Robotic Welding Systems:

A guide to implementing automated welding in your facility

Part 2: Implementation and Deployment

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Introduction

The first part of this ebook, Robotic Welding Systems, focused on the early stages of planning for automated welding, including defining your goals and welding process, and learning about system options.

Part two is about what to expect and plan for with a new automated welding system in place. It covers changes to shop culture and training needs to anticipate for equipment operators, as well as risk assessment and safety equipment options. Details on how robotic welding can boost efficiency and even expand your repertoire are explained next. Finally, learn how built-in data collection and analytics let you track performance, identify problems, and plan for the future.

1. Employees and shop culture

Most companies don't intend to use automated welding to reduce welding staff. Rather, they're responding to needs for increased production and efficiency. Automating the repetitive, simple, and high-volume welding work is a way to free up skilled welders for more complex jobs or high-mix work where robotics may not be suitable. It also changes the look and feel of the facility and the work, and brings new skills and responsibilities. A mindset shift is required by everyone involved to adjust to the change in culture.

Job security and employee buy-in

You'll want to create an internal team to work with an automation vendor, make plans, and implement the project. Team members typically include welders and other equipment operators, engineers, operations managers, as well as quality, safety, and maintenance staff. This group's commitment to a successful transition and their enthusiasm for the changes influences other employees and helps with buy-in. This is especially the case if it's your company's first experience with automated manufacturing equipment.

You can improve the odds that the coming automation transition is a positive experience in these ways:

- Emphasize the big picture. Explain how robotic welding is a positive change for the whole company, affecting the continuous improvement of operations and end products as well as gaps in staffing.
- Don't make assumptions about buy-in.
    - Older employees may welcome the change to their workload or physical challenges of welding work.

    - Younger employees might not immediately see the need to invest in a larger cell that can be expanded in the future. Remember that mindset is more often about personality than age.
- Get hands-on. Provide early and frequent opportunities to get familiar and comfortable with the equipment. This helps employees trust that they will still have a role to play.
- Keep lines of communication open. Management and decision makers foster transparency and build trust by communicating about the project and directly addressing fears and questions of workers.
    - Directly address concerns of being replaced by a machine, especially if they perceive their work as highly specialized. Emphasize the shift in the nature of the work and opportunities to learn more skills. Try to include your best welders in planning so they can rally fellow welders.
    - Reassure engineers that they can get their usual work done and won't become the programmers or tech support for the new equipment and workflows.
    - Demonstrate how safety and ergonomic concerns will be better for safety inspectors.
    - Provide examples of how part consistency and production will be improved and human error will be reduced over time for quality and inspection staff.
- Create a plan for new roles and responsibilities. Identify who does what and document these changes to your workflows (e.g. powering the robot up or down, placing calls to your integrator with questions, documenting troubleshooting efforts, reloading gas tanks or wire spools).

Skills and training

Training and hands-on interaction with the new equipment increases employees' comfort levels. Keep these points in mind as you plan for training:

- Your automation integrator probably offers training on operation, trouble-shooting, and the computer interface that runs the machine.

- Certified and experienced welders will still need training on the operating system, safety guarding, setting up and removing parts.
- Non-welder operators may need training about what makes a quality weld and how to inspect finished pieces for errors. This is in addition to the safety and operational basics of the cell.
- Engineering and maintenance staff may need additional specialized training (e.g. programming, using teach pendants, troubleshooting, adjustments to the robot).
- Experienced welders can be helpful during set up and initial use while debugging and checking for errors and quality, but most of the time it won't be welders running the machine.
- Users should be trained on and comfortable with the human-machine interface (HMI), analytics, and dashboards they'll use most often.
    - Consider how you'll set up levels of access and permissions for the different people working with the equipment (e.g. which features should be adjustable by the operator and which should be restricted to programmers and/or maintenance technicians?).
- Technicians and maintenance personnel should be trained on basic programming, including hand-guided "training" of the robotic arm and any teach pendant technology.
- Provide explanations of key automation terminology (e.g. end effector or end-of-arm-tooling, power source, teach pendant).
- Ensure everyone who will come into contact with the workstation and welding equipment understands and practices using all standard safety protocols and procedures .

Case Study Example

Improved quality on jobs

Before: A scroll fan blade required reaching under a rounded plate to weld, but it was difficult to access and make good quality welds.
Now: Welders who used to do this work now prefer the automated process because it reliably produces fewer defective parts.

The changing nature of work and developing an automation mindset

The very nature of manufacturing work changes when robotics are incorporated into the process. Welders and operators will notice these changes the most and it takes time to adjust (see section 2 for more on the physical changes to welding work). A successful transition depends on developing an automation mindset in these ways:

- Work should focus on maximizing machine uptime – an idle or underutilized machine impedes production and wastes money.
- The goal of an operator's work will change from pacing the manual activity they currently do over an eight-hour shift to maintaining the flow of components and parts in and out of the welding machine.
- Previous experience with manufacturing automation influences how quickly employees make the transition. If this is your facility's first robotic equipment, the learning curve could take months instead of weeks.
- Operators, engineers, and maintenance staff need to think in terms of what system components to check if there is a problem with the equipment. This could include part and robot set up, rebooting the computer, or checking connections.
- Especially in the early days, schedule some of your best acclimated operators and welders on each shift to ensure gains made during one shift are not lost during the next.

> **“A successful transition depends on developing an automation mindset and getting the whole team on board.**

2. Ensuring Safety

Welding is dangerous work due to exposure to heat, fumes, and bright light as well as prolonged standing and lifting. Automated welding does shift some of these hazards off the welder, but it doesn't eliminate them. New risks are also introduced. It's important to understand how the physical work of welding changes when robots are introduced, and to incorporate safety equipment and procedures. Critically, everyone who works with the equipment must follow safety guidelines each and every time.

Changes to the physical work of welding

As in other trades and types of manufacturing, welders are working to older ages and then not always being replaced quickly by younger workers. Automation helps make traditionally manual, physical labor more ergonomic and adaptable to changing needs of employees. In addition to reducing the physical demands of welding, use of motorized carts, hoists, or conveyors to move parts around the cell can further reduce stress and strain on workers.

Job satisfaction is important too. Consider a welder in a facility without air conditioning, donned in helmet, gloves, and jacket for hours, making the same weld on a very basic part for an entire shift. If a robotic welding machine took over the work on this basic part, the welder could have an opportunity to work on different and more interesting weldments. He or she might also be happier operating the welding cell and getting a break from the heat and monotony. Chances are he or she will appreciate the change.

Risk assessment and safety standards

A comprehensive risk assessment should be done at the very beginning of the planning process and revisited as necessary. Be sure results of the risk assessment are integrated with your internal safety standards too. Keep these points in mind as you plan for worker safety:

- Welders may be among the first operators of the new equipment, but typically, they won't run it over the long term. Welders are frequently redeployed in other areas of the facility for complex or high-mix welding. Therefore, operators with less welding experience must be trained to recognize and deal with common hazards of welding.
- When defining and categorizing risks, consider them individually and note the severity of the injury, the overall possibility or likelihood of injury occurrence, the possibility or likelihood of avoiding the injury, and the frequency of exposure to the particular risk.

- In addition to welding hazards, look at risks posed by secondary equipment like conveyors, material handling equipment, additional robotic arms, or suspended or raised equipment.
- ANSI and RIA (Robotics Industries Association) standard ANSI/RIA R15.06-2012 addresses robotic safety considerations including guidelines for:
    - Operations of robot under normal operating conditions and during teaching/programming, maintenance, setting, and cleaning
    - Unexpected startup or power surge or loss
    - Access from all directions around machine/cell
    - Misuse, whether intentional or accidental
    - Computerized controls failure
    - Application hazards (i.e. welding spatter, fumes, heat)
    - Increased welding volume also means greater exposure to heat, fumes, spatter, and flashes of light. Foot traffic and facility layout should also be taken into account when designing a work cell.

- Most if not all of your existing internal safety standards for welding still apply (e.g. status or condition of equipment at idle, guarding arc flash with a screen, allowable sizes of pinch points, required distance of light curtains from machinery). These should be documented and a copy given to your automation vendor.

Safety equipment and design

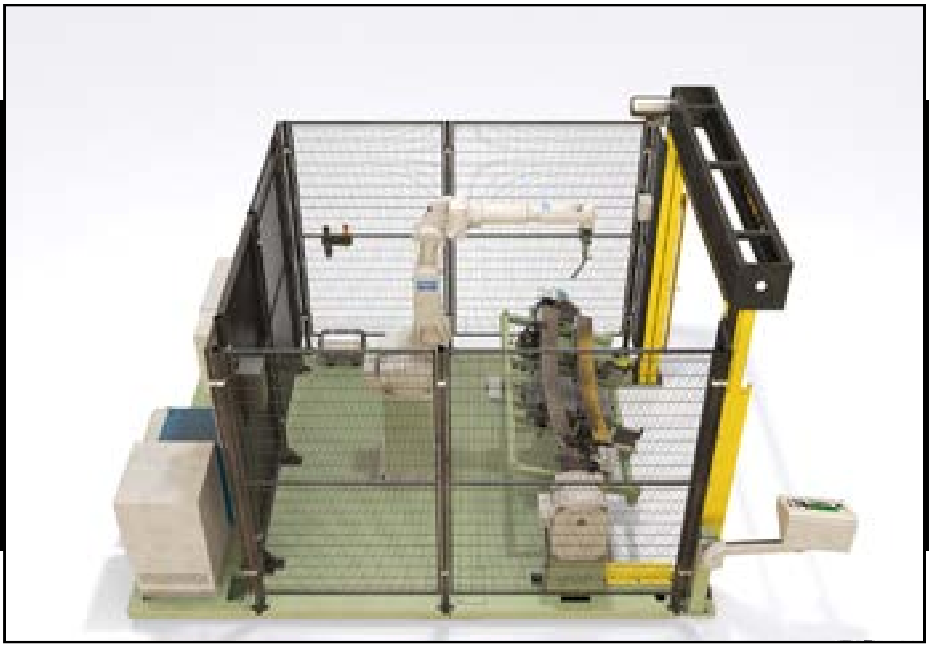
Operators, programmers, maintenance staff and others will all have reason to get close to the equipment for various purposes. Workers must be kept safe while still having adequate access to the machinery to get the job done.

Unfortunately, it's not uncommon in manufacturing and industrial settings for employees to avoid or create workarounds for safety equipment. If it's inconvenient, overly complicated, or time-consuming, it can be hard to convince people that bypassing safety equipment is not worth the risk. Simply put, safety must be a part of your company culture as an expectation at all levels and with accountability for those who don't comply.

Keep in mind safety equipment, design, and procedures vary based on the specifics of the application. Here are some examples commonly used with robotic welding cells:

- Guarding on exposed motors, gears, and belts
- Light curtains and perimeter monitors programmed with fast response time and located an appropriate distance from the machinery to allow it to come to a stop before a person can reach a point of danger.
- Physical barriers including overhead and sliding doors to block access to equipment and contain spatter.
- Area scanners that use radar to scan for planned and unexpected motion (e.g. scanner recognizes the machine's movements within a certain range and all other motion is considered potential human movement and triggers equipment to stop).
- Redundant or combination safety systems to prevent someone from turning a machine on while another person is in the cell, or that prevent an operator from accidentally turning it on with a stray motion (e.g. key lockout systems, clamps that won't move into position until a light curtain is no longer broken, two-hand power buttons).

- Locking guard and gates that cannot be propped open or removed.
- Operators must be trained on safe use of equipment, such as lock out/tag out systems. These allow one person to enter and engage their key or lock so no one else can run the equipment while the cell is occupied.
- Controls to prevent unintended operation or motion (axis limiting, hand guiding controls, monitored stops, power and force limiting controls)
- Indicator lights or other clear ways to show what mode/status the machine is in, and positive controls for initiation and reset of the machine, emergency stop, speed control, teach controls



Some hazards persist even when the power is off. For example, some machines continue to move due to inertia for a short time after power is cut. And any robot fitted with a dangerous end-of-arm-tool, such as a hot welding torch or a blade, is hazardous even when still.

Safety planning should also consider what happens to the equipment when the cell is de-energized or de-pressurized. This includes any equipment that must slow to a halt gradually, be lowered from an overhead position, or disengage from other equipment.

3. Planning for flexibility and the future

The system and capabilities you install today, including any plans for potential expansion of the welding cell, can influence the types of projects you take on in the future. Leaving yourself enough space to add a second robotic arm or conveyors or material handling equipment later makes expansion or adjustment easier. For example, it may be possible to add equipment that accepts larger or more complex welding work since you have the skeleton of the system in place already.

If one of your goals is to minimize return on investment (ROI) time for the equipment, maximizing machine uptime is key. Setting yourself up now for a wider range and volume of projects in the future is a great way to do that. See Section 4 for more on what contributes to ROI.

Do a walkthrough of your facility with an eye to welding work with automation potential, and think about ways you might expand the cell(s) you're currently designing. Keep these points in mind as you consider options:

- Welding robots have historically been large, industrial machines used in high-volume, low-mix production environments. As collaborative robot (also called cobot) technology continues to evolve however, some companies have begun using these smaller arms for welding. They have a smaller footprint and can be mounted on mobile platforms, making it possible to use them in multiple parts of a shop or for a larger mix of parts.
- Well-designed tooling can add flexibility to the system.
  - Use a fixture that can accommodate a family of parts that are similar so any one of them can be welded in that cell with simple changeover (e.g. three or four types of automobile seats).

- Cells can be designed to swap out fixtures as long as the general shapes, sizes, and materials of the parts are similar.

- If you anticipate doing a certain type of work in the future, consider installing a manual or automated positioner which is more flexible and easier for workers to adjust than a flat table.
- Balance any extra costs associated with flexible design with your budget and timeline – your integrator can help you select features that grow or expand with your needs (e.g. you may select simpler fixtures now but include mounting holes and brackets with the intention to switch them for motorized adjustable ones in 18 months, or select controllers that can be upgraded with new operating software and a touchscreen in the future.
- Look at a variety of welding cell configurations to maximize space, uptime, and throughput (e.g. single-robot cell, cell with one robot installed and space for a second, or cell with a single robot that moves between two or three workstations).
- Automation changes your production volume, so consider building in space to add a second robot or cell at a later date to accommodate more components, different sizes, or different access points as your capabilities increase.

Boost throughput with more machines.
Some companies start shifting from skilled welders to welding machine operators with a one to one ratio of operators to machines, then gradually move to one operator to several as more machines added.

4. Data collection, KPIs, and getting a ROI

Simple observation will usually tell you if your production rates are up or if quality issues are resolved. But to make business decisions that drive revenue and market share, you need the data to back it up and clarify the details.

Data is objective, not a guess or opinion, and today's automated welding equipment makes it easier than ever to track and analyze your operations.

Depending on your company's priorities and perspective, you may focus on one or all of these types of data:

- Process data – if the actual welding parameters are achieved and data about individual parts
- Production data – workflow in and out of the cell, operational effectiveness, and the bigger picture including up and downstream processes
- Quality/inspection tracking – time and date tracking on barcoded parts and assemblies that verify or certify some aspect of that part's production

The data you collect can be exported into reports or customizable dashboards for easy access and decision making, for example:

- Which shifts are consistently low or high
- Which operators' data indicate training needs
- Arc-on time, total deposition, and error frequency, sorted by part type or shift
- Where in the process bottlenecks appear
- If the welded component is within specifications or creeping out of bounds
- If a part or lot from one of your welding machines may be defective and a liability risk
- How long it takes to ramp up to a given production goal
- Debugging and troubleshooting bad welds or other problems

Most welding systems include build-in data collection features as part of their operating system and many can be networked with your other equipment and accessed in the cloud or on a secure local server. This lets you compare production data from different departments or facilities. You may also be able to integrate the onboard software with your manufacturing execution system (MES), enterprise resource planning (ERP), or inventory management system.

Key performance indicators (KPIs)

Just about any aspect of your welding operations can be tracked or calculated based on data the equipment collects. The numbers can show trends over time (e.g. a shift, a week, a month) or trace a single part through the welding process.

But just because you can track everything doesn't mean it's necessary. Determine the figures that are most meaningful for your needs, and focus on those. Some important KPIs include:

- Throughput
- Cycle time
- Scrap or rework rates, where parts must be removed and fixed by hand
  - Determine the root cause and make adjustments to the machine
  - Discover problems with tooling if issues persist or worsen
  - Especially helpful during debugging/troubleshooting with new parts
- Inspection parameters, especially if dimensions are trending toward limits
- Welding parameters
  - Current, length of arc, angle of torch/gun, manipulation of components, speed (CLAMS), heat/temperature, gas flow and pressure
- General machine uptime
  - Identify if downtime is due to operator load time, equipment failure, tooling adjustments, etc.

    - This data can be operator-dependent and varies based on their individual processes.
    - Commonly monitored in multi-shift production where one operator or shift outperforms another
    - Identify who needs additional training or familiarity with the system or who knows more of the “tricks and tips” to keep up the flow of parts
- Compare welding production data with trends from equipment and workstations up and downstream to see how the welder fits into overall productivity (e.g. a high rework rate on subassembly A adds to manual welding labor time and creates a backlog at the next station where it is joined with subassembly B, and could have a chain effect down the line)

Revenue, reduced spending, and ROI

Several factors influence the speed and amount of return you see from your investment in robotic welding. Even after you recoup the cost of the equipment, savings continues as long as you use it, adding to your profits and ability to expand automation. For example, if your hourly production rate increases, the outcome might be higher sales or the ability to fill larger orders. As a result, your revenue increases, which helps directly offset the cost of new equipment and accompanying expenses. If you hope to expand your use of automated welding or other robotic manufacturing processes, a good strategy is to start with whatever process has the lowest barrier to entry, in terms of budget or impact on production and build from there.

Taking a comprehensive view of ROI adds up:

- Employee cost savings such as
    - Redistributing staff to equipment that is easier to use, thereby making the best use of their skillsets
    - reassigning skilled welders to manual tasks that requires their expertise
    - Possible reductions in wages, paid time off, sick leave, training expenses, and even hiring, HR, and onboarding costs
    - Improved safety and related savings from injuries and medical issues, safety gear

- Repeatability and consistent weld quality from the system
  - Reductions in scrap/rework time and materials
  - Potential reduced liability risk for safety-critical parts (e.g. where a human welder might exceed part requirements to be sure it's made correctly, a properly adjusted machine can meet specs with the same amount of materials on each part
  - Gains in speed and efficiency mean you can produce more parts in less time and make it feasible to fit additional or larger orders into your schedule, creating revenue
- Savings from acting on data analytics
- Monitor use of consumables such as weld wire or gases
  - Data lets you monitor patterns of use closely and predict purchasing needs more accurately
  - This has a smaller effect on ROI but does add up over time, especially if you add additional cells or arms
- Onboard "asset health monitoring" software
  - Catch equipment problems before they require an overhaul or total replacement.
  - Makes it easier to keep up with planned maintenance and monitor wear and tear (an excellent alternative to running the machine until it fails)

> **Even after you recoup the cost of the equipment, savings continues as long as you use it, adding to your profits and ability to expand automation.**

Conclusion

No two facilities have the same production goals, challenges, or resources. For that reason, no one robotic welding system fits all situations. Your application, workforce, and budget determine the equipment and set up, and how extensive it is.

What's more, automation impacts the flow and culture of a workplace no matter if it's a single workstation or a bank of robotic arms working in concert. An experienced integrator familiar with welding can help you examine current processes, design the best solutions, and prepare for the changes to come.

Need a Plan First?

If you aren't quite ready to implement yet, check out Part 1 of this ebook. It walks through each step in the planning process: determining what challenges and goals you have, welding process details, and information about the system's components.

Download the Guide

Notes

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