Drive & Control
profile

Taylor-Winfield Technologies launches new flash welding innovation with Rexroth motion control for hydraulics

By combining a Rexroth IndraMotion MLC L45 motion logic controller with Rexroth hydraulics, Taylor-Winfield developed a welding solution for joining advanced high-strength steel that is scalable, precise, affordable and can be adapted to various applications.

Challenge:

Develop a welding solution for joining advanced high-strength steel that is scalable, precise, affordable and can be adapted to various applications

Rexroth Solution:

- IndraMotion MLC motion logic controller
- IndraControl VPP human machine interface (HMI)
- Rexroth 4WRPH proportional directional valve
- Rexroth external hydraulic gear pump
- Rexroth development environment: IndraWorks with Open Core Engineering

Results:

- Precision to meet welding curve requiring micrometer positioning within millisecond time frame
- 50% machine cost savings using one controller
- Easy setup of profiles
- Flexibility to accommodate third-party data acquisition systems such as LabView
- Easy integration of motion logic controller with hydraulic power units

IndraMotion MLC for hydraulics enables patented welding process for 50% less cost

Welding is a key industrial operation where technological innovations have been improving productivity and quality. That's especially true for a technique known as flash-butt welding, which uses electrical resistance to heat the ends of two metal pieces that are forged together into continuous coils, wheel rims,

rods, band saw blades, and other shapes requiring seamless joints at parent metal strength. Older machines use manual cams to move pieces together at the right velocity. Today's advanced high-strength steel (AHSS) products, however, need much greater accuracy and controlled timing—down to a few milliseconds and thousandths of an inch. One solution is to replace the cams with electric servo drives and use multiple PLCs to control the process, but that can result in a machine that is too expensive to be widely adapted. Taylor-Winfield Technologies, Inc. (www.taylor-winfield.com), a welding and metal joining technology innovator in Youngstown, Ohio, devised another approach—use just one single Rexroth IndraMotion MLC L45 motion logic controller with Rexroth hydraulic drives, a package that is extremely precise and scalable. This solution moves the work pieces together with precise accuracy and timing, can be adapted to various applications and is more affordable than other options for joining AHSS steel.

With the use of hydraulics, the Forced Freeze welding process solution can be scaled to any size application without adjusting the controller.

"There's a growing need for flash-butt welding in aerospace, automotive, appliance, and other industries requiring seamless joints in products made from high-strength metals," says Blake Rhein, vice president of sales and marketing for Taylor-Winfield. "In these applications, the ends of the metal pieces must be moved together very precisely to create a solid, homogeneous joint. Our solution uses one Rexroth IndraMotion motion controller to operate a proportional Rexroth hydraulic servo valve in a closed-loop automation system. The solution, in combination with our patented "Forced Freeze" welding process, is so simple and accurate; we believe it will revolutionize how this type of welding is done around the world."

Bosch Rexroth libraries and Open Core Engineering principles enable LabView to connect directly to the core of the MLC for control of the complete machine, all on one HMI.

Creating a flash welding innovation with Rexroth automation

Rhein estimates that flash welding is about 20 percent of the overall resistance welding market, which includes spot and seam welding. He notes that "resistance welding simply means that two pieces of metal act as resistance for an electric current. When the current travels between the two separated pieces of metal, a short circuit occurs that heats the ends to a molten state that makes it possible to forge them together to reach parent metal strength and thickness after trimming."

"Flash-butt welding is a two-stage process," Rhein explains. "The first stage is the 'flashing' phase, in which electrical current is applied to two work pieces separated by a small gap. As the two pieces are brought together, electricity arcs across the interface and the temperature at the ends reaches anywhere from 600 to 900 degrees Fahrenheit, depending on the material being joined."

"At the required temperature, the second stage known as the 'upset' phase, begins. The two work pieces are pushed together using a moving

Taylor-Winfield implemented a closed control loop in which the IndraMotion MLC controller gets position signals from a transducer and then controller a position change by activating the Rexroth hydraulic power unit.

and stationary platen with enough force to cause the ends to forge together. This action 'upsets' the material, meaning that excess material and impurities are forced out of the top and bottom of the joint and subsequently removed by trimming to reach parent metal thickness."

Because the process removes irregularities and impurities, flash-butt welding can successfully join a wide variety of materials: narrow and thick shapes, wide and thin metal sheets, and ferrous and nonferrous materials.

But to make a successful weld, the moving platen and electrical current of the two work pieces must be precisely controlled.

"In early machines, the distance between the two work pieces was manually controlled," says Rhein. "The operator would dial in the proper current, and then a cam would control the speed of the moving platen and draw the pieces together to start the flashing phase."

"But a cam process cannot deliver the precise timing and speeds required to join today's AHSS metals. It takes automation to precisely move the pieces together at exactly the right speed and temperature to create a strong, homogeneous weld."

Taylor-Winfield uses the Rexroth MLC L45 motion logic controller to automate the process. A welding curve that depicts the logarithmic relationship between the two pieces in terms of time and position is loaded into the controller (see Figure 1). The overall weld schedule lasts from 2 to 30 seconds depending on the material. But during the flash phase, the position of the mobile work piece accelerates dramatically to generate forces up to 1,000,000 pounds per square inch to forge the pieces together.

Mike Prokop, Taylor-Winfield's Innovation Leader and assistant chief electrical engineer, notes that "only the Rexroth IndraMotion MLC motion logic controller has a scan rate fast enough to meet our position and timing requirements. We have implemented a closed control loop in which the IndraMotion MLC controller gets position signals from a transducer. Then the controller initiates a position change by activating the Rexroth hydraulic power unit. A Rexroth 4WRPH proportional directional valve activates a linear positioning cylinder that moves the platen containing the mobile work piece toward the stationary work piece."

Precision in milliseconds and micrometers

Depending on the material, the pieces begin with a quarter-inch gap between them. A critical part of the process

Figure 1. Non-standard weld curve for Taylor-Winfield's Forced Freeze process enabled by Rexroth IndraMotion MLC controller for hydraulics.

occurs when the pieces are just a few micrometers apart.

"The entire process is broken down to milliseconds," says Prokop. "The work pieces accelerate to generate the forces needed to forge them together. In flash welding, you want smooth acceleration of the moving platen. You don't want the moving platen to freeze in position. However, with the Taylor-Winfield Forced Freeze welding process we purposefully linearly advance the moving platen during the flashing cycle. The pieces are offset, for example, 50 micrometers apart for two milliseconds. During that offset time, the joule heating goes through the roof, similar to when the standard freeze occurs—that's why we call it forced freeze. Then the platen movement resumes into the upset phase of the welding cycle to complete the process. The additional heating dramatically improves the weld quality."

According to Prokop, a Rexroth touchscreen IndraControl VPP 40 human machine interface (HMI) makes it easy to select the proper weld schedule and modify the weld curve for the particular material. "The operator can use the HMI's touchscreen to edit flashing time, flashing distance, weld current, upset time, all the factors that change the slope of the weld curve. It kind of mimics the curved shape of the old mechanical cams. But now instead of changing a cam, you can call up a new curve and customize it with the touch of a finger."

Prokop's team worked with Dan Martincic, electrical engineer for Rexroth distributor Hydrotech, Inc., (www.hydrotech.com), in Cincinnati, Ohio, who developed the

Figure 2. How the flash-butt welding process works: An electric current creates a short circuit between two pieces of metal, heating the ends to a molten state so they can be forged together into a parent metal quality weld.

event-driven motion control profile for the controller with Taylor-Winfield engineer Nick Maillis. "The idea of a cam continues to influence how we program automation systems," Martincic says.

The MLC controller is loaded with Flex Profile, a motion programming platform from Bosch Rexroth that adapts segment-based cam technology to simplify the task of defining motion segments for electronic and hydraulic motion control tasks.

Martincic explains, "The beauty here is that the programming from electric to hydraulic is not different. In fact, the programming is exactly the same for hydraulics or servo-drives, which is one of the unique features of using the IndraMotion MLC. The Flex Profile function in the MLC controller provides an object definition that lets us translate the traditional cam-based model and their associated cam tables to a schedule-based event-driven model. I worked with Bosch Rexroth hydraulics experts to create a motion profile for the hydraulics used in the Forced Freeze process."

The motion profile and weld curve for the Forced Freeze process is completely non-standard. Five position points are involved: the start position, the initiate offset freeze position, the end of the freeze period position, the upset or forging position, and lastly, the final upset position.

"The simplicity that Flex Profile provides to program this curve was a big plus on this project," says Martincic. "We could work in the same Rexroth motion control environment we use for electronic or hydraulic drives. Once our team set it up, Taylor-Winfield could develop the profiles needed for each individual application."

Mark Berndt, the Rexroth senior sales engineer who worked with Martincic, notes that "the MLC platform has the intelligence to handle processes ranging from the Forced Freeze function, as well as general machine control. It sends messages over a

serial communications link to the weld controller that dynamically changes the weld schedule. If an annealing option is needed, the controller can reposition the weld seam, and then activate the welding transformer to provide the required heat levels during the annealing process. And if a data acquisition option is needed, it can be integrated directly into the Bosch Rexroth VPP40 with a third-party high-speed system, such as LabView."

Taylor-Winfield also utilized Rexroth's Open Core Engineering which enabled the ability to interact with the core functionality of the controller using standard programming tools to develop custom functionality and motion sequences. Mark Berndt credits Open Core Engineering for reducing cost and simplifying HMI screen development directly in LabView. Bosch Rexroth libraries enable LabView to connect directly to the core of the MLC for control of the complete machine including Flex Profile, welding schedules, recipes, motion and hydraulic axis control all on one Bosch Rexroth HMI (VPP40)—eliminating the expense of separate PC's for Machine Control and LabView.

Taylor-Winfield's Mike Prokop was very pleased with the integration of the IndraMotion MLC for hydraulics platform with Rexroth hydraulic components, a complete package that was able to achieve the required accuracy and precision. "Basically, we took the traditional flash welding process and took it to a whole new level," he says. The Forced Freeze flash welding process can be implemented on new machines and can be added to existing flash welding machines as a controls upgrade. Additionally, with the use of hydraulics, the solution can be scaled to any size application without adjusting the controller. This method, with advanced Rexroth motion control technology and hydraulics, will enable new levels of precision for the flash welding industry that can be customized to a variety of applications.

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