ROBOTS IN WELDING OF AUTOMOTIVE COMPONENTS

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In the present day industrial scenario, there is cut-throat competition and only the best and fastest can survive through. The key words that govern today's manufacturing industries are Productivity, Quality and Consistency. If these are neglected, the industry is definitely bound to loose out from the fast track. The realization of this fact has lead to the large-scale automation of today's manufacturing and production units. The ever higher demand for quality products at the lowest lead times is only possible through worry free automation of manufacturing activities. Automation has seen itself in every manufacturing operation right from raw material processing to dispatch of finished goods to the customer.

The widespread benefits of automation are lately being realized in the field of welding automotive components too. The automation could be a simple one with a mechanism to guide the torch on the work-piece or vice versa, or it can be much more flexible using an Industrial Robot. The benefits of a Robot such as tireless working, consistency, productivity gains, lesser rejections and better quality is being reaped by the fabrication units for maximum benefits.

The majority of the early installations were in spot-welding applications in the automotive industry and today it is unusual to see a car plant without a pair of 100 Robots doing spot welding of the car body. These successes lead to Robots being tried for other welding operations like the Arc Welding. However the task was not simple, since the industries were not geared up for the quality and consistency requirements of the input components for Robotic welding. Many of the successful installations are due to concentrated efforts of the Robot manufacturer and the user.

One of the major applications of Robotic Arc Welding, especially Gas Metal Arc Welding is in the field of two wheeler frames and its sub-assembly component welding. A typical two-wheeler frame is made up of tubes, joined to each other in different forms along with sheet metal reinforcements and brackets. The thickness of the sheet metal, tube may vary from 1.0mm to 3.0 mm. Generally the tubes, sheets are made of steel, but aluminium is also used sometimes. Some of the components in the automotive industries that are Robotic welded are

Two-wheeler Manufacturing units

- Chasis or frame.
- Exhaust muffler.
- Swing Arm brackets.
- Front fork assemblies.
- Fuel Tank
- Wheel drum

Car and Heavy Vehicles manufacturing units.

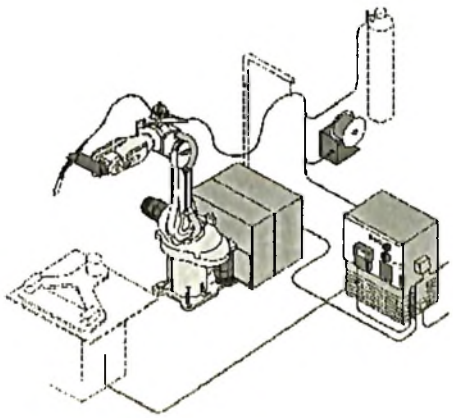
- Exhaust
- Door Sash.
- Under Body frame.
- Wheel Drum
- Seat fabrication

Earth Movers (Heavy Welding)

- Excavator Bucket welding
- Boom welding
- Tipper body

Robotic Welding gives a high degree of flexibility in setting up the parameters for welding. Process equipments are developed that can be easily controlled through the Robot for varying parameters like the Voltage, Current and the Welding speeds. Advances are also made in the development of equipments that would operate reliably, such as torches designed for Robotic welding and automatic torch cleaning devices, to ensure that the torches are kept in optimum condition. There are certain special features incorporated in the Robot to carry out quality welding. Torch guard is a special feature, which stops the Robot immediately on sensing a slight collision. This prevents damage to torch. Servo torches use servomotor for wire feeding. Better results can be achieved in welding of aluminium and thin sheet metal plates with servo torch. Seam tracking can be done using laser beam (MIG EYE for FANUC Robots), which identifies the seam and shifts the path accordingly. Coordinated motion of Robot and Positioners realize higher speed and higher quality welding by proper torch orientation and constant welding speed.

The location of the robotic welding cell inside the plant is of great importance. It should be located such that there is sufficient place and provision to store the input components. The components should be handled with ease to Welding Station and provide easy accessibility for maintenance of the Robot and other peripheral equipments. So one has to start with the Plant Layout before venturing in to the design of the Robotic Cell. The figure shows a typical Robotic Arc welding work cell.



The main items involved in a Robotic Arc Welding Cell for welding frames are generally;

- Robot
- Welding Power Supply Unit.
- Positioners and Indexers.
- Component Holding Fixture.
- Automatic Torch Cleaning Unit.
- Torch Recovery Jig.
- Welding gas unit.
- Welding Wire Spool.
- Exhaust System
- Safety fence and Interlocks.

Robot

Nowadays, six axes Robots are generally used because of the high degree of flexibility they offer. A Robot with appropriate reach must be selected, so that it can reach to all the weld beads on the frame. Enhanced Servo Motor technology through reduced size and weight and increased torque performance is now being incorporated within Arc Welding Robots to realize faster and efficient working.

Weld Power Source:

The economic success of a fabrication is critically dependent on the selection of the most cost effective welding procedures. Hence the importance of companies keeping abreast of the latest developments in arc welding technology to ensure that the most cost effective and reliable procedures are used. The latest developments and technologies have made it possible to achieve high speed welding, without compromising with the quality and appearance of the weld. Robots are now available with integrated weld power source that enable better control of the welding parameters.

Positioners and Indexers:

Robot is a flexible tool, however at times this flexibility becomes insufficient due to complicated

profiles of the component. Torch posture and torch angle are two important criterions that decide the welding quality. Therefore it is very much essential to present and orient the component in the appropriate fashion for welding. Positioners and Indexers are used for this purpose. They provide better approach and accessibility for welding. Positioners can be single axis, 2 axes or up to 4 axes, based on the complexities of the component and the demands of the application.

Component Holding Fixture:

A component holding fixture locates and clamps the component to be welded. The locating points on the fixture must be such that it locates the component with precision and repeatability. The fixtures must be designed for accuracy and rigidity. The fixture is either placed on a stationary platform or on a positioner or an indexer when the component profile is complicated. The design must also enable free access of the Robot weld-gun to the welds. Some of the points that need to be considered during design of welding fixtures are as follows:

- Details subject to wear, such as pins and bushings should be hardened.
- Areas subject to weld spatter must be of Class II copper.
- Do not permit grounding paths through moving bushes or toggle clamps.
- Fixtures should allow for some adjustments by shims or threaded stops to allow for dimensional variation found in parts.
- Cover cylinders, shafts and slides that are subject to weld spatter with protective shields made out of aluminium.
- Precision-bored dowels must hold component that are subject to replacement and that require accurate location.
- Fixture design must accommodate part distortion and maintain part location and alignment during welding.

Automatic Torch Cleaning Unit

This is equipment that is used to clean the spatters off from the welding torch. The unit compromises of a reamer, which rotates inside the torch to give the cleaning action. Additionally a torch-cleaning unit may also have a wire trimming unit and an anti-spatter fluid dip.

Torch Recovery Jig.

One of the major problems in Robotic arc welding is the shifting of the Robot path when there is damage on the torch. A torch recovery jig calibrates the damaged torch and accordingly shifts the path. This avoids the tedious job of reteaching the Robot, thus saving valuable production time. The technology is available with FANUC Arc welding Robots.

Others

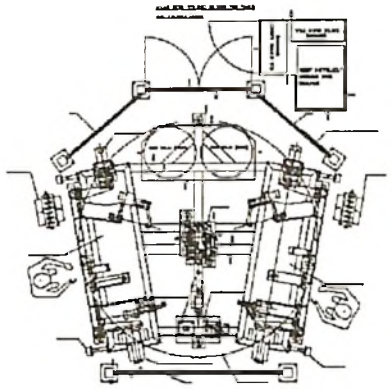
The other items in a Robotic cell are the welding gas cylinders, wire spool, exhaust system etc. The welding gas is generally carbon dioxide or a mixture of carbon dioxide and Argon gas. It can be supplied through a single cylinder or through a cylinder bank. Wire spools supply the wire to the wire feeder. An overhead exhaust system is provided to suck the welding fumes and leave it in to the open air. The entire cell must be enclosed within a safety fence and sufficient interlocks must be provided to prevent any mishap.

Some of the commonly used concepts of Robotic Welding Cell in a two-wheeler industry are shown below.

Concept-1:

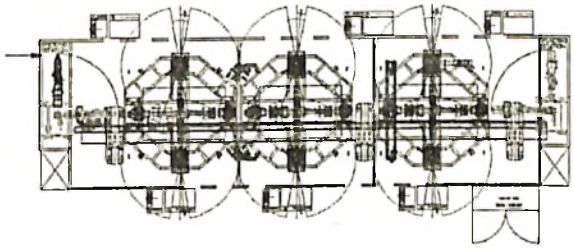
In this concept one Robot and two fixtures are used. The fixtures are mounted on the Servo Positioners, which can rotate along its axis. The Positioner axis is controlled through the Robot and can rotate simultaneously with the Robot. The fixtures on each positioner could be for the same frame or different frames. Design changes can be met by changing the fixture alone on the Robot. Such cells are easy to manufacture, have lesser lead times and can be put

into operation within a short time. However they suffer from limitations like higher cycle time and difficulty in controlling distortion.



Concept -2

In this concept two robots weld a single frame on each side. Such concepts are used where there is a requirement to control the distortion on the frame and also achieve lesser cycle time. Simultaneous welding of the frame by two robots controls distortion. With simultaneous welding, the heat input balancing on the frame can be done more effectively leading to lesser distortion. Since two robots share the total welding the cycle time is halved.



Concept -3

This is a variation of concept-2, except that four Robots are used to do the welding on a single frame. Such layouts are also aimed at reducing distortion and cycle time. The cell is quiet dense, as a result one or more Robot waits to avoid collision between Robots during welding.

From the analysis so far we have seen that controlling distortion is an important factor. But the question arises what is Distortion and what are the factors affecting it?

Welding involves highly localized heating of the metal being joined together. The temperature distribution in the weldment is therefore non-uniform. Normally, the weld metal and the heat-affected zone (HAZ) are at temperatures substantially above that of the unaffected base metal. Upon cooling, the weld pool solidifies and shrinks, exerting stresses on the surrounding weld metal and HAZ.

If the stresses produced from thermal expansion and contraction exceed the yield strength of the parent metal, localized plastic deformation of the metal occurs. Plastic deformation results in lasting change in the component dimensions and distorts the structure. This causes **distortion** of weldments.

Factors affecting distortion are:

- Amount of restraint
- Welding procedure
- Parent metal properties
- Weld joint design
- Part fit up

Restraint can be used to minimize distortion. Components welded without any external restraint are free to move or distort in response to stresses from welding. This restraint does result in higher residual stresses in the components.

Welding procedure impacts the amount of distortion primarily due to the amount of the heat input produced. The Robot has better control on the heat input specified in a welding procedure, since it can control the welding parameters as per the requirement.

Parent metal properties, which have an effect on distortion, are coefficient of thermal expansion and specific heat of the material. The coefficient of thermal expansion of the metal affects the degree of thermal expansion and contraction and the associated stresses that result from the welding process.

Weld joint design will effect the amount of distortion in a weldment. Also root gaps indreases distortion. Therefore care must be taken to produce components with good joints and fit -up.

Part fit up should be consistent to fabricate foreseeable and uniform shrinkage. Weld joints should be adequately and consistently tacked to minimize movement between the parts being joined by welding.

How to make Robotic Welding Installation Successful?

Robots are used for all types of welding applications. Some have long cycle times and some have short cycle times. Some are in multiple- robot lines and some are in simple work-cells. Regardless of how we are using Robots, there are some areas we have to examine to increase productivity:

Optimize the process

Robotic welding process can be made the best by using the proper weld wire, wire diameter, power source, shielding gas, torch angle and weld joint position. Robot should deposit the same amount of weld material, since over welding is expensive and wasteful.

Minimize Part and Joint Variations

Welding on inclined planes necessitates slower travel speeds to produce a given quality level. Weaving to fill gaps or touch-sensing greater lengths to find joints will cause additional cycle times. Robots always work better with better piece part consistency and fewer variations. Any improvements in the upstream part production processes will result in improvements in the welding process.

Optimize the Robot path and movements

The program should be made for smooth, even motion at the weld joints. Air-cut time must be minimum by programming all air cut motion as joint moves with continuous termination and at maximum speeds.

Optimize cell design and parts flow

The layout should be made considering the factors like movement of input components to the welding cell, movement of welded components from the Robot Cell, Storing facilities for components and placement of other equipments considering there importance.

Using simultaneous Functions and minimize waiting sequence

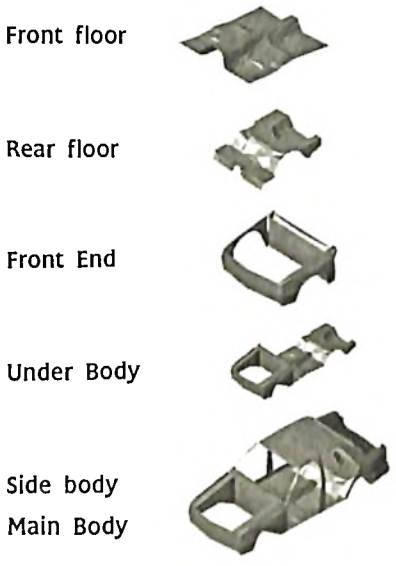
Robot programs run in a sequential manner, executing one step at a time. We should look for areas in which different functions can work simultaneously. For example when operator loads a new component, the Robot can do the torch cleaning operation.

Routine Maintenance.

Planned and scheduled maintenance, preferably during nonproductive hours, consumes less time and is more effective than reacting to unexpected breakdowns. Maintenance for a welding Robot includes daily tip changing and cleaning of the fixture and torch. It also includes periodic check for cable wear, axis lubrication, and wire liner changes. Proper and timely attention to these tasks will yield better welds and increased machine availability and production time.

Robotic Spot Welding

The spot welding robot is the most important component of a robotized spot welding installation. Generally such installations are used in car and automobile industries for manufacturing body in white. Some of the important components that are Robotic Spot welded in a Body in White factory are



Welding robots are available in various sizes, rated by payload capacity and reach. A spot welding gun applies appropriate pressure and current to the sheets to be welded. There are different types of welding guns, used for different applications.

Typical components of an integrated robotic spot welding cell:

Spot Welding Robot
Spot Welding gun
Weld Timer
Gun Tip Dresser
Cable Dressout.

The figure shows a car body building line with Robots.

Spot Welding Robot

A robot can repeatedly move the welding gun to each weld location and position it perpendicular to the weld seam. It can also replay programmed welding schedules. A manual-welding operator is less likely to perform as well because of the weight of the gun and monotony of the task.

Spot Welding Guns

Spot welding gins are normally designed to fit the assembly. Many basic types of guns are available, the two most commonly used being the direct acting type, generally known as a "C"- type gun, where the operating cylinder is connected directly to the moving electrode, and the "X"-type(also known as "Scissors" or "Pinch") where the operating cylinder is remote from the moving electrode, the force being applied to it by means of a lever arm. C guns are generally the cheapest and the most commonly used. There are many variations available in each basic type with regard to the shape and style of the frame and arms, and also the duty for which the gun is designed with reference to welding pressure and current.

Pneumatic guns were generally used earlier but nowadays servo guns are usually preferred because they are faster, and they apply a uniform electrode force.

Weld Timer

An automated spot welding cell needs control equipment to initiate and time the duration of current. A spot weld timer (weld control unit) automatically controls welding time when spot-welding. It also may control the current magnitude as well as sequence and time of other parts of the welding cycle.

Gun Tip Dresser

The function of the electrodes is to conduct the current and to withstand the high pressures in order to maintain a uniform contact area. Uniform contacting areas should therefore be maintained.

Good weld quality is essential and depends, to a considerable degree, upon uniformity of the electrode contact surface. This surface tends to be deformed (mushroomed) with each weld.

In automatic tip dressing, a tip dresser is mounted on the line where it can be accessed by the welding robot. The robot is programmed to dress the electrodes at regular time intervals. The dressing can be done after each working cycle, after every second cycle, and so on. It depends upon how many spot-welds are done in each cycle. The dressing takes approximately 1 to 2 seconds, and is performed when the work pieces are loaded, unloaded and transported. Maintaining proper electrode geometry minimizes production downtime and utility costs and increases weld efficiency.

Cable Dressout

One of the major problems in Spot welding Robots is the problem of twisting, wear and tear on the cables. The cables must be properly routed along the arm to avoid twisting and rubbing. Some swiveling arrangements may also be used for doing this. Nowadays Robots are available in which the cables can pass through the arm, thus avoiding twisting.

Conclusion

As the automotive industries are growing, they are realizing that quality products can be produced only by separation of skilled labour from the processes and automating it. Hundreds of small and medium-size manufacturers and job shops are learning what major corporations have realized for many years - that robotic welding is not only highly productive, but also very affordable. In fact, for most shops it's cost economical to weld many jobs using Robots. In times when companies need to streamline operations and fine-tune manufacturing costs, robotic welding just makes sense.