Consider motor rotating at 1440 rpm.

Torque at the output of the motor = (Motor HP)*5252/ RPM Motor =12.27 N.m

In case of gear box the efficiency is typically a motor provided to account for the frictional losses in the gear drive.

Considering the friction factor is equal to 0.9;

Torque = 12.27*0.9*20 = 220.86 N.m

Similarly the torque for other two gear box is also calculated.

For the motor 1 and 2

Torque at the output of the motor = (Motor HP)*5252/RPM MOTOR = 0.25*5252/ 1440 =1.2 Nm

For the Gear box

Torque*Reduction ratio

Assume reduction ratio 48= 1.2*48 = 57.6 N-m

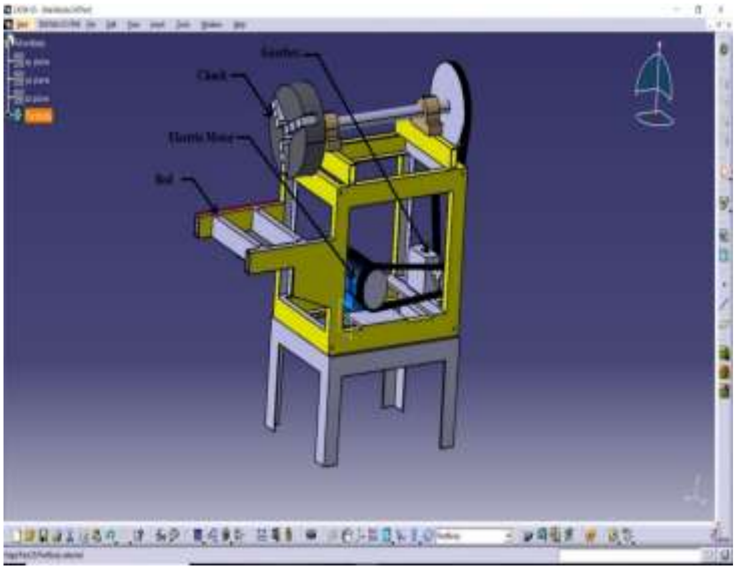

Fig -2: Chuck and Positioner assembly

3.2 Bed & Motor Assembly

Below pictures illustrates the bed onto which welding torch is mounted. Guided by lead screws, the bed facilitates movement in 2 directions (X and Y axes). 0.25 HP motor along with gearboxes are mounted at each bed to obtain motion through PLC triggering mechanism. The torch is mounted on the bed with a fixture fitting in between the slots of the bed. With subsequent modifications, the fixture can be used for internal as well as external weld overlay process.

Motor: Crompton 3 Phase 5 HP 4 Pole Foot Mounted Induction Motor, GF7005

Power rating: 90 KW, RPM: 2880 RPM, Weight: 63 Kg, 230 VAC

Calculation of rpm:

Motor 5 HP 2880 RPM

Torque needed to determine the chuck position assembly

Weight of the assembly = 50 Kg x 10 (Considering g=10m/s2)= 500N

Diameter of chuck/positioner = 16 inch = 0.4064 m

NOTE: The Chuck is coupled to a pulley on a similar shaft which is supported by two roller bearing at its either ends.

Torque required = 1/2*D*N

Which is equal to = 101.6 N-m

From the above results a standard 5 hp motor and a gear box with reduction ratio 20:1 is chosen.

To drive the chuck and reduce its speed to amplify the motor torque.

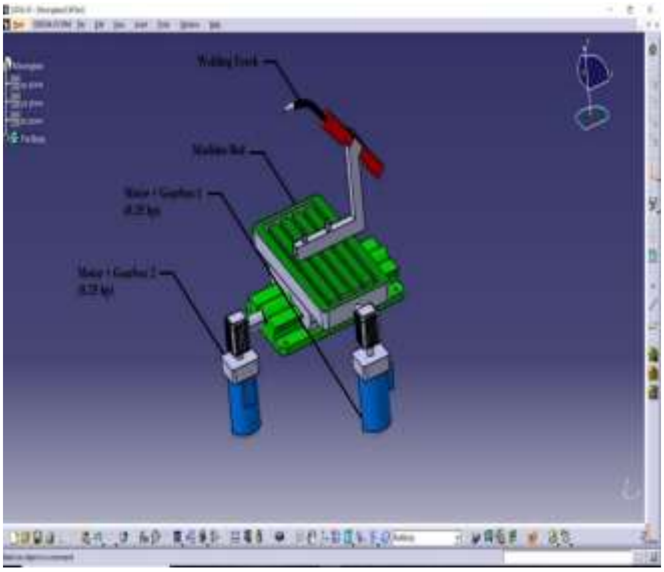

Fig -3: Bed and motor assembly

3.3 Electrical Panel

The panel consists of all the electrical mountings including PLC, SMP, MCB's, connectors, VFD's etc.

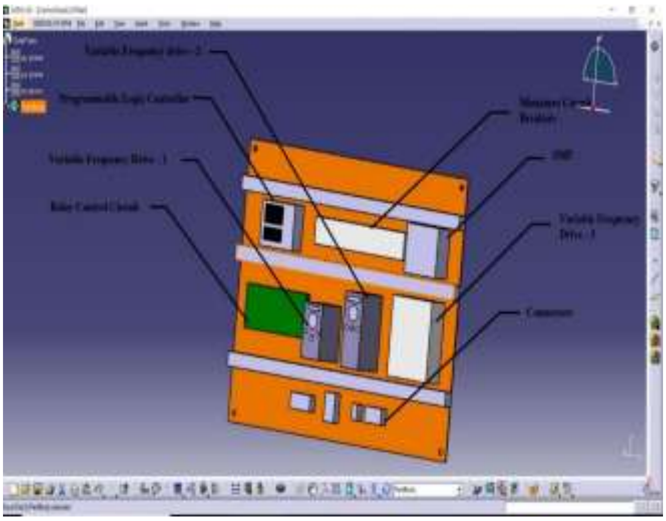

Fig -4: Electric Panel assembly

3.4 V Belt

Design for speed ratio for belt drive

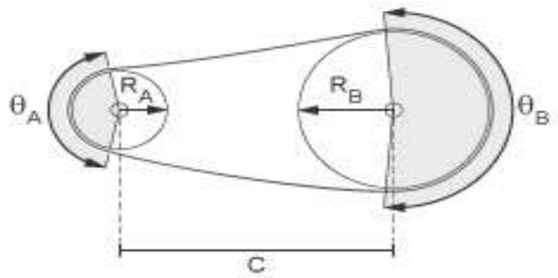

Fig -5: V belt drive assembly

It can be expressed mathematically as $N_2/N_1= D_1/D_2$

D1	diameter of the driver	8
D2	diameter of the follower	4
N1	speed of the driver	2880 rpm
N2	speed of the follower	?

$N_2 = 144$ rpm

Distance between driven and driving pulley

The distance between driving and driven pulley is given by $C=D_1+D_2$

Where

D1	Diameter of the driver pulley	8
D2	Diameter of the driving pulley	4
C	Distance between driving pulley and driven pulley	?

Therefore;

$C_1=2\times8 + 4 = 20$ inches

$C_2=2\times5+ 14.5 = 24.5$ inches

Determination of belt length

The belt length can be obtained as

$L=2C+ \pi/2(D_1+D_2)+ (D_1+D_2)/4C$

$L_1= 2\times20+\pi/2(8+4) + (8+ 4/4\times20)$

$L_1=66.89$ or 67 inches

$L_2= 2\times24.5+\pi/2(15+5) + (5+ 15/4\times24.5)$

$L_2=85.56$ or 86

Therefore A67 and B86 are selected

3.5 Final Assembly in software

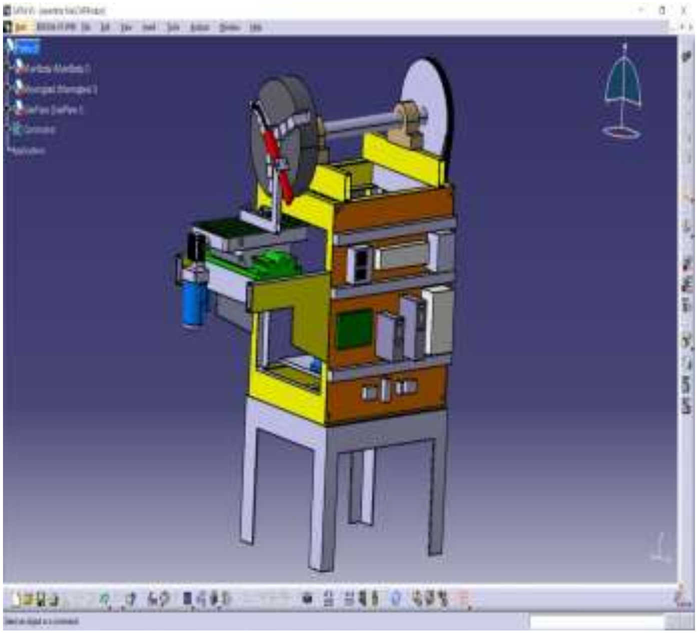

Fig -6: Final software Assembly

4. FINAL ASSEMBLY

Fig -7: Side view of manufactured weld overlay machine

Fig -8 Front view of manufactured weld overlay machine

Fig -9: Final Assembly of Weld Overlay automation with welding apparatus

5. RESULTS

After successful completion of the manufacturing part along with electrical circuitry, trial runs were taken.

Parameters such as welding gun position, gun angle, etc. were changed and following outcomes were observed-

1. **Trial 1**

Chuck rotation- Clockwise rotation
Welding gun position- At right hand side of chuck
Welding gun inclination- At right angle w.r.t to vertical

Fig -10: Trial 1

Observations-

- Non uniform weld deposition
- Irregular weld characteristics

2. **Trial 2**

Chuck rotation- Clockwise rotation
Welding gun position- At left hand side of chuck
Welding gun inclination- At right angle w.r.t to vertical

Fig -11: Trial 2

Observation**s**-

- Incomplete weld layer
- Excess filler deposition at certain spaces

3. **Trial 3**

Chuck rotation- Clockwise rotation
Welding gun position- At left hand side of chuck
Welding gun inclination- Approx. 15-20o with vertical

Fig -12: Trial 3

Observations-

- Completed run of welding
- Fairly uniform weld deposition
- Steady deposition rates

6. CONCLUSIONS

We Aim & Visualize our project to be of extreme Resourceful in the areas of petrochemical, power generation Industries where internal overlay of more resistant metal increases the durability of these highly exposed parts, their surfaces. We believe that it will also Increase in productivity Increase in consistency of quality, Reduction in requirement of skilled labor, Reduction of weld repairs. It will also uplift the productivity rates, optimize cost & quality. With additional customization, the mechanism can be used for variety of jobs offering flexibility in terms of job dimensions and weight. The low cost automation can be employed across various industries. Added to this, installation of sensors and related mechatronic components can help achieving extreme precision and minimum human dependability.

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