Design of welding fixture and Robot programming

ShindeVilas[a], GaykarSuraj[b], SatputeNavin[b], SatputePallavi[b], SheteHarshada[b]

[a]Staff [b] Student

Department of Production Engineering, Amrutvahini College of Engineering, Sangamner,
Savitribai Phule Pune University, Pune, Maharashtra State, India

Abstract

This paper aims to study the Mastering, calibration, payload, TCP, work object, robot teaching & execution of ABB robot (IRB1410) for welding purpose. Industrial robot have been used in industries in order to reduce the capital investment and increase the production. In the current scenario, robots are programmed to perform critical operations like gripping & welding. Robot welding is mainly concern with use of mechanized programmed tools, known as robots. Which completely automate a welding process by both performing the weld and link the part. Robots are quite versatile and hence have been used for a variety of welding types such as resistance welding and arc welding. Implementing the robotic welding lead to increase the efficiency of the production system. To achieve this modern concept for implementing robotic welding is used in industrial environment. In this production system produce good quality welding and find out shortest path travel by tool.

Key words: robotic welding, welding fixture, Robots, welding types, Arc welding.

1. INTRODUCTION

The initial part of this paper introduces the background history of welding, welding, shielding gas, filler material as well as welding defects. The first industrial robot created by the George Charles Devol in 1954, who is known as father of robotics. With the advancement in technology, efforts were made to minimize the involvement of human in manufacturing by replacing them with robots and automating the process. A robotic arm is a robot manipulator, usually programmable with similar functions to a human arm.. The links of such a manipulator are connected by joints. X, Y & Z are called as prismatic joints and Ө, ф & Ψ are known as rotary joints. In Cartesian type of robot all 3 are prismatic joints (x,y,z). In cylindrical type robot 2 prismatic (x,y) and 1 rotary (Ө) joint. In spherical or polar type robot 1 prismatic (x) & 2 rotary (Ө, ф) joint. In articulated or jointed robot all 3 are rotary (Ө, ф & Ψ) joints. Robotic welding is a use of mechanized programmable tools which completely automate a welding process by both performing the weld and handling the part. While often automated are not necessarily equivalent to robot welding, seens a human operator sometimes prepares the materials to be welded. Robot welding is commonly used for resistance spot welding & arc welding in high production application. The number of arc welding automation robot station is growing very rapidly. The two most common stations are the GMAW (Gas Metal Arc Welding) station and the GTAW (Gas Tungsten Arc Welding) station. This two stations are the most common because they are so well suited to robot system. Typically a robot arc welding station is comprised of a robot, A robot controller, arc welding equipment, a work clamp and motion devices to hold workpiece accurately in position, robot motion devices to move around the robot for a larger working range and better weld position and safety devices. In advanced welding, a carries the torch while part to be welded is fixed in place. The robot can be taught the positions and path by a pendant, but many users prefers offline programming. The advanced welding is done in combination with 3D CAD model. The CAD model is analyzed by the program to create paths, cycle time as well as simulation. This enables the robot to keep working while next job is developed. Robots can handle a wide range of welding application.

a)Continuous robotic welding.

b)Spot robotic welding: A type of resistance welding spot welding join thin metals that resist electrical currents is typically used in the automotive industry to join sheet metal frames together.

c)Stitch robotic welding: It is a type of welding technique not a welding process. Stitch welding involves initiating a weld, welding for the portion of the joint length terminating the weld and then starting again along the joint a specified distance from the previous weld. Stitch robotic welding is also known as intermittent robotic weld. Stitch welding is not a continuous weld across a joint, but a weld broken up by space gaps in between welds, which results in a “Stitch” look. It is not as robust and durable as seam weld. It is used to prevent heat distortion and to also reduce the cost of welding if a long continuous weld is not necessary.

The last part of this paper is robot teaching as well as programming and PLC programming.

2) Historical development of welding:-

Edmund Davy of England is credited with the discovery of acetylene in 1836. The production of an arc between two carbon electrodes using a battery is credited to Sir Humphry Davy in 1800. In the mid nineteenth century, the electric generator was invented and arc lighting got to be mainstream. During the late 1800s, gas welding and cutting was developed. Arc welding with the carbon arc and metal arc was developed and resistance welding turned into a realistic joining process. In the early 1900s, chemical welding found its place in the industries. The resistance welding process were developed, including spot welding, seam welding, projection welding and flash butt welding. ElithuThopson originated resistance welding. Thermite welding was invented by a German named Goldschmidt in 1903 and was first used to weld railroad rails. Oxyacetylene welding become the universal method of welding between 1905 -1930. The electric arc and resistance welding process become established in 1925, start replacing oxyacetylene welding in mass production. Although arc welding development halted by poor quality weld pool. The atmosphere of oxygen and nitrogen in contact with the molten metal caused brittle and sometime porous welds, which led to the development of shielding gases. The earliest solution was the covered electrode to produce gases which would protect the molten weld metal from the atmospheric contamination. Beginning in 1920 Gas tungsten arc welding (GTAW) is ideal for welding magnesium, stainless steel and aluminum by using helium as inert gas in non-oxidizing atmosphere. The gas shield metal arc welding (GMAW) was successfully developed during Mid 90s. One of the basic changes that made process more usable is tungsten electrode continuously fed through electrode wire enabling use of small diameter electrode wires and the constant power voltage source. But the cost of inert gas was high. Due to need for narrow fusion, low thermal distortion and high quality weld of complex geometry, led to laser welding in recent time. Although initial problem involving short pulses of energy, laser welding was able to generate deeper welding without leaving much splatter. Moreover part remain in ambient temperature which enables low post weld operation time and rapid solidification.

3) Gas metal arc welding (GMAW):-

Gas metal arc welding is an arc welding process that uses an arc between a continuous electrode and the weld pool. It was developed in late 1940s to weld aluminum and also known as metal inert gas (MIG) welding. The heat of arc is used between a continuously fed consumable electrode and the work to be welded. The surface of the base metal and end of electrode is melt by the heat. The melted off the electrode is transferred across the arc to the molten pool. The depth of the penetration is controlled by many factors, but the primary one is the welding current. If the penetration is too much, the arc will burn through thinner material and reduced weld quality. When welding other than flat

ISBN: 978-93-88441-69-8

position, the molten metal will run out if molten pool is too large. An envelope of gas fed through the nozzle provides shielding of the molten pool, the arc and the surrounding area.

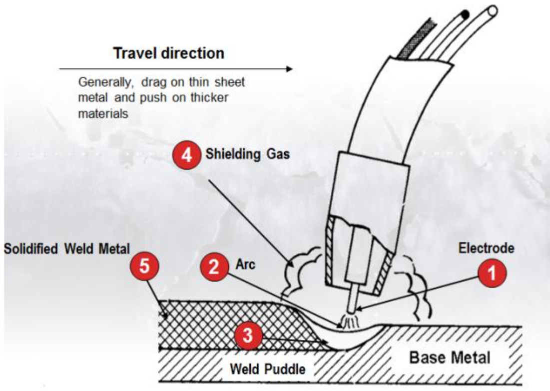

Fig.1GMAW process [6]

The shielding gas could be inert, active or a mixture. The arc is maintained automatically and travel and guidance can be handled manually or automatically. The work piece dictates the combination of the electrode and shielding gas. The metal transfer mode depends on the type and size of the electrode as well as shielding gas.

Advantages:-

1)High use of filler material, operator factor and deposition rates.2)Easy to automate.3)Elimination of slag and flux removal 4)Reduction in smoke and fumes.5)Less skill needed for semi-automatic process than manual shielded metal arc welding.6)It is versatile process with very broad application ability.

Limitations:-

1)Equipments are more complex and expensive than stick welding process.2)Unable to reach inaccessible welding areas with available guns.3)Sensitive to impurities and failures.4)Wind and drafts affects the efficiency of the gas shielding envelope around the arc area.5) Welding equipments need high maintainance.

4) Shielding gas for Mild Steel:-

Argon plus Carbon Dioxide:- One of the most popular mixture is 75% argon and 25% carbon dioxide for GMAW process. It is widely used on thin steel, where less penetration and good bead appearance is needed. It provides better appearance over 100% $CO_2$by reducing spatter. This mixture can also be used in out of position welding, thin sheet metal welding and when fit up is poor.

5) Robotic MIG Welding:

In this case study the work material selected is Mild steel (MS).

The parameters of the MIG welding for MS is as follows:

A)Metal Preparation:

Unlike stick and flux-cored electrodes, which have higher amounts of special additives, the solid MIG wire does not combat rust, dirt, oil or other contaminants very well. Use a metal brush or grinder and clean down to bare metal before striking an arc. Make sure your work clamp connects to clean metal, too. Any electrical impedance will affect wire feeding performance.To ensure strong welds on thicker metal, bevel the joint to ensure the weld fully penetrates to the base metal. This is especially important for butt joints.

a)Equipment Preparation:

Check your cables. Before striking an arc, check your welding equipment to make sure all of the cable connections are tight fitting and free of 0fraying or other damage.

Select electrode polarity. MIG welding requires DC electrode positive, or reverse polarity. The polarity connections are usually found on the inside of the machine.

Set gas flow. Turn on the shielding gas and set the flow rate to 20 to 25 cubic feet per hour. If you suspect leaks in your gas hose, apply a soapy water solution and look for bubbles. If you spot a leak, discard the hose and install a new one.

Check tension. Too much or too little tension on either the drive rolls or the wire spool hub can lead to poor wire feeding performance. Adjust according to your owner's manual.

Inspect consumables. Remove excess spatter from contact tubes, replace worn contact tips and liners and discard the wire if it appears rusty.

ISBN: 978-93-88441-69-8

a)Wire Selection:- For steel, there are two common wire types. Use an AWS classification ER70S-3 for all-purpose welding. Use ER70S-6 wire when more deoxidizers are needed for welding on dirty or rusty steel. As for wire diameter, 0.030-inch diameter makes a good all-around choice for welding a wide range of metal thicknesses in home and motorsports applications. For welding thinner material, use a 0.023-inch wire to reduce heat input. For welding thicker material at higher total heat levels, use 0.035 inch (or 0.045-inch wire if it is within your welder's output range)

b)Gas Selection:- A 75 percent argon/25 percent carbon dioxide blend (also called 75/25 or C25) works as the best all-purpose shielding gas for carbon steel. It produces the least amount of spatter, best bead appearance and won't promote burn-through on thinner metals.100 percent CO_2 provides deeper penetration, but also increases spatter and the bead will be rougher than with 75/25.

c)Wire Stick Out: Stick-out is the length of unmelted electrode extending from the tip of the contact tube and it does not include arc length. Generally, maintain a stick out of 3/8 inch and listen for a sizzling bacon sound. If the arc sounds irregular, one culprit could be that your stick out is too long, which is an extremely common error.

6)ABB Robot flex pendant programming method:

a)Mastering:-Mastering is the process by which the robot controller “KNOWS” the position of its axes. Without mastering, the robot could not take advantage of its high pose and path accuracy.

b)Calibration:- In addition to improving robot accuracy trough software (rather than by changing the mechanical structure or design of robot), calibration techniques can also minimize the risk of having to change application programs due to sight changes.

c)Payload:-Robot payload is the weight of arm can lift. It includes the weight of the end of arm tooling. Maximum payload varies from robot to robot.

d)TCP (Tool Centre Point):-

The tool center point (TCP) is the point in relation to which all robot positioning is defined. Usually TCP is defined as relative to a position on the manipulator turning disk. The TCP will be jogged or moved to the programmed target position.

e)Work Object:- Defining a work object means that the robot is used to point out the location of itie. to make robot workholic. This is done by defining three positions, two on the x-axis and one on the y-axis. When defining a work object you can use either the user frame or the object frame or both. The user select frame and the object frame usually coincides.

f)Robot teaching:- In robot teaching, the point and commands are provided for the robot which is on the work piece by using the flex pendant. In robot teaching we creates the different-different routines. Routines are deals with the commands like MoveJ, MoveL, Set as well as reset etc.

g)Execution:- In this phase we will execute the routine which we want to run. In this two types of execution first one is by using flex pendant and another one is automatic by using the PLC.

Robot Welding teaching:

1)Go to ABB main 2)Select Jogging 3)Select Work object, tool 4)Set the TCP 5)Enter main manu 6)Go to Program editor 7)Select Routine 8)Select file option 9)Select new routine10)Teach the Robot 11)Procall this Routine in main module 12)Execute the Program

7) PLC programming:-

Instead of operating manually for automatic cycle PLC is used.Weld Start & Weld Stop as per the PLC program. Teach Pendant is also connected to the PLC so that Programs done by the Teach Pendant can be save in PLC also.

PLC programming languages:-

-Relay ladder or Relay ladder logic

-Sequential function chart

-Functional block diagram

-Structured text instruction list

-Continues function chart

PLC:- DELTA PLC

Programming Language:-Relay Ladder Logic.

Type of instructions:-Relay instructions.

8)EXPERIMENTATION:

Case study 1:-Generating name AVCOE on MS plate of thickness 1mm.

Gas used: CO_2 (100%)

Workpiece metal: Mild steel

Welding Type: MIG Welding

Fig.2 Experimental Setup

Fig.3 Case study Result

Program:

```
PROC AVCOE()
    MoveJ [[395.76,299.07,-513.74],[0.94934,0.0171626,0.31377,-0.00279752],[-1,0,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v100, z50, tWeldGun\WObj:=wobj_fixture;
    MoveJ [[246.12,209.01,-248.93],[0.954346,0.289768,0.0221103,-0.0690571],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v100, z50, tWeldGun\WObj:=wobj_fixture;
    MoveJ [[32.34,102.58,-82.00],[0.949863,0.243686,0.175739,-0.0865669],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v100, z50, tWeldGun\WObj:=wobj_fixture;
    MoveJ [[33.91,102.38,13.84],[0.977462,0.127235,0.167175,0.0207852],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v100, fine, tWeldGun\WObj:=wobj_fixture;
    WaitTime 2;
    Set DO10_5WeldStart_Stop;
    MoveL [[94.45,102.38,16.19],[0.977456,0.127237,0.16721,0.0207722],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
    MoveL [[154.84,100.65,18.41],[0.977435,0.127353,0.167249,0.0207278],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
    MoveL [[243.97,100.64,19.65],[0.977438,0.12733,0.16725,0.0207401],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
    MoveL [[340.81,100.66,19.35],[0.977458,0.127254,0.167182,0.0208025],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
    MoveL [[380.77,100.68,18.92],[0.977466,0.127113,0.167236,0.0208493],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
    MoveL [[380.78,155.08,18.01],[0.977459,0.127159,0.167246,0.0207981],[-1,-1,-1,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09
```

```
+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
        MoveL [[380.77,210.83,19.46],[0.977459,0.127166,0.167245,0.0207946],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
        Reset DO10_5WeldStart_Stop;
        MoveJ [[380.78,210.91,-114.54],[0.977493,0.126935,0.167212,0.0208394],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v1000, fine, tWeldGun\WObj:=wobj_fixture;
        MoveJ [[380.79,268.75,20.03],[0.977466,0.1271,0.167251,0.0207946],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v1000, fine, tWeldGun\WObj:=wobj_fixture;
        WaitTime 2;
        Set DO10_5WeldStart_Stop;
        MoveL [[314.04,269.58,20.95],[0.977455,0.127172,0.167265,0.020763],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
        MoveL [[242.12,272.92,21.78],[0.977451,0.127187,0.167276,0.0207617],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
        MoveL [[166.59,275.32,21.31],[0.977466,0.127118,0.167234,0.0208385],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v10, fine, tWeldGun\WObj:=wobj_fixture;
        Reset DO10_5WeldStart_Stop;
        MoveJ [[166.57,275.32,-113.14],[0.977437,0.127268,0.167308,0.0207069],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v1000, fine, tWeldGun\WObj:=wobj_fixture;
        MoveJ [[334.82,275.40,-396.85],[0.977462,0.127129,0.16727,0.0206867],[-1,-1,0,0],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]], v1000, fine, tWeldGun\WObj:=wobj_fixture;
    ENDPROC
```

Results:

Workpiece Deformation, High rate of scattering, Improper welding, Boding between deposited material & w/p material is not proper, therefore after the welding the weld material is easily removed.

Causes: 1) W/P deformation is due to no clamping is there. 2) High rate of scattering because of improper gas combination used. 3) Due to W/P deformation shape of workpiece gets changed because of this welding is not done in proper way.

9) Conclusion:-It is found that for proper robotic welding proper fixture, proper gas mixture & workpiece material plays the important role in the quality of welding. Also a wire feed rate, tool travel speed is also have to take under consideration. Heat generation is the main factor in robotic welding. Programming should be done as the tool travel distance should be as minimum as possible so that the production rate will increase as production time will gets reduced.

References

[1]Saurabh Kumar., Khotiyan Sandeep Kumar, “Investigation of Microstructure and Mechanical Properties of TIG and MIG Welding Using Aluminium Alloy”. International Journal of Education and Science Research Review. Vol-1. 2014

[2]A.Gnanavelbabu, P.Arunagiri&D.Dhanasekar "Implementation of Robotic Welding for the Improvement of Production Systems" International Journal of Engineering Trends and Technology (IJETT) – Volume 49 Number 5 July 2017

[3]Tang Sai Hong, MortezaGhobakhloo, WeriaKhaksar"Robotic Welding Technology" RESEARCHGATE

[4]By J. Norberto Pires, Altino Loureiro, T. Godinho P. Ferreira, B. Fernando, and J. Morgado "Using Object-Oriented and Distributed Software to Assist Industrial Robotic Welding Applications" RESEARCHGATE JUNE 2003

[5]StefaniaPellegrinelli, Nicola Pedrocchi, Lorenzo Molinari Tosatti, Anath Fischer, Tullio Tolio "Multi-robot spot welding cells for car body assembly"ScienceDirect 1 Aug 2016

[6]http://www.zoombd24.com/gas-metal-arc-welding-gmaw-components-and-working-principles/