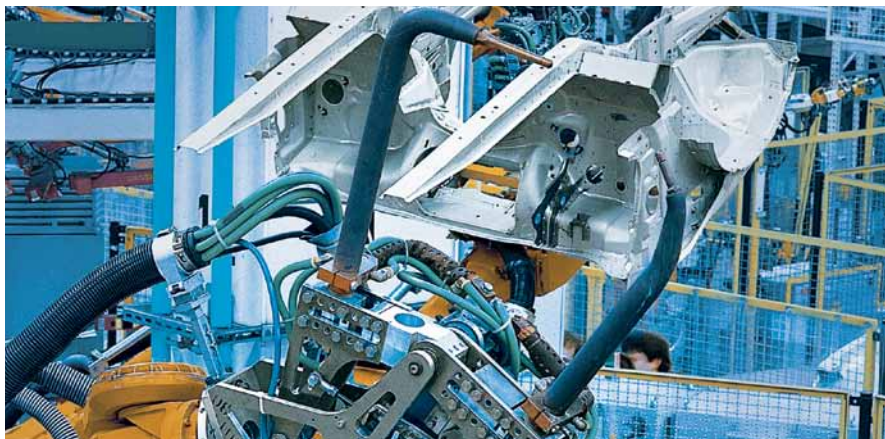


Drive & Control profile

Adaptive control of resistance welding



Today's global automotive marketplace demands the highest quality performance and throughput from automated welding systems.

Improving quality & productivity in automotive manufacturing

The global automotive market is placing an increasing premium on the quality and fundamental durability of every car manufactured—not just the luxury segment, but the models in every vehicle segment need to be produced with the highest levels of precision, “fit and finish” and structural integrity to protect the vehicle's value—and the competitive strength of the manufacturer's brand across the globe.

To help accomplish these goals, leading-edge manufacturers are investing heavily in advanced automation platforms that offer two fundamental advantages: High-volume manufacturing of very high quality vehicles, coupled with

extremely detailed control of every key process—including use of latest-generation digital platforms that capture and track a broad range of production data.

The widespread implementation of high-speed, automated MFDC Resistance Welding in today's automotive manufacturing platform is one significant example of this kind of investment. Robotic resistance welders provide a highly cost-effective and proven method of rapidly welding hundreds of parts per hour. To track and ensure the quality of these welds (crucial to many aspects of the vehicle's performance and value) both destructive and ultrasonic testing of selected components is conducted in all operations.

Challenge

Achieve near-perfect uniformity and repeatability in high-speed resistance welding operations and reduce costs and weld quality failures associated with offline sampling and testing of welds

Solution

Rexroth's PSI6000 series weld controls equipped with the PSQ 6000 system provides adaptive control of resistance welding, integrating advanced controls with current, voltage and resistance monitoring to automatically adjust welding time and current to ensure each weld is executed to the highest quality.

Results

- 100% inspection and real-time control of welding processes enables high-quality, high-throughput automated welding
- Reduces need to pull samples and conduct destructive weld tests
- Dramatically reduces resistance welding expulsion, increasing safety and reducing contamination
- Significant reduction in weld variability and a concomitant increase in weld reliability
- Documentation of weld quality can be automatically integrated into manufacturer's quality tracking and control processes

However, a key process improvement for high-speed welding is not yet broadly adopted—and it is one with the potential to revolutionize the quality, flexibility and productivity of welding platforms: In-process inspection and real-time adaptive control of resistance welding.

Adaptive control advances welding performance

Adaptive resistance welding control utilizes cutting edge controls platforms to adjust, in real time, precise functional characteristics of the welding system so that every weld is performed within the tightest quality tolerances. It creates the framework to significantly reduce, or potentially replace ultrasonic weld inspection technology.



Real-time adaptive control of high-speed welding systems is crucial to maintaining highest levels of throughput and product quality.

Typical manual ultrasonic inspection methods involve taking a sample part from the line and subjecting it to a manual, standalone inspection—as a representation of the quality of that particular welding process, during a given production run. While it is non-destructive, it is time-consuming and has the potential to introduce repeated inconsistencies, based on a tester's opinion of what represents a good weld.

Adaptive resistance welding control integrates the inspection of each weld, and the real-time control of how each weld is performed, to vastly improve the reliability of the welding process and simultaneously maintain the highest levels of welding throughput.

The Bosch Rexroth PSQ 6000 adaptive welding system provides one of the most advanced platforms for real-time control of welding. During automated welding, parameters such as current, voltage and resistance are monitored once per millisecond; these parameters are constantly compared in real time against a previously established master resistance curve that controls the quality of the process.

This master resistance curve is generated through a mathematical calculation of previously captured stored current, voltage and resistance curves of known good welds.

During a weld in Adaptive Control, actual values of current, voltage and resistance are compared to the master values for a good weld. The PSQ 6000 works together with the weld controllers constant current control system to automatically raise and lower the welding current and weld time in real time to keep the actual welding parameter values as close as possible to those of the master curve—with the anticipated result that the weld will have the equivalent quality.

Key benefit: Inline, real-time correction of welding

Process control is the foundation for successful, cost-effective automation. Today's high-speed controller technology can integrate complex data such as high speed sampling data of current voltage and resistance, process those inputs against proven performance curves and then adjust



Rexroth's advanced PSQ 6000 adaptive welding system enables high-performance real-time control of automated resistance welding.

the performance of the automated production platform to prevent faults, errors or less-than-acceptable product from being created in the first place.

Adaptive resistance welding control demonstrates the value of this approach—it substitutes the time-consuming process of pulling test components during a production run, manually testing weld quality and then correcting weld schedule data (current and time) to compensate with a fully integrated solution that saves time, improves weld quality and ensures that 100 percent of all welds are inspected and their quality documented by the control system.

Rexroth's adaptive welding platform measures the weld current and voltage at the electrode. Mathematical algorithms calculate resistance curves and energy balance. Data from the weld such as PSF (Process Stability Factor), UIP (Weld Quality Factor) and explosion are stored and made available for monitoring and trend analysis. The current is then adjusted to compensate for minute differences as welding proceeds. In special circumstances, sheet combinations with different thicknesses and coatings can be welded by a single program, for special process applications (i.e. manual gun applications.)

This kind of control also enhances welding flexibility, which helps manufacturers be more responsive to fast-changing market needs. For example, Rexroth's automated platform can store and operate multiple welding schedules, as well as change schedules much more quickly when demand for different components, body types or product changeovers have to be welded to meet sudden changes in demand.

Key benefit: Repeatability of welding process

Every manufacturing process is subject to variations—with resistance welding, these include:

- Part fit up
- Part thickness variations
- Misaligned electrodes
- Variations in coating materials or thickness
- Sealers
- Weld force variations
- Shunting
- Machine tooling degradation

All welding gun tips undergo wear—its elemental part of the process. Much of the weld testing regimen was developed precisely to assess how that wear is affecting weld quality, so it could be adjusted before weld quality impacts the component's integrity.

Rather than discovering the impact that these variations have on welding production after dozens or even hundreds of components have been processed, adaptive resistance welding control automatically compensates to keep production and quality up to the levels you need. As gun tips undergo wear, for example, the PSQ 6000 platform compensates for changes in their output, so that the welds remain reliable.

The result: Significant reduction in the variability of welds, and a concomitant increase in weld reliability—a fundamental measure of the quality of welding processes, and ultimately the quality of the vehicle being produced.

A system such as the Rexroth PSQ 6000 also provides an information framework to assure manufacturers that the weld reliability is actually being achieved: Since 100% of the

welds are inspected in real-time, the platform captures a record of each weld, and any variations the controller made to ensure that the weld was within the established parameters. This is a significant improvement, from a process control perspective, from selecting and testing sample components and projecting the weld quality from the results of the sampling.

Key benefit: Improved safety and operational quality

Adaptive resistance welding control provides an important improvement in worker safety and operational quality through the virtual elimination of welding explosion. Many highly automated resistance welding operations, with multiple robots carrying out hundreds of welds a minute, generate a significant amount of explosion because they do not have real-time control.

The result is the potential for a constant cascade of hot, dangerous sparks that can impact worker safety, leading to increased healthcare costs, lost worker productivity and the need for enclosures and other expensive protective devices and procedures.

Adaptive resistance welding control modulates the current flow to the welding tools to such a precise extent that explosion becomes practically non-existent. Instead of delivering a constant flow of power to the guns, which in certain instances and with certain materials is in excess of what is needed to complete the weld, the real-time feedback of conditions on the component's surface enables the PSQ 6000 controller to adjust the power flow to just the right level to complete the weld without generating explosion.

Not only does this increase worker safety, it reduces the dirt and contamination associated with constant explosions in the welding workspace. Reducing particulates on the production line floor means a cleaner environment, with less need for maintenance; it also eliminates contaminants that can interfere with sensitive electronic connections, sensors and other production line equipment. In addition, some studies have shown that it is possible to reduce overall energy consumption by welding tools through adaptive control, since only the amount of energy needed to complete the weld is being delivered to the tool.

Key benefit: Cost savings throughout welding process

The true value of any technology to improve automation is measured in how it can ultimately help a manufacturer generate savings through improved productivity and/or elimination or reduction of manufacturing costs. Adaptive resistance welding control offers multiple pathways to improving the total cost of ownership of welding systems:

- Major reductions in testing costs—including labor, time for testing, documentation, cost per part tested and scrapped and testing materials
- Elimination of weld quality spills and quarantine requirements

- Increased weld reliability leads to reduction in costs associated with poor part quality (rework of components, recalls, rebates, legal liability, etc.)
- Increased throughput from 100% weld inspection—translates into lower cost per part with higher levels of production
- Reduction in explosion-related costs—better worker safety, cleaner workspace with less contaminants and better quality welds

While there are costs associated with adding adaptive control to resistance welding platforms, Rexroth developed a model for broadly comparing costs of a platform that used manual destructive testing versus use of adaptive welding control.

On a theoretical resistance welding platform of 14 robots welding 150 spots per part, generating approximately 800 parts per day in three shifts, the return on investment was significant: Even after factoring in the cost of the PSQ 6000's components and programming, a manufacturer could expect to reduce the cost of testing and quality control for resistance welding by more than 30% over six years, through reductions in labor costs, materials costs, scrapped test materials costs and time.

This savings does not include any savings associated with improved parts quality—and with adaptive control,

100% of parts welded are tested and the quality of the welds documented.

Adaptive control essential to maximizing value of resistance welding

The Rexroth Adaptive Resistance Welding solution is designed for today's world-class automotive manufacturers, those that are committed to investing in cutting edge automation technology that adds value to their vehicles by improving product quality, increasing productivity and enabling a sustained return on investment.

This platform includes the PSQ 6000 Adaptive Feedback control platform, a range of powerful authoring and analysis software tools and a complete family of Bosch Rexroth PSI6000 weld controllers, transformers and other system components—a comprehensive solution that has been engineered for efficient integration and retrofitting into Rexroth's resistance welding platforms.

Adaptive control of resistance welding can transform the contribution your Rexroth resistance welding system makes to your automotive manufacturing operations, helping reduce losses related to poorly made welds, increase welding throughput and elevate your control of automated welding processes to a whole new level.

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