



PROGRAMMING ABB INDUSTRIAL ROBOT FOR REDUCING WELDING CYCLE TIME.

Sanket .Dattaram.Parab, V.S.Narwane

PG (Dept. of Mechanical Engineering), Assoc. Prof. (Dept. of Mechanical Engineering)
K. J. Somaiya College of Engineering Vidyavihar (Mumbai), India
Email : snkt.prb@gmail.com, vsnarwane@engg.somaiya.edu

Abstract- In Industries like aerospace, Automobile, heavy Industries welding is the process which is very commonly used but according to Statistics of Manufacturing Institute's there is shortage of skilled workers in the manufacturing sector. Thus automation in welding is inevitable.

For increasing its production capacity Godrej Security Solutions decided set up automation line , thus a Master Frame of same dimension as that of Defender safe outer body was manufactured from square Pipes & 5mm thick plates for defining work object & teaching positions welding seams accurately as C-shells used in manufacturing Defender safe have some tolerance in their dimensions. As utilization time of robot increases, cycle time of process decreases which fulfils basic requirement of automation line. So the programming of welding robot in robotic cell is of immense importance. This paper covers programming & interfacing of ABB IRB 1600ID robot used for reducing cycle time in Godrej Security Solutions.

Keywords- welding robot; programming of robot; reducing cycle time.

I. INTRODUCTION

A robot is defined as an automatically operated machine that replaces human effort although it may not resemble a human. A robot is designed and meant to be controlled by a computer or similar device .A robotic system that can be used together with the robots to perform the necessary tasks. The motions of the robot are controlled through a controller that is under the supervision of the computer which is running some type of program. Thus if the program is changed, the actions of the robot will be changed accordingly. Thus the robot is designed to be able to perform any task that can be programmed (within

its limit and work envelope) simply by changing the program [1].

The aim of this project is to program a robot to perform welding operation in sync with reciprocating fixture & gantry loader-unloader so that welded outer body is continuously fed to automation line. This programming was done with an industrial robot (ABB IRB 1600) using RAPID programming language. The IRB 1600 ABB robot also has a control module and a flex pendant where all the programming instructions are written & edited.

II. SYSTEM DESCRIPTION

To illustrate this project, the block diagram of the system is as illustrated in Figure.1. Fixture & Loader-unloader gantry are used to bring the workobject in Robotic cell. The main focus of this project is programming robot & interfacing it with other components of system for continous welding of Defender Safe outerbody in Robotic Cell.

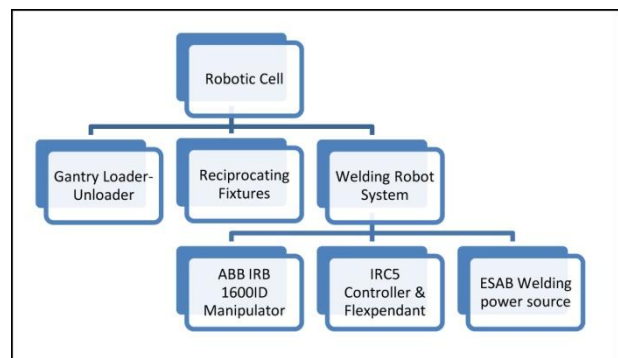


Figure 1: System Block Diagram

A. Component Study

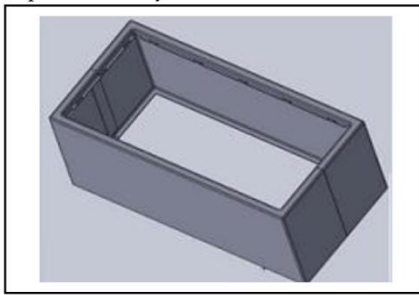


Figure 2: Assembly Diagram of Defender Safe Product

The outer body of Defender Safe product consists of C-shaped shells along with two joint strips, two vertical stiffeners & two horizontal stiffeners are welded together to get outer body as illustrated in Figure 2 which are drafted using Solidworks Design software [2]. The C-shaped shells are manufactured by bending & folding operation of 5mm thick M.S. plate. While Horizontal & Vertical Stiffeners are manufactured by laser cutting operation, followed by notching.

B. IRB 1600ID Manipulator

The IRB 1600ID is a 6-axis industrial welding robot which can floor mounted, tilted and inverted, designed specifically for manufacturing industries that use flexible robot-based automation. The robot is equipped with an operating system called Robot Ware 5.13. This Robot Ware controls the motions, development and execution of programs. The IRB 1600ID robot manipulator has a weight of 250 kg and a repeatability position accuracy of 0.02mm. The average speed of the robot based on TCP velocity is 2.1 m/s. The robot uses a voltage supply of 200 – 600 V with 50 or 60 Hz frequency and a reach of 1.5m. [3].

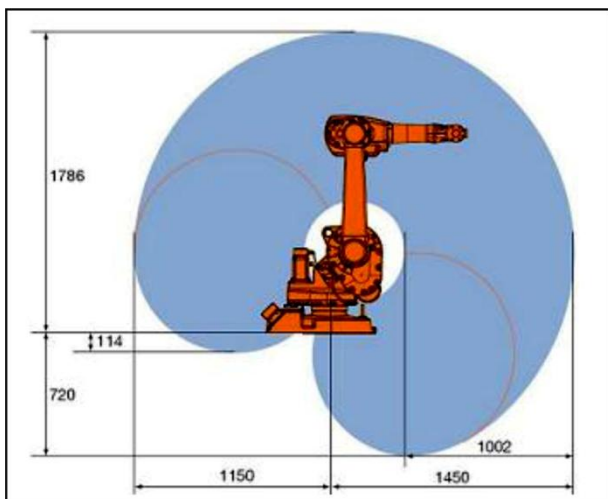


Figure 3: Workspace Diagram of IRB 1600ID Robot.

C. Flexpendant

The flexpendant which is also referred to as the teach pendant unit, is a hand held operator unit used to perform many of the tasks involved during the operation of a robot system such as modifying the work object, jogging

the robot manipulator, modifying RAPID programs and it is used to create instructions using teach method and jogging.[4].

D. IRC5 Controller

The IRC5 controller contains all the functions required to move and control the robot manipulator. The controller consists of two modules, the control module and the drive module. The control module contains all the control electronics such as main computer I/O boards and flash memory. The control module runs all software necessary for operating the robot system. The drive module contains all the power electronics supplying the robot Motors.

An IRC5 drive module may contain nine drive units and can handle six internal axes plus two or additional axes depending on the robot model [4].

E. Layout of Robotic Cell [5].

- (A) Orientation Trolley- has conveyors for pushing two C-Shaped shell forward & proximity sensors to detect the left & right hand side of C-shaped Shells.
- (B) Loader-will pick up the unit & put on reciprocating fixture.(Y-direction).
- (C) Reciprocating Fixture - moves to & fro linearly in x-direction to bring the outer body in work envelope of robot.
- (D) Welding Robot 1- welds two Joint strips & 4 stiffeners to form outer body of Defender Safe.
- (E) Unloader-will pick welded outer body of Defender Safe & places it on Transfer line.

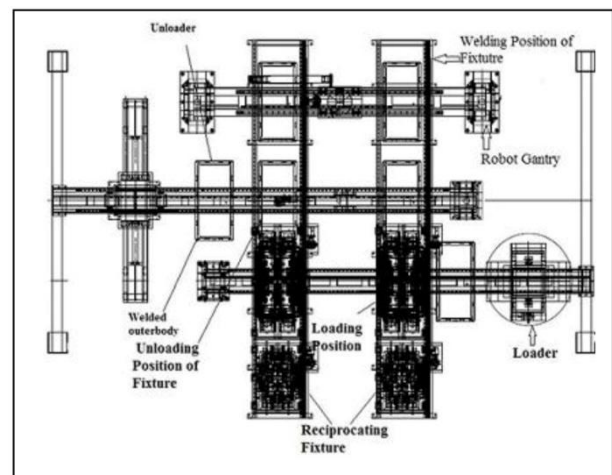


Figure 4: Layout of Robotic Cell.

A. Welding Parameters

Proper parameter setting of welding is needed to achieve smooth, spatter-free welding & also to get good welding quality. Usually Material thickness, wire diameter, voltage, wires feed speed & gas flow rate are important factors. ABB has collaboration with ESAB for providing wire feeder, wire spool & welding source. Thus according to ESAB manual [6] welding seams in

Defender Safe Product are in 1F/2F & 3F/4F positions & following are the recommended parameter settings for those positions.

Table I: Recommended welding Parameters by ESAB [6].

Position	1.2mm (15-20mm stick out)			Ø1.2mm (Wire Diameter)	Gas Flow Rate (l/min)
	I (A)	v wire (m/min)	U(V) Voltage		
1F/2F	180-300	6.0-14.0	24-31	Suitable	15-20
3F/4F	180-250	6.0-10.0	23-28	Suitable	15-20

Thus we made two welding schedules on basis of guidelines provided by ESAB manual [6].

Table II: Actual Welding Schedules used in Robot Program

Components	Joint Strips	Vertical & Horizontal Stiffener's
Position	3F/PF	1F/2F
I (A)	180-300	180-250
v wire feed Rate (m/min)	6.2	10.4
U(V) Voltage	22.5	26.5
Welding Schedule	9	1
Gas Flow Rate(l/min)	15-20	15-20

III. PROJECT IMPLEMENTATION

The main objective of this project was to reduce cycle time & give consistent weld quality with given tolerance of outer body size of Defender safe. Thus layout study (Fig.4) was done for fixing position of loading, unloading & welding of Defender Safe. Positioning is needed so that Gantry-Loader precisely loads the outer body shells on both the fixtures & also it should unload welded outer body precisely. Gantry loader, Unloader & Reciprocating fixtures use servomotor for its movement which is programmed by Mitsubishi Q series PLC. Thus by using PLC first HMI for Loader-Unloader gantry Fixture & Robot Gantry was made for ease of positioning. Plumb-bob as shown for centring as it is y-axis equivalent of a "water level".

B. Calibration of Robot

After positioning, calibration of every axis is done as it is necessary for accurate robot movements. In ABB IRB 1600ID Robots there is calibration mark on every axis. Robot is jogged in individual axis mode & every axis is matched with calibration mark as well it is ensured that reading of individual axis at this position is 0°. [7]

C. Workobject Definition

A work object is a coordinate system used to describe the position of a work piece. All programmed positions will be related to the work object frame which is related to the world coordinate system. This is done by defining three positions, two on the x-axis and one on the y-axis. Master frame (Fig 5) was made from hollow square pipes of sizes 40X40mm & 25X 25mm. All stiffeners & joint strip were also welded to this master frame. Same body

were used to teach location of welding seams to Robot. On top of square frame for blocks were welded at center of length & width to define X1, X2 & Y1 points. The points X1, X2 & Y1 are defined in such a manner that origin of work object is center of cubic space of body. The work object is defined in such a way that it utilises maximum work envelope of robot & and robot can also reach at all points in body with ease & without singularity problem. The work envelope of Defender Safe were from X= -775mm to +775mm, Y= -392.5mm to 392.5mm & Z= 0 to 740mm. [8]

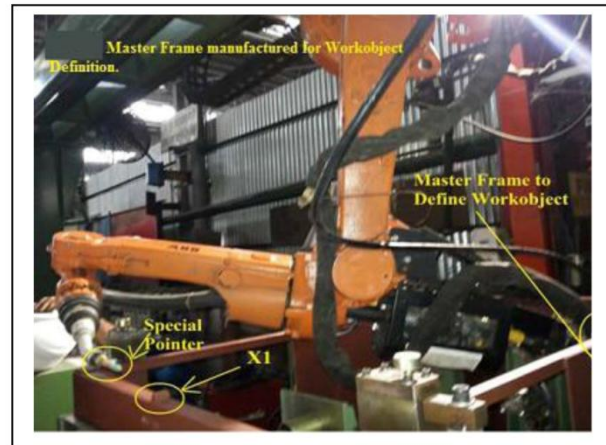


Figure 5: Master Frame manufactured for work object Definition.

D. Safety Interlocks

Safety interlocks are of immense importance:-

- Avoid machine accidents because of interference of two machines.
- To prevent any possibility of accident which may cause danger to the life of operator.

To configure safety interlock a chunk of bits are reserved in two categories DO (Digital outputs) & DI (Digital Input). But same numbers of bits were reserved in PLC of main controller as that of IRC5 controller of robot.

Interlocks are configured using cross connections. The purpose of Logical Cross Connections is to check combinations of digital signals. This can be used to check or control process equipment that are external to the robot. The functionality can be compared to the PLC of main controller. By letting the I/O system handle logical operations with signals, a lot of RAPID code execution can be avoided. Logical Cross Connections can replace the process of reading signal values; calculate new values and writing the values to signals. [9]

E. Teaching Robot to weld.

For programming robot to weld it should be taught about welding seam orientation, air cut points, welding seam length & other parameters. Usually for teaching robot to weld it is jogged with the help of Flexpendant to all

welding seam positions & coordinates of that point are recorded in various instructions within the program. Teaching is more precise than offline programming as it records actual coordinates & the possibility of robot colliding while execution of program is also eliminated. A total welding stitch length is 1.5m in outer body of Defender Safe Product which includes 16 welding seams on Joint strip (8 on each) in 3F/PF position, 20 welding seams on vertical stiffener (10 on each) in 1F/2F position & 12 welding seams on horizontal stiffener (6 on each) in 1F/2F position.

F. Smartac Routine

Smartac is a tactile sensor used to find the location of inconsistent weld joints and offset the programmed points in a weld program. Once welding program is complete smartac program is developed & its offset distances are included in welding program to compensate the variation in dimension C-shells manufactured by bending & folding process. [10]. The combined flowchart of smartac & welding program routine is as illustrated in Figure 6.

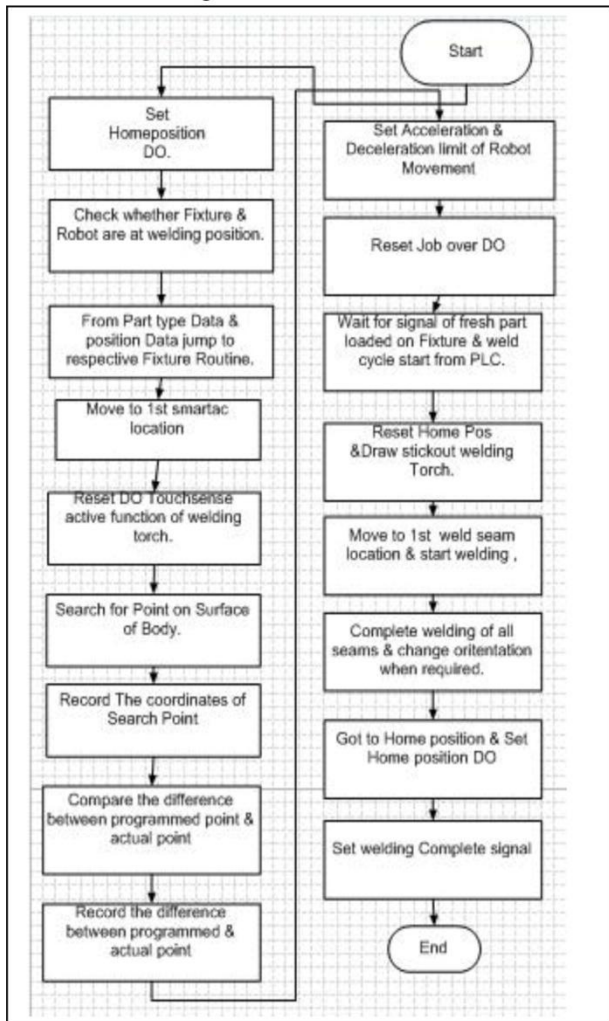


Figure 6: Flow chart of Software Programming

IV. RESULTS AND DISCUSSIONS

A. Result

Figure 7 show the picture of the ABB robot welding Defender Safe Body & Figure 8 shows uniform welding beads obtained by welding Robot on Vertical Stiffener of Defender Safe.



Figure 7: Robot Welding Class-A Body of Defender Safe



Figure 8: Uniform welding beads obtained by welding Robot on Joint strip of Defender Safe.

B. Discussion

Before actual welding program could start dry run was taken so that actual simulation of the robot moving through the paths and targets could be visualised & welding seam location could also be confirmed. The

basic structure of welding & other routines was written into the flexpendant, but actual value of Move J, Arc L & smartac points was recorded in to it by teaching. The work object was created in such way that it could enable the welding torch to reach each of 48 welding seams with ease.

While welding trials it was noticed that the filler material while welding joint strip in 3F/PF position was dripping & welding bead was not uniform. This problem was solved by reversing the path of traverse of robot, first robot used to go from downward to upward direction but later it was reversed. In addition shielding gas flow rate was adjusted & orientation of welding torch was adjusted to get perpendicular shielding gas flow so that the filler material deposition will be uniform. Thus joint strip welding beads become uniform.

In some cases while welding robot used to give joint supervision error while welding seams at corner of Defender Safe product as its 5th & 4th axis would get collided with walls of outer body of Defender Safe product. The zone data was modified for the critical paths as shown in Figure 8 in which there were possibilities of robot axis colliding with fixture or Defender safe. In such cases a zone from the range of 10mm (z10) to 200mm (z200) was used in particular Move J instruction depending up on criticality of path was defined as illustrated in Table III.

Table III: Zone data for points used in Rapid Program

Zone data	Value
Fine	The robot will go exactly to the specified position
z10	The robot path can cut corners when it is less than 10 mm from the destination point
z50	The robot path can cut corners when it is less than 50 mm from destination point

All the 48 welding seams on outer body of Defender Safe were successfully programmed on both the reciprocating Fixtures and Robot Interfacing with main controller was successful.

The programming of welding seam, traversing path and an interfacing was done on the robot proved to be efficient for Class- C of Defender Safe Product. The robot was able to move through all the programmed paths at maximum speed. Despite variations in C-shells due to bending process the robot was able to weld with same accuracy due to use of smartac feature. (Bit III. E)

V. CONCLUSION AND FUTURE WORK

In this paper, an ABB welding robot is programmed for welding & also smartac routine is created to program to compensate the variation in dimension C-shells manufactured bending & folding process. The Robot was able to weld with the maximum speed and accuracy for all paths and routines created for both fixtures and the

robot was also able to achieve the cycle time for which it was programmed. Hence, the intended objective planned until 1st stage has been achieved.

Future work will concentrate on creating welding torch cleaning routine for spatter cleaning. Since the Assembly line of Defender Safe product is mixed production line it will also focus on modifying welding & smartac routine for all models of Defender safe & implementing main program by calling the routines(welding, torch cleaning & smartac) as required by production.

VI. ACKNOWLEDGMENT

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