CHAPTER - 3
DESIGN AND DEVELOPMENT OF FCAW CLADDING SYSTEM

3.1 INTRODUCTION
To find the effects of process parameters on bead geometry in cladding, it is essential to lay the beads accurately in order to have uniform straight overlay with uniform overlap [1]. This is achieved by providing precise longitudinal and transverse movements to the work piece and controlling these movements independently and accurately. Hence those requirements demand an automatic cladding system for the movements of slides and for starting and stopping of the cladding operations as per the design. Such a system will also have the advantages of consistent quality, productivity and reduced operation fatigue. Moreover this system needs only a semiskilled operator [2-4].

On the basis of the above fact it was found essential to design an automatic cladding system consisting of welding machine, the manipulator and the process control system. The two axes automatic linear manipulator was designed and fabricated to perform cladding. The design and fabrication work of the manipulator was carried out in the Welding Research Cell, Coimbatore Institute of Technology, Coimbatore, India.

The following factors were considered while designing the cladding system.
1. Size of the workpiece to be cladded
2. Length of the overlay along the X and Y direction
3. Area of the work piece to be cladded
4. Welding gun and positioning system
5. Easiness for operation
6. Operators safety

3.2 DESIGN AND FABRICATION OF AUTOMATIC, DIGITAL, TWO AXES LINEAR WELDING MANIPULATOR
This manipulator facilitates cladding the desired area. This has two main units:
1) Mechanical system and
2) Electrical drive and it control unit.

3.2.1. Mechanical System
It provides the relative motion between the welding torch and work piece and consists of three main parts: a) Main frame or Base, b) Work table and c) Welding head. In this present system, welding torch is held stationary and the work is moved linearly.
The mainframe is built up of steel angles, and is mounted on level adjuster to make the manipulator workpiece table horizontal. Stiffeners are provided wherever necessary to provide rigidity. Welding head and work table with their driving motors are mounted on this main frame. These motors drive the worktable in X and Y directions accurately.

The worktable was designed to have a total area of 900 x 600 sq. mm. The design and fabrication of feed drive was based on Cartesian co-ordinate system. There are two slides for X & Y directional movements with the X-slide fixed above the Y-slide. The translational motion of each slide is accomplished by means of DC motor, lead screw and nut. The two square threaded lead screws having a length of 700 mm in X direction 900 mm in Y direction with a pitch of 4 mm are used for X and Y directional movements. The mating nut is made up of gunmetal to reduce friction. There are four limit switches to stop the worktable at its extreme positions in both X and Y directions. Taper roller bearings, which were mounted back to back at each end supporting the lead screw, have been preloaded by tensional nuts provided at both ends of the shaft.

The welding head consists of a vertical frame on which the welding torch can be fixed. A vertical screw rod provided with a handle helps to move the torch up and down in order to set the distance between the nozzle and the plate at the desired level. Provisions are also made to slide the torch horizontally so that the torch can be moved in the transverse direction also. A fire resistance bellow is provided over the screw rods to prevent the dirt, slag and spatter falling on them. Fig. 3.1 shows the designed and fabricated automatic linear digital manipulator.

3.2.2 Electrical Drive And Its Control Unit

It gives power to the mechanical system through a standard drive package consisting of motors with speed regulators [5,6]. The start and stop switches of the work table, its speed control switches for both direction, and on/off switches with power indicating bulbs and emergency halt switch are also provided on the control panel. Emergency stop switch, limit control switch and automatic tripping on motor overload for long duration are provided for safety. The lead screws carrying the worktable are well lubricated to minimize friction and the work table movements on either direction are calibrated for their linear speed and for better accuracy. The table movement is converted into electrical signal and measured accurately with a digital meter.

The parameters to be controlled with FCAW cladding system are arc voltage, wire feed rate, nozzle to plate distance and angle of electrode. As the welding is an automatic type and once the welding parameters are preset welding will be executed by operating the trigger switch. The location where welding is to
be done on the plate is determined by the transverse and longitudinal table movement.

3.3 POWER SOURCE
This sub system facilitates the deposition of the desired filler metal on the base metal by FCAW welding technique by providing necessary electrical power, filler metal and inert gas or carbon dioxide gas shielding. The power source is designed to provide an extremely versatile and accurate supply of high performance FCAW welding. Most FCAW is done with constant voltage power source because arc length self-regulation is good, and constant speed wire drive system is less complicated than voltage controlled systems [7]. There is no trouble when using constant potential power source with high short circuit current capability. The wire speed is proportional to the welding current drawn from the power source. A good dynamic response is possible in constant potential power source. FCAW may be DCEP or DCEN and hence versatile. As per AWS specification for flux cored electrodes CO₂ shielding gas is used with DCEP.

Electrode positive gives low spatter and stable arc [8]. DCEP gives low dilution, high deposition rate and used for thick deposit [9]. Cored electrodes designed for DCEN polarity do not require shielding gases. Most of the time shielding gas is used to control the puddle chemistry and not the metal transfer.

But the shielded gas reduces spatter and stabilizes the arc. A conventional three-phase transformer rectifier system was used to produce the DC power. The power source used is INDARC - 400MMR having DC welding current 350A at 42V at 100% duty cycle and 400A at 40V at 75% duty cycle. The power source has facility to read digitally, the arc voltage, welding current, wire feed rate and welding speed. Before the commencement of the welding the welding process parameters viz. arc voltage, wire feed rate, gas flow rate etc. have to be preset. The starting and the finishing of the welding is controlled by operating a trigger switch provided in the welding torch. The power source used for the cladding system is shown in Fig. 3.2.

Flux cored wires are relatively fragile compared with solid wires and hence the drive roll pressure is kept low. The flux-cored wire does not feed as easily as solid wires. The cored wires can buckle and collapse if they are pushed around too sharp a bend. So FCAW guns are made with larger curves and seem bigger than the GMAW guns. Wire feeder need special feed roll for use with flux cored electrodes. Some feeders use two rolls others four. Usually when there are two rolls one roll is driven by the feeder motor and other turns freely and is used to apply pressure to the wire. Most feeders have an adjustment that can change the pressure applied to the wire. The amount of drive roll pressure supplied by the
spring helps to control the feed force. Some rolls are made with V-grooves, others with knurl mark to avoid slipping.

If the rolls skid the wire feed rate will be slow and the arc becomes longer and longer and causes burn back. So the conduits and liners should be kept clean [9].

3.4 SYSTEM PERFORMANCE AND ITS CAPABILITY

The designed system was successfully engaged for cladding in flat position. The cladded surfaces were found to be good and defect free. The troubleshooting was done as follows:

If there was no arc initiation then the power supply, ground connection and the burn back of the nozzle were checked and the defects were rectified and if there was any porosity found the quantity of the shielding gas was increased suitably. Also during initial use of carbon dioxide from the fresh cylinder, some amount of gas was let out, and little quantity of gas was rejected at the end, to avoid the moisture contamination.

It is found that the above manipulator and welding machine perform well as per the design requirements.