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"Sharpening Skills..... Serving Nation"

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Robotic & Automated Welding

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ABSTRACT: -
Welding is the joining of metals. What welding does is join metals or other materials at their molecular level with the technology we have at the moment. I say "at the moment" because welding technology is always changing, and with so many military forces relying on it to make their defense products, there are welding processes we are yet to hear about. What we know about modern welding is that there are four components to a weld. The four components are the metals themselves, a heat source, filler material, and some kind of shield from the air. 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 oxy-fuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after.

Robot welding is a relatively new application of robotics, even though robots were first introduced into US industry during the 1960s. The use of robots in welding did not take off until the 1980s, when the automotive industry began using robots extensively for spot welding. Since then, both the number of robots used in industry and the number of their applications has grown greatly. In 2005, more than 120,000 robots were in use in North American industry, about half of them for welding. Growth is primarily limited by high equipment costs, and the resulting restriction to high-production applications. In 2014, FANUC America Corp. introduced a low cost arc welding robot to provide small manufacturers with a cost-effective robotic arc welding solution.

Keywords: Welding, automated robot system, program .type of welding, welding requirement, use in industry, servo motor, torch nozzle, etc)

1. INTRODUCTION

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 SMAW, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as GMAW, SAW, FCAW and ESW. Developments continued with the invention of laser beam welding, electron beam welding, magnetic pulse welding (MPW), and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is commonplace in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality Due to continual increase in the need of high production rates, accuracy and labor costs, automation have been adopted to the welding technology. First automation applications started with mechanized, automatic and semi-automated MIG-MAG systems

as well as SAW. Robots have been used in many industrial applications including welding technology in order to increase efficiency, reduce overall costs, and increase productivity and product quality as well safe working conditions. After using of first robot on spot welding in 1970s, arc welding robots were first introduced after 10 years later due to accuracy problems.

- MIG-MAG and TIG welding are mainly preferred Hazardous working conditions may lead to use robots.
- Flexibility in different production line.
- Reduction in overall costs
- Increase productivity
- Eliminate human faults
- Increase repeatability in accuracy

LIMITATIONS:

- Not feasible for small amount of workless adaptation capability for design changes during production
- Accessibility.
- Adaptive control mechanism and software are not still efficient

Scope of welding processes:- In the case of the arc welding methods we employ, even the movement of the torch is automated: therefore, the welding operators tend to become machine operators. We consider that it is vitally important for the welding operators to master the contents of "Semi-automatic arc welding, "specified in the MANUFACTURING PART , as the basics of welding and as a comprehensive body of technical knowledge, so that they will never depart from the principles of welding. Therefore, we will develop this training course in line with that mindset.

Figure 1 Welding

- Thus, robotic welding is feasible for high and medium size production numbers
- The dimensional tolerances must also be determined during production. Superiorities to semi-automatic systems:
- High efficiency
- Improved health and safety
- Increased quality
- Strong welds

Figure 2 Welding Robot

Welding terms and definitions (frequently used terms)

Welding :- An operation to join two or more pieces into one piece by means of heat, pressure, or both, so that the joined piece is continuous. Remarks: This definition is valid regardless of the use or absence of a filler metal.

Arc welding: - A process performed by means of the arc heat. This method can be roughly divided into two major variants: A.C. arc welding and D.C. arc welding.

Automatic welding:-A collective term denoting various methods which utilize a machine or system to perform continuous welding, without continuous assistance from an operator

Mechanized welding:-A welding process in which various operations, such as parts feeding, wire feeding, clamping, feed, rotation, reversal, discharge, etc., are mechanized and power-driven.

Weld zone:-A collective term denotes the weld metal and the surrounding heat-affected zone.

Heat-affected zone:-A portion of the base metal which has not been fused but whose metal structure, metallurgical properties and mechanical characteristics have changed due to the heat generated by welding or cutting.

Weld metal:-Part of the weld zone has fused and solidified during welding. (In the case of the resistance welding method, "nugget" is applicable as the weld metal.

Figure 3 Weld Zone

Deposited metal:-The filler metal deposited into the weld zone.

Fused zone:-Part of the welded zone; it is the portion of the base metal, which has fused and solidified.

Welder:-A machine used for welding. This is a generic term applied to various kinds of welding equipment and is generally an aggregate of several components

Torch: - A device used for heating, welding or cutting metallic or other materials by the use of a gas flame, gas-shielded arc, or plasma arc.

Base metal: - Metal pieces (or metallic materials) which are welded together or cut by melting.

Welding materials:- A collective term which covers coated electrodes, welding wires, flux, shield gas and other consumables used for welding.

Consumable nozzle:- A metal tube which guides the welding wire to the welding zone and at the same time supplies electric current. This metal tube fuses and becomes part of the deposited metal.

Semi-automatic arc welding An arc welding process, for which the welding wire is automatically fed but the operation of the welding torch is handled manually. Sometimes, it is simply called "semi-automatic welding."

Theoretical throat thickness:-The throat thickness used for design calculations. It refers to the size of a fillet weld, i.e., the height of a triangular fillet weld as measured from the root of the joint.

Extension length:-The length of the wire which is extended beyond the tip of the contact chip.

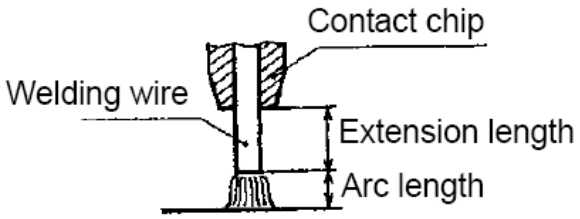


Figure 4 Extension Length

CO2 arc welding:-

1. **Principles of CO2 arc welding process.**

The welding wire, which is wound in the form of coils, is fed by the feed rollers through the flexible conduit tube to the welding torch. Electricity is supplied through this wire via the contact chip in the torch, an arc is generated within the stream of CO2 gas between the wire and the base metal, and, by means of the heat generated by the arc, and both the welding wire and the base metal are continuously fused

The wire is used as the electrode and deposited onto the base metal; thus, the wire is consumed. So, this welding method is called "consumable electrode-type welding." Necessity of CO2 gas mainly comes for protection, since direct contact of the arc or the fused metal with the surrounding atmosphere (oxygen and nitrogen) would effect badly on the welded metal.

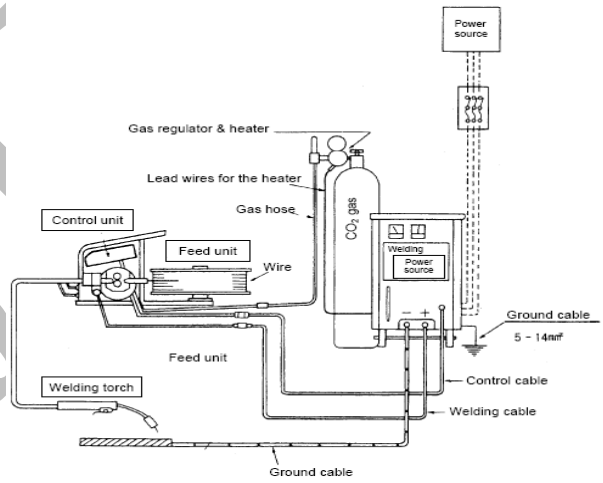


Figure 5 Formation and connection of welder

Manipulator:-

- Mechanisms which supply necessary movement for welding
- The most used mechanisms (robots) are:
  - 6-axes vertical Articulated: 3 dimensional welding can be done.
  - 5-axes Hybrid Articulated: fast vs mostly preferred for horizontal parts.

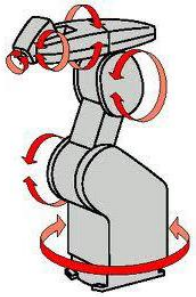


Figure 6 Robot AXES

Control Unit:-

- Movement of the torch is determined
- Reference points (knot points) and welding parameters on these reference points are determined
- The control unit controls these guidance.
- Control unit determines the rotational speed of joint (linkage) motors, speed and moments according to the data obtained from positional sensors.
- Number of axes and additional units (positioner, slider and secondary robots)…
- Control units are able to handle up to 15-axes.
-

Figure 7 Welding Torch systems

Welding Torch systems:

- Water cooled is used to reduce spaterring and increase torch life.
- Composite nozzle material used to increase torch life
- Spring systems used to minimize the torch-work piece collisions and thus positional accuracy is maintained.
- Welding torches must be cleaned regularly.
- Welding torch cleaning unit consists of 3 parts:
    1. Torch cleaner
    2. Torch lubrication
    3. Wire cutting

"Wire feeding unit:-Wire feeding must be supplied during welding process without any interruption."

Figure 8 Wire feeding Unit

Welding speed & repeatability:-

- Robots used in welding technology have 0.75-1.5m/s (45-90 m/min) linear speed.
- In fact, 5 m/min is upmost limit for robots, but maximum travel speed and time interval between each weld affect the total time.
- Small radii movements may lead to unstable welding speed. The solution is to incerase the rotational speed of linkage motors.
- Repeatibility Most of the welding robots have +0.2mm repeatibility accuracy. For instance,
- MIG/MAG welding robot is allowed to deviate from welding line as half of the wire diameter.
- Deviations may lead to faulty welds.

Robotic Welding Cell:-

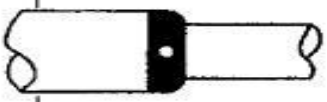
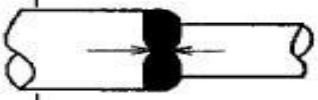
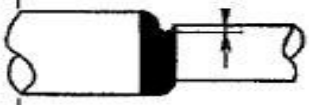
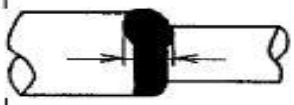
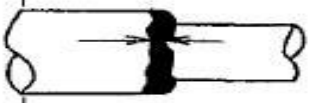
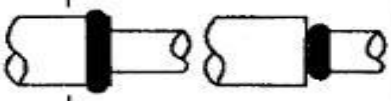
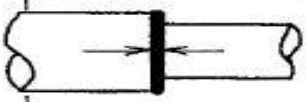
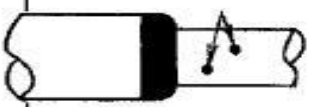
- Purchasing robots and welding equipments.
- Software and Hardware requirements.
- Robotic systems, power supply, torch unit, positioner, security facilities etc.
- Working space must be planned in the factory.

Interface and Signaling:-

- Welding robots must communicate with all the other systems used in the production line For instance, work piece positioner, power supply units, control panel, fixturing, locks and security panels,
- CIM is the key approach in that sense.
- Some of the standard protocols must be used in order to integrate all the facilities in a welding cell: Modbus, Profibus, Canbus.

How to confirm weld quality

a) Defective bead appearance, causes and countermeasures

Items	Causes	Checking/adjustment
Pinhole 	• Insufficient CO_2 gas • Contamination of base metal	⇒ Any gas leakage? ⇒ Is the gas pressure of the container sufficiently high? ⇒ Remove any heavy contamination!
Insufficient bead-lapping 	• Insufficient lapping • Slip between the work piece and the drive • Unstable initial arc	⇒ Check the setting. ⇒ Fix the grip device. ⇒ Recheck the welding conditions. ⇒ Recheck the target position.
Undercut 	• Too fast welding speed • Too high welding current. • The targeted position is wrong.	⇒ Adjust the welding speed. ⇒ Check/adjust. ⇒ Check/adjust.
Overlap 	• Too low welding current. • The targeted position is wrong.	⇒ Check/adjust. ⇒ Check/adjust.
Irregular bead 	• Wear of the chip • Inappropriate welding conditions • Clogging in the conduit tube	⇒ Check/replace. ⇒ Check/re-adjust. ⇒ Clean.
Cracks/flaws 	• Too high welding current/ voltage. • The base metal is a high-carbon steel.	⇒ Check/re-adjust. ⇒ Pre-heating/post-heating is needed.
Misaligned bead 	• The torch position is misaligned. • The positioning of the work piece is inappropriate.	⇒ Check/re-adjust. ⇒ Fix the positioning device.
Narrow bead 	• Too low welding current/ voltage.	⇒ Check/re-adjust.
Sticking of spatter 	• The movement of the cover is defective.	⇒ Check/repair

Important Functions of an Arc Welding Robot:- The Robot Program

(A) Programming Method. First generation robots were programmed by manual operation. However, in modern technology, there are four common methods for robot programming; namely: Programming by a Teach Pendant. The operator uses a dedicated teach pendant for robot teaching and program editing. Teaching is carried out for the tool center point (TCP) and the LCD display panel is adopted for menu guide. It is easy to use but restricted in application and extension. A teach pendant is the most popular device in robot programming

Figure 9 Teach Pendent

- Programming by Manual Lead-Through. A well trained welding expert will hold the holder near the torch and program by manual lead-through. This was common in first generation robots, however, in modern technology, this is only used for spray painting robots.
- Programming by a Robot Language. The robot is programmed by a program language using a monitor and a keyboard. There exist several command, motion, and operation level languages. Commonly used robots can take advantage of a broad range of motion level languages. The operation level language only describes the final goal of the process, and the sequence of motion and data are generated automatically. This programming method still remains very much in the research stage.

Programming by a Simulator. A graphic simulation is performed and it is translated into the language of the robot. This is also referred to as off-line programming. The welding data is composed of start data, main data, end data, and weaving data.

CONCLUSION:

Robot Welding has raised the production much more than the manual welding. There is no hazard in working even in hazardous conditions. Besides the products will be more durable and smooth finish having top quality control so that it will attract the consumers. Therefore the producers prefer for robot welding for mass production at less price.

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