Historically, robotic welding has been a complex solution that needed four key factors to be profitable for a company:

- A high volume of parts
- A highly repetitive welding task
- An in-house programming expert to set the application
- In-house welding knowledge to fine-tune robot welding settings

Although robotic welding applications have been profitable for large manufacturers producing a high volume of parts, things are much different for medium-size and job shop businesses. Frequently, manufacturers of this size do not have the four factors to make robotic welding effective and profitable.

Smaller scale manufacturers, for example, often say that programming a welding robot takes longer than the time needed to produce parts. So while automating welding for low-volume production runs does not necessarily give the best immediate return on investment, it becomes a crucial consideration when looking at industry and labor trends.

The shortage of available skilled employees is a major problem for industrial manufacturing. According to the American Welding Society, 40% of manufacturing companies declined new contracts due to insufficient availability of skilled workers. At the same time, 90% of all manufacturing companies lack robotic installations due to a lack of flexibility. (Source: National Institute of Standards and Technology)

When skilled employees are hard to recruit and retain, a viable solution is to efficiently automate welding processes. Additionally, as labor costs rise, an investment in automation accelerates ROI and improves a company’s competitive position.

The Kinetiq Teaching tool was developed to simplify the process of programming a robot to weld.

The tool was developed to reduce the time needed to teach the robot a task and make the process more intuitive, making it easier for job shops to justify purchasing a robotic welding cell.

TRADITIONAL PROGRAMMING METHODS

Traditionally, programming a robot involves one of two possible approaches.

PROGRAMMING THE WELDING ROBOT VIA THE TEACH PENDANT

The first approach is to move the robot to each point of its trajectory using twelve of the teach pendant buttons (one per direction and per axis). This requires the user to select the appropriate coordinate frame (joint, robot, tool or user) that will define the direction in which the robot will move when a button is pressed. The speed is set manually by the user, for example, when moving from one point to the other and when the position needs to be set precisely. It is important for the user to verify that the frame, direction and speed are set appropriately before moving the robot, especially when the tool is located near a rigidly fixed object (which is always the case for welding applications). Moving in the wrong direction often leads to tool-damaging collisions.
In addition to moving the robot through the points defining the trajectory, the user must learn a “robot brand-specific” programming language and enter these instructions in a text file using the teach pendant. If positioning the robot presents a challenge, navigating through all the possible instructions within the teach pendant can also be a hard and time-consuming task.

PROGRAMMING THE WELDING ROBOT OFF-LINE

The second approach is off-line programming, which consists of loading in specialized software, the robot cell and the parts that need to be welded. The programmer can generate the robot trajectory on the computer and may have the aid of some automatically generated paths. Weld instructions must then be inserted to produce the program to load in the robot controller.

This approach requires extreme precision in the definition of the robot cell (robot position, tool geometry, work table shape and position, etc.), as well as the manufactured part and the jig(s) used to fix the part to the table. Any error in these definitions could result in a bad trajectory or a collision during run time. This often means having to do modifications in the field with the teach pendant (the first approach mentioned above). Also, a CAD file is required to detect all possible obstacles in the robot cell in order to foresee any possible collision.

These two teaching methods require a high level of expertise and expensive programming tools. Even for expert users, the time required for programming the path makes these approaches cost-efficient only for productions of approximately 100 units or more. The consequence of these limitations is that very few job shops that produce low volumes have robotic applications.

A NEW APPROACH: INTUITIVE TEACHING OF WELDING TASKS

KINETIQ TEACHING

Kinetiq Teaching is a new solution that leverages a welder’s knowledge to greatly reduce the programming knowledge required to teach a task to a robot. Through this add-on tool, welders or operators are able to hand guide the robot and program welding tasks by selecting sequence options via an ICON-based touch screen interface on the teach pendant.

With Kinetiq Teaching, the end user moves the robotic welding tip next to a work piece by physically hand guiding the robot. Once the welding point is reached, the welder selects a procedure through a touch screen interface. After all the points are recorded, the welder can review the programmed trajectory, modify it as needed and proceed to weld.

Experienced welders can set welding jobs and oversee more than one robotic welder at a time. These advanced welders can also train less-skilled personnel to program the welding robot and can act as a technical adviser and a quality assurance resource. By being able to quickly program the robot for simple jobs, the experienced welders have more time to use his/her expertise for more complex tasks.
SPECIFIC FEATURES

**Hands-on approach with the teaching robot**

The user can move the robot by applying forces directly on the tool. In this way, the teaching points will not require cumbersome and confusing algorithms when using the teach pendant. Full motion is available (in all degrees of freedom), and the user has the ability of locking axes to keep either the rotation or the translation. Crashes are reduced while teaching because the robot is moving in the direction it is pushed/pulled. Speed control provides coarse-to-fine positioning control as the torch gets close to the joint.

**Fast and simple creation of welding trajectories**

A user-friendly, touch screen menu has been designed to set arc welding and targeted jobs. All the useful functions for arc welding are easily accessed using a graphic toolbox. It is no longer necessary to learn a complex robot programming language. The teaching environment was created to have the look and feel of a smartphone application.

**Flexible welding capabilities**

The Kinetiq Teaching application uses the mature, precise and built-in welding functionality of the robot’s controller. This includes the use of linear or circular interpolation to reduce the number of programmed points for the path geometry.

**For advanced users**

It is possible to export an INFORM job (native Motoman language) that can be edited manually so that all the features of the Yaskawa controller are available. Saved programs can be imported back into the Kinetiq Teaching environment for point modification or sequence editing.

**BENEFITS**

Kinetiq Teaching was designed to leverage the knowledge of skilled employees and operators by enabling them to move the robot with their hands. Users can intuitively program robot sequences and movement by using a dedicated teach pendant interface, and adjust the process specific parameters and playback of the trajectory that was programmed. This can be done without in-depth knowledge of programming.

This tool presents a great opportunity for companies to allow a skilled employee (or any operator) to intuitively program a robot, save 20-50% on robot programming time and make a quick return on investment for high-mix, low-volume applications.
EXAMPLE OF A TRAJECTORY TAUGHT WITH KINETIQ TEACHING

EXAMPLE OF A BASIC WELD

To illustrate how Kinetiq Teaching works, see the diagram below. In this example, a welding path is composed of two straight lines. A welder will first teach the trajectory and then make small touch-ups in a second step. For the first recording, refer to the schematic representation of Figure 1 for the recorded steps.

Setting the “Home” – Point 1

When the job is created, the trajectory has only one instruction: the “home” instruction (Point 1 in Figure 1). This instruction refers to a safe position, which is away from the table and parts, for all possible setups. This position should be chosen well above the table to allow the robot to move anywhere with a simple motion. During playback, the robot will move towards this position using an “air cut” motion.

The target position of the home instruction can be modified by selecting the icon in the trajectory timeline, activating Kinetiq Teaching, then moving the robot to the desire position and clicking on the “modify position” button.

Record the approach – Point 2

Once the home position is properly set, the next step is to record an approach point (Point 2 in the figure). This motion will bring the robot closer to the part to be welded, yet far enough away from it to make sure that the robot will not hit the object (or table). If required, two or more approach points can be taught, for example, if an object needs to be avoided. To insert an approach point, the user activates Kinetiq Teaching, then moves the robot to the desired position and clicks on the “air cut” instruction in the toolbox.
The instruction is inserted after the selected item in the trajectory timeline. It is not necessary to click on the timeline if the previous item is already selected. For the approach point, the “air cut” instruction is normally used since it produces faster motions which are preferable for large displacements (linear motion can cross invalid robot positions which would trigger an error).

**Teach a welding position – Point 3**

The next step is to teach the first position of the welding path (Point 3). The position is taught by activating Kinetiq Teaching, then moving the robot to the desired location and clicking on the “linear motion” instruction in the toolbox.

Because this position needs to be precise, adjust the sensitivity of the Kinetiq Teaching mode by using the “Fast” and “Slow” buttons on the teach pendant. The “linear motion” instruction is used for this step to avoid hitting obstacles when moving close to the table and the parts.

**Enter Arc Start and welding parameters – Point 4**

Once the first point of the welding path is taught, insert the “Arc Start” instruction (Point 4) by clicking on the appropriate icon in the toolbox.

One parameter is required for this instruction, which is the Arc Start File number (or ASF#). This parameter defines the welding parameters for starting the arc. It refers to the configuration file defined outside of the Kinetiq Teaching application using the standard Yaskawa application. In this example, the user enters the number “12” which refers to the previously programmed welding parameters used for right angle welding of ¼” steel plates.

**Teaching the welding path – Points 5, 6, 7**

The welding path’s first segment is a straight line. To make sure that the angle of the torch remains constant during the motion, the user can lock the orientation by toggling the motion mode to “Translation only.” The robot is then moved to the end of the first segment using Kinetiq Teaching, and the “linear motion” instruction (Point 5) is added.

In this example, the welder first tries to perform the right angle motion by rotating around the corner of the path (we’ll see next how this part of the trajectory can be modified). The robot tool is rotated using Kinetiq Teaching, and another “linear motion” instruction (Point 6) is inserted after the previous end point.

The last welding segment (Point 7) is recorded by adding a “linear motion” instruction, similar to Point 5.

At this position in the trajectory, it is important to insert an “Arc Stop” instruction (Point 8) which will turn off the welding torch. Similarly to the “Arc Start” instruction, the “Arc Stop” requires an Arc End File number (AEF#) which defines the parameters used to shut down the arc. The user enters the number which refers to the shape and material of the welding.

**Complete the loop - Points 9 and 10**

To move away from the welding path, a retract position is recorded (Point 9) using a “linear motion” instruction to avoid touching nearby obstacles.

Finally, another “home” instruction (Point 10) is added to make sure that the robot finishes its trajectory in the same position as it started. The new home instruction copies the position of the previously recorded home (Point 1). There is only one home position, and if you modify any of the home positions, you modify all of them. This position should be chosen to make sure it is easy to move around the robot, for example, to remove and feed new parts in the welding jig.
CONCLUSION

Expert programmers have noticed reductions in set-up times of 20-50% with Kinetiq Teaching and manual positioning. Users with little welding or robot programming background can quickly learn how to program a path (FABTECH 2013 visitors were taught how to program a simple lap joint weld in just a few minutes with no prior training).

Because it is easy to use, many job shop size companies with high-mix, low-volume batches should see a significant ROI with the Kinetiq Teaching tool. Companies will also benefit from lower costs and the improved quality that automation can bring it is still recommended that at least one employee be factory trained on the robot.) Once the robotic welding cell is installed, in-house employees can benefit from reduced start-up and teaching times, and they can supervise less-skilled operators on Kinetiq Teaching or part loading to maximize productivity and efficiency.

For more information about Kinetiq Teaching, please contact us at info@motoman.com.