Welding Robotics Project Considerations & Economics

Prepared By:
W.F. Garth Stapon
Automation Sales Specialist
Airgas Northeast
What is the Required Investment?

- **Robotic Cell**
  - *Complete, ready-to-go packaged solutions*
  - *Solutions to fit most applications based on size & complexity*
    - Low end - $60-75K before tooling (limited reach)
    - Mid-range - $75-150K
    - High end - $150K+ (i.e. large complex projects)

**Integrated Solutions**
- *Generally custom, engineered solutions*
Why Consider the Purchase of a System from a Distribution Partner?

- Local service and support
- Consumable stream means you will get support through integration
- Menu approach that offers multiple options on the scope of the equipment
- Access to the Industries leading players
- National footprint for multi site support
Cost Analysis

**Robotic Cost Analysis**

Cost analysis for robotics takes into account the following factors:
- Weld size
- Arc on Time (Operating factor)
- Weld metal deposition rate
- Labor cost
Total Labor Time = Total Arc Time + Non Arc Time

Total Labor Time is the amount of time spent by the welder to complete the assigned task

Total Arc Time is the amount of arc time a welder spends during one welding cycle. It is measured in minutes. Total arc time is also as a basis to compare the amount of welding time per hour. When converted to a percentage of total arc time of welding per hour, this time is normally referred to as the operating factor.

Operating Factor = \frac{\text{Arc Time}}{\text{Total Labor Time}}
What factors impact arc time?

- Non arc time is the time used by a welder to perform tasks other than welding such as:
  - Set up time including part loading & unloading
  - Arm air movement from weld to weld
  - Grinding (pre and post weld cleaning)
  - Inspection
  - Fixing poor fit up
  - Changing wire
  - Changing shielding gas
  - Changing contact tips
  - Repair of weld defects
The concepts of Total Arc Time and operating factor appear to be simple but in assessing the total cost of welding, many factors have the cumulative effect of reducing welding “arc-on” time thus they have an adverse impact on total welding cost. Electronic monitors can be added to a welding cell and the general reaction is how can my arc time be with manual welding be this low?
Typical Arc Time Manual and Robotic Welding

- Manual Mig – 10 to 30 percent
- Robotic Mig – 20 to 50 percent
Case History Robotic Cell ROI

Manual Welding Operating Factor

- Manual welding operator factor is a function of several variables including the welding process selected. It will normally be in a range depending on the part being welded, weld size, joint design and joint length.
- With one client, we measured manual Mig welding with .035 wire operated at approximately 175 amps. (1/4 base metal)
- This equated to an approximate wire feed speed of 280 -300 inches per minute.
- When asked why these parameters were chosen, this was selected as a comfortable operating current for their manual welding operations. No real data was collected previously to determine the optimum operating conditions.
Why consider the use of .035 wire on ¼ inch Material?

- Use of the .035 wire was a wise choice for manual welding as it helped to reduce over welding.
- Over welding is a major cost driver.
- Using a smaller diameter wire will result in a higher current density resulting in an increase in the electrode melt rate of approximately 5-7% when compared with the use of an electrode that has a larger diameter when used at the same operating current.
Manual Welding Cost Factors

- Using a manual welding wire feed speed of 300 ipm, the deposition rate at 100% operator factor would be approximately 5 pounds per hour.
- The actual deposition rate is less than this because of the operator factor – which is accounted for in the calculation.
- We can attach arc monitors to measure exact operator factor but the GMAW (Mig) process is normally in the 10-30% range.
On this application (1/4”) with an arc welding robot, we could use an .045 diameter wire at 450 inches per minute which will yield a deposition rate of approximately 12 pounds per hour at 100% duty cycle.

The actual deposition rate will be less than this because of the operator factor.

A robotic cell can typically weld more than 40% of the total time available but to be conservative, we will use a lower operator factor (Under promise over deliver)
Using .035 wire, based on a wire feed speed of 300 ipm and an operating factor of 20% the actual deposition rate will be:

- 5 lbs x 0.20 operating factor = 1 lb/hour actual deposition rate

For the sake of this calculation, let’s assume a fully burdened shop labor rate of $50.00/hour

The cost to deposition one pound of weld metal is approximately $50.00/1 or $50.00 per pound of weld deposited
The advantages of Robotic welding are numerous these include:

- Improved weld quality
- Reduced over welding
- Less post weld clean up
- Increase operator factor (duty cycle)
- Higher deposition rate
  - Manual welding deposition rate single wire 4-12 pounds per hour @ 100% duty cycle - actual deposition rate 0.4-3.2 pounds per hour
  - Automated welding deposition rate single wire 6-17 pounds per hour @ 100% duty cycle - actual deposition rate 1.8 – 8.5 lbs per hour
  - The weld metal deposition rate is a function of the wire diameter, wire feed speed, arc voltage, operator factor, shielding gas selection & welding position
Automation Advantages

- Faster torch travel speed
- Improved weld appearance
- Reduced operator skill
- Reduced weld time
- Improved wire deposition efficiency
- Lower total welding cost / foot
- Lower rework
- Consistent weld penetration
Automation Deposition Rate

- 12 lbs/hour @ 100% Duty cycle X 0.4 operator factor = actual weld metal deposition rate of 4.8 lbs / hour.
- Assuming a fully burdened shop labor rate of $ 50.00 / hour the cost to deposition one pound of weld metal is calculated as follows:
  - $ 50.00 / 4.8 = $ 10.42 cents per pound of weld deposited.
- Note – this deposition rate assumes that a head stock/tail stock is used and all welding takes place in the flat or horizontal position.
Automation Deposition Rate

- Based on an annual wire consumption of 20,000 pounds, we assume that 1/3 of the assemblies could be robotically welded.
- This equates to 6,666 pounds of filler metal estimated to be used by a robot.
Cost Summary

- Cost per pound Manual welding
  - \( 6,666 \times \$50 / \text{lb} = \$333,300 \)

- Cost per pound Robotic Welding
  - \( 6,666 \times 10.42 / \text{lb} = \$69,460 \)
Cost Summary

- **Annual Savings Estimate**
  
  $333,300 - $69,460 = $263,840 Annual Savings

- Estimated cost for a robotic cell $200,000 (with tooling)

- $200,000 / $263,840 = .758 years X 12 months = 9.09 months payback.
Shielding Gas Selection for Automation

- Gas selection depends on several factors including:
  - Base metal chemistry
  - Welding position
  - Base metal thickness
  - Base metal cleanliness
  - Type of metal transfer
  - Joint fit up
Mig Shielding Gas Selection
Carbon Steel

- Spray and pulsed arc transfer

  - Argon / CO2 (>82% argon)

  - Argon/CO2/O2 (>90% argon) – Good for gap bridging due to enhanced puddle fluidity

  - Argon/Helium/CO2 (>70% argon, >25% Helium/Balance CO2) – ideal for stainless and nickel alloys
Shielding Gas Selection 300 Series Stainless Steel (Mig)

- Argon < 3% O2 – spray and pulsed arc transfer – mild thermal conductivity – some base metal oxidization

- Argon/ < 2 % H2 / < 3% CO2 – all metal transfer types – reduced oxidization (300 series only)

- Argon / < 5 % CO2 – lower levels of CO2 for improved corrosion resistance – reasonable thermal transfer properties

- Argon / 3% CO2 / 2% O2 – may be suitable as a multi process mix but typically yields higher levels of oxidization when welding stainless steel
How Important is Tooling?

- Tooling can play a critical role in the success of the project. This is perhaps the element that is most overlooked when considering an automation investment.

- Depending on part complexity, tooling can be expensive.

- Unfortunately, this is also an area where some fabricators may try to reduce cost.

- Without a complete understanding of the fit-up or joint-design issues that are unique to automation, they may try to design the tooling in-house.

- This may result in a false economy, since poorly designed tooling can hinder the success of the robotic cell via restricted torch access and excessive change-out intervals.
Improperly designed tooling may cause a requirement for post-weld repair.

Other issues, such as positioning the part in the same place every time and the need to change out tooling quickly, should be considered.

Typically, it is most economical to weld in the flat or horizontal position, as deposition rates can be increased.

Tooling options such as a headstock/tailstock can rotate the part during welding, which may contribute to quality and productivity improvements of 20 per cent or more.
Six steps to help yield success

- Optimize the system which includes programming support, filler-metal and shielding-gas selection.

- Pay attention to tooling design and be prepared to invest at least as much as you did for the robot.

- Weld in the flat or horizontal position when possible.

- Consider bulk wire and gas supply to maximize cell up-time.

- Give careful consideration to who will operate the system as the investment can be maximized with a fully trained operator with welding skill.

- Work on dimensional control of the parts being welded. A laser or precision plasma-cut part can be welded more economically as the part fit-up is consistent.
Critical Questions

- How many parts do you plan to make?
- What is the base metal type?
- What is the base metal thickness?
- What is the size of the part?
- Do you plan to powder coat the part?
- What is the weight of the part?
- Do you have a laser or precision plasma?
Critical Questions

- Will a welder be operating the cell?
- What input power is available?
- What is your budget?
- What is your ROI requirement?
- What is your burdened labor rate?
Critical Questions

- Do you require multi process capability?
- Do you wish to rent or purchase the unit?
- What are the service conditions of the completed part?
- Can we weld in the flat or horizontal position?
- Do we need to perform post weld finishing?
Thank You

- Questions?