

Automated vision inspection, optimization of welds in automotive line assembly

The latest evolution of automated vision inspection of welds in automotive line assembly has proven to produce precise, reliable, and repeatable results for manufacturers by reducing rejects, rework, labor hours and operational costs, while increasing production throughput.



Inspecting weld seams on an automotive battery frame using automated vision inspection.
VITRONIC Machine Vision

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Automotive component manufacturers face several production challenges. Among the most vital is maintaining a high level of product quality, supported by consistent production throughput with systems that ensure profitability. A key function in this process is assembly, especially as the demand for more automated sensing and control devices, connectivity, infotainment, and electric vehicle components like battery trays, continue to push the need for more complex assembly requirements.

The need to manufacture more complex assemblies poses challenges for process engineers in their manufacturing and assembly functions. Particularly so, as automotive component manufacturers are increasingly mandated by stricter requirements to document quality assurance of their manufactured products along each step of production.

Weld-seam safety

A critical component supporting vehicle safety in automotive manufacturing is maintaining integrity in weld seams. Today's cutting-edge technology uses automatic welding for assembling vehicle body frames, axle components, powertrain systems, passenger seats, steering wheels, electric vehicle battery trays, and dozens of other components.

Defective weld seams, especially in safety-relevant automotive components, can lead to serious problems for manufacturers. The need to rework mis-welded components, interrupted production lines, and in worst-case scenarios product recalls and liability claims, can cause manufacturers significant costs. Consequently, inspecting welds for defects becomes a critically important function in automotive component assembly.

Latest evolution of automated weld-seam inspection

Manual inspection of welds in automotive assembly is prone to errors and costly to perform. Production efficiency can be increased considerably when the inspection of weld seams is fully automated. Automated weld seam inspection has been successfully used since the mid-1980s in the international automotive and automotive supply industries, including all Tier-1 suppliers and integrators.

The continual evolution of automated inspection technology, combined with advances in robotic assembly and computing capability, have enabled the latest generation of inspection systems to perform with extremely high reliability. Every weld seam is automatically inspected and documented after each manufacturing step to minimize serial defect trends and ensure product quality traceability.

Integrated inline inspection

The latest evolution of automated weld-seam inspection technology consists of an inspection cell with a sensor that is installed directly in the welding station at various locations. Because the inspection takes place in the welding line directly, it is easy to quickly intervene in the upstream welding process should a component require rework. As a result, defects are consistently identified and reduced, processes are optimized, and down time, reworking and waste are avoided.

This latest inspection technology does not require a dedicated station or dedicated robot. The inspection system can be easily retrofitted to existing lines, regardless of the welding solution used. Supporting the inspection cell-sensor is high-performance computer processing capability equipped with software for trending and analytics.

Unique to this new generation of automated weld inspection is an exceptionally broad sensing range. The inspection criteria can be configured to suit diverse requirements and applications.

The system is extremely reliable, even when it encounters flat seams, highly reflective materials such as aluminum, seams with differing geometries, and fast image recording speeds.

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This expanded range of inspection includes the following parameters:

- Throat thickness
- Distance in X, Y
- Undercuts
- Hole/burn-through
- Weld connection signal jumps
- Seam connection angle
- Seam width/length
- Seam width/position for overlap seams
- Seam position
- Convexity or incompletely filled groove
- Seam irregularity
- Weld volume
- Butt weld
- Surface irregularity
- Object height
- Porosity
- Spatter
- Gap width for overlap seams
- Unequal leg length
- Deepening

Expanded inspection range

The automated weld inspection can pinpoint the exact size and position of each defect and classifying them. It clearly identifies the tiniest geometric and cosmetic deviations.

Simplified reworking

All information relating to the weld seam inspection is visualized in the software of this latest-evolution weld-seam inspection system. From setting parameters for inspection to the display of defects for reworking. Clear visualization of defects in live operation are displayed as:

- a) Real images
- b) Precise, detailed inspection images
- c) 3D visualization

Defects can be easily analyzed and reworked because of the various visualizations. The software provides detailed instructions for reworking.



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The latest evolution in weld seam inspection, from VITRONIC, inspects weld seams for an automotive manufacturer.

The optical inspection system is a fully automated solution that inspects all weld seams and detects defects as small as 0.1 millimeter, visualizing these for reworking. VIRO WSI uses laser triangulation. This allows laser seams and fine brazed seams to be inspected quickly and with high resolution in 3D. The sensors were specially developed for inspections on reflective materials like aluminum.

As well as being objective and independent of external influences, VIRO WSI consistently follows predefined quality criteria.

Seamless documentation and analysis

In the VIRO WSI system, all weld-seam inspections are seamlessly documented, stored in an integrated database, and are fully traceable during the entire production process. From this data, operators can quickly identify any potential for production optimization, and immediately determine any action that may be required. Completed rework and evaluations of inspection results are then manually entered into the database.

The parameters for quality inspection can then be adjusted during the production process and automatically applied to the next system cycle. This minimizes costly reworking and scrapping of parts.

The database enables operators to initiate effective long-term optimizations and implement these on an ongoing basis. This ensures more efficient processes, reduces costs, and continually enhances the quality of the automotive component manufacturing.

Integrating weld data with process data supports process optimization

Inspection data may enable operators to identify weld-seam errors, but it does not reveal what caused them. Supporting this new generation of weld-seam inspection is WeldLoop software, also from **VITRONIC**, which links data from VIRO WSI weld-seam inspection with a welding system's process data. This allows large data volumes to be efficiently analyzed and trends recorded graphically.

The software enables visual representation of the connections between optical image data, measured

understandable. Operators can independently access results and rework defects using an integrated touch display, or through external visualization stations. In addition to purely manual reworking, a special classifier also supports automated reworking.

VIRO WSI automated weld-seam inspection

Leading the evolution into this new generation of automated inspection of weld seams is the VIRO WSI Weld Seam Inspection System, designed and manufactured by **VITRONIC Machine Vision** – a leader in specialized products and software for image-based quality inspection, identification, and process optimization.

Integrated Inline Inspection, Expanded Inspection Range and Simplified Reworking were introduced by the VIRO WSI Weld-Seam Inspection System, and constitute integral functionality of its operation.

These systems are successfully being used by leading automotive OEMs and Tier-1 suppliers.

deviations can be detected very quickly, and possible sources of errors can be pinpointed.

By performing trend analyses and visualizations, technicians can quickly detect deviations and their possible causes, as well as the welding station where they occurred. This enables action to be taken immediately to eliminate error sources, and it optimizes the accuracy of the inspection itself.

The additional data obtained from WeldLoop can be used to optimize the welding process much faster and in a more targeted way to prevent future defects. As a result, manufacturers can significantly cut costs, reduce downtime, and avoid waste.

Weld-seam optimization of critical automotive components

An automated weld-seam inspection system like VIRO WSI combined with process optimization software, WeldLoop, supports manufacturers in delivering automotive components of consistent high quality, while having a direct impact on better managing production volumes and costs.

Vehicle body weld-seam inspection

Weld-seam detection presents a particular challenge with flat vehicle body seams. Even the slightest defect can affect the integrity and salability of the vehicle. All welding defects in the vehicle body – on both visible and invisible seams – need to be detected immediately after the welding process and corrective actions swiftly implemented. The latest evolution of automated weld-seam inspection is ideally suited to ensure only perfectly welded vehicle bodies leave the production line.

Weld seam inspection for axle components

Axle beams and transverse control arms are essential elements of a safe chassis subframe. Their quality is critical to the long-term safety of vehicle occupants. The most advanced automated weld-seam inspection should be employed to identify defects and get them corrected before the axle components reach further processing stages.

Weld-seam inspection in EV battery production

In the production of electric vehicles (EVs), lithium-ion (Li-ion) batteries play the leading role. It is the most expensive of all components in EVs. The battery directly affects the driving performance, driving experience and durability of the vehicle. Flawless Li-ion batteries are, therefore, a key factor in EV operation.



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VITRONIC VIRO WSI inspects weld seams on an axle carrier for a Tier-1 supplier.

Defect-free contacts are essential for powerful, long-life Li-ion

batteries. Even the slightest deviation can reduce their performance and durability. With cell housings the weld seams must guarantee a hermetic seal over the entire life of the battery. Battery boxes are often integrated into the bodywork as a structural element. They are an important component in passenger safety, and therefore, must be stable and able to withstand a crash.

Light-weight materials are mainly used in EV batteries and battery housings, such as thin foils and non-ferrous metals like copper and aluminum. Laser welding allows thin and small components to be joined precisely at high speed.

Such expensive interruptions can be prevented with an automated inspection system that monitors the welding process in real time. Using a sensor to constantly measure several spectral ranges of light and heat emissions relevant for quality of weld seams in battery production, the latest evolution inspection systems, like VIRO WSI combined with WeldLoop software, report anomalies outside the tolerances indicating potential quality problems. These parts can be immediately detected, automatically rejected and rewelded. The cause of the defect can be identified and resolved more quickly before further defects are produced.

The latest technology in weld-seam inspection is ideally equipped to ensure that only Li-ion batteries with defect-free contacts and cleanly welded battery modules and housings are manufactured.

Consult a weld-seam inspection professional

Because weld quality is critical in automotive component manufacturing, it is important to consult an experienced weld-seam inspection specialist who knows the specifics and priorities influencing weld inspection for assembly of specified automotive components.

When assessing weld-seam inspection systems, components manufactured and serviced from a single-source supplier, such as VITRONIC with VIRO WSI and WeldLoop, will ensure the smoothest integration within an assembly production line and backup service support.

Consulting with an inspection specialist early in a project will ensure the most comprehensive and detailed weld inspection technology is utilized, and the most optimum procedures have been put into place. This will facilitate manufacturing to achieve the desired production throughput and improve process control while reducing rejects, rework, labor hours and operational costs.