Visual Weld inspection

From Manual to Automated solutions....

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Weld Inspection

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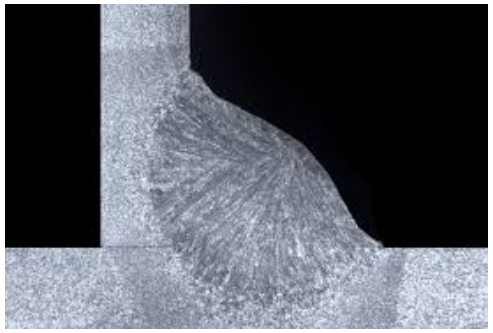
Weld Inspection

Overview of Discussion

Weld Inspection

- Why is it needed?
- How is it done?
- Pitfalls
  - Objective vs. Subjective
- Alternatives to increase levels of success
- Q&A



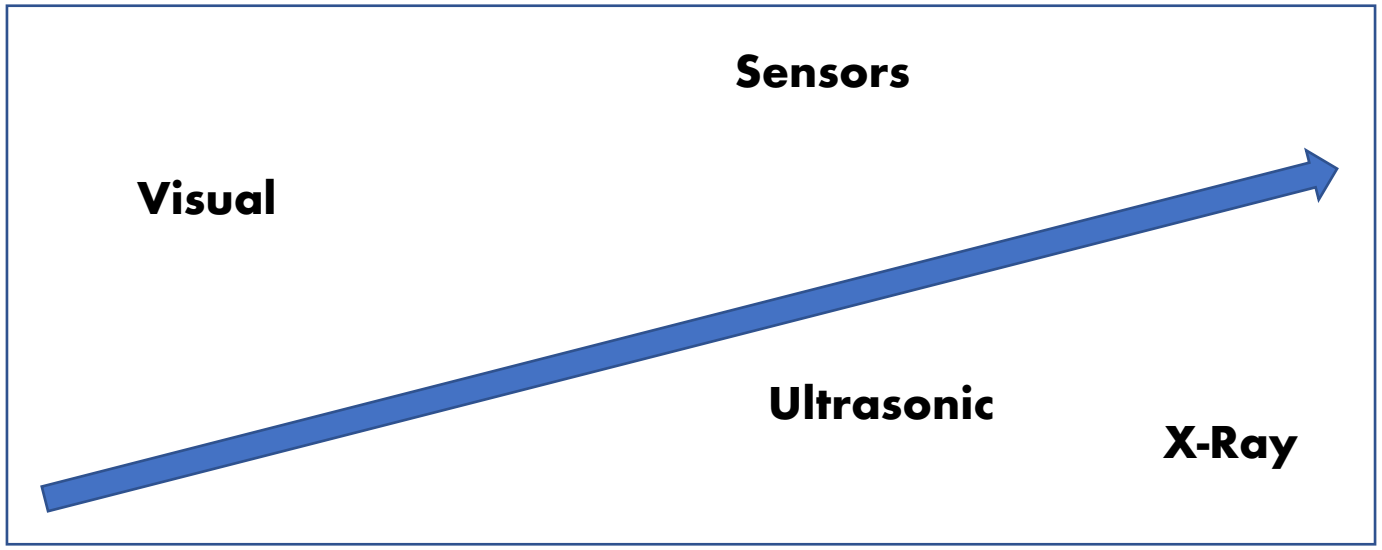
Weld Inspection

Why is it Needed?

- **Welding processes are imperfect**
  - Inspection required to ensure the deliverable meets the requirements of the product
  - Failure to address defects, which occur, can lead to potentially catastrophic failure of the weldment.
- **Parts are imperfect** and variations can occur in anything from hole locations to trim edges which can alter how they fit throughout the joining process.
- **People are imperfect** (generally speaking) and 2x checking of work is always wise plan. Mistakes can happen anywhere from material prep to completion of weld.
- Even the most qualified inspectors **are not 100% accurate.**
- Various **inputs** go into the welding process, **some easily controllable, others not.**
- Specs detail what is required for maintaining in service requirements and it is on the producer to **ensure the products meet the design intent.**

Weld Inspection

How is it Done?



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Manual Weld Inspection Pitfalls

Consistency Issues

Will not catch 100% of defects

- Count the # of e's in a page of writing. Your mind will not process certain ones regardless of you seeing it.

Even with redundant 200/300% checks defects will still get out the door

- Bad welds being called good

Over repair can be very costly

- Good welds being called bad
- Increased time and process
- Increased labor cost

Manual Weld Inspection Pitfalls

Financial Issues

- Allowing defects to go out the door can be extremely expensive
  - Poor customer ratings may decrease chance of future work
  - Remote rework at customer facility

- Cost of containment
  - Sorting for repair requires more labor heads
  - Customers may start to require 3rd party inspection
    - Costs can be as high as 100k/week

- Cost of a recall
  - Poor public image
  - Massive customer fines
  - Lawsuits from customers and end-users

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Manual Weld Inspection Pitfalls

Operator Issues

Manual Inspection is entirely operator dependent

- Fatigue throughout the shift can make the inspector less effective as the day goes on
- Even the best inspectors are only 80% effective

Issues outside of work can cloud inspector judgement

- Fight with spouse
- Yesterday's game
- Money troubles

Manual Weld Inspection Pitfalls

Training Issues

Hiring quality workers

- Difficult to find and keep qualified inspectors
- Qualified inspectors can be very expensive to employ

Training costs

- Can take weeks or months to train personnel for welding inspection
- Need to train multiple inspectors per shift
- Employee turnover will require employers to find new inspectors and pay to train them all over again

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Alternatives to Manual Weld Inspection

Ultrasound

Pros

- Can find defects under weld surface
- Portable equipment
- Can be used on many different weld joints
- Lower cost for equipment
- Non destructive testing process

Cons

- Highly dependent on qualified operators
- Training costs
- Surface defects still require visual inspection
- Qualified operators are very expensive to employ
- Almost impossible to automate
- Needs secondary process outside of line

Alternatives to Manual Weld Inspection

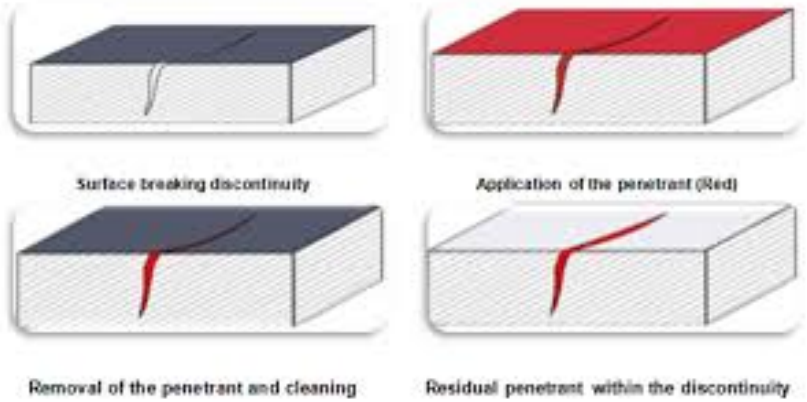
Dye Penetrant/Mag Particle

Pros

- Very easy to find surface defects
- Portable equipment
- Can be used on many different weld joints
- Lower cost for equipment
- Non destructive testing process

Cons

- Highly dependent on qualified operators
- Training costs
- Qualified operators are very expensive to employ
- Requires secondary process outside of line
- Can not automate
- Slow speed cannot do on 100% of product



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Alternatives to Manual Weld Inspection

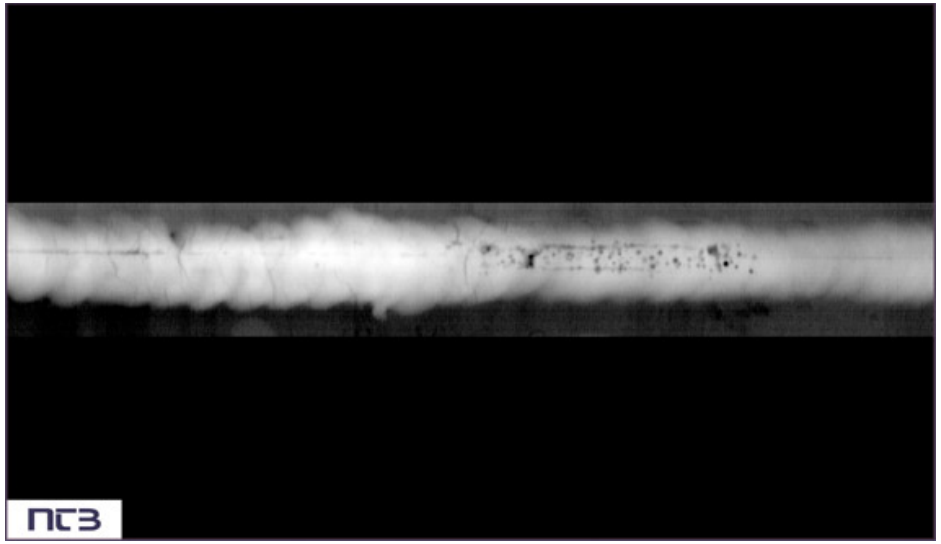
X-Ray

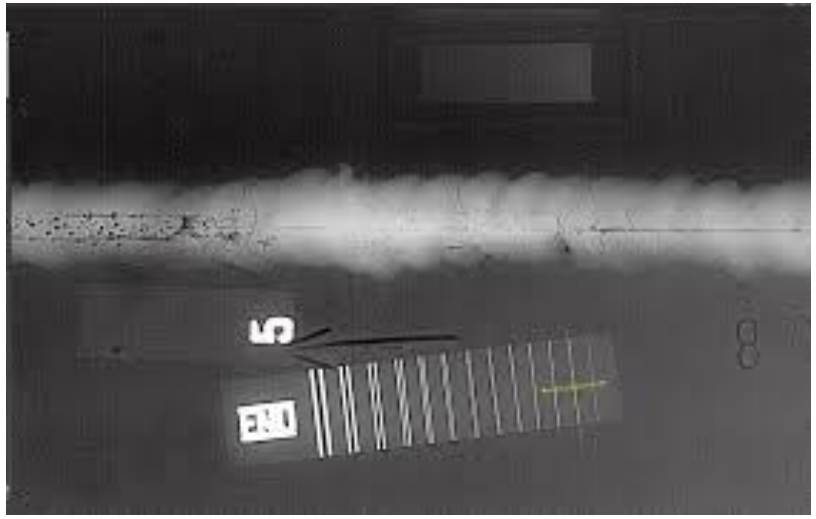
Pros

- Can find surface defects and sub-surface defects
- Can be used on many different weld joints
- Non destructive testing process
- Can be automated

Cons

- Highly dependent on qualified operators
- Cost of equipment
- Qualified operators are very expensive to employ
- Radiation safety concerns
- Slow speed cannot be used on 100% of product
- Only a 2 dimensional picture of the weld and defects





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Alternatives to Manual Weld Inspection

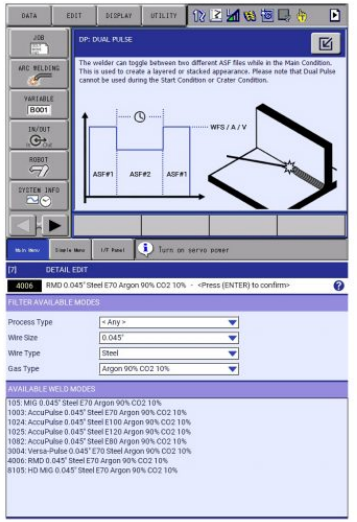
In Process Controls/Weld Parameter Monitoring

Pros

- Low cost, most welding machines have these capabilities built in
- Locks out process, only authorized personnel can change settings
- Realtime monitoring of arc parameters (volts, amps, wfs)

Cons

- Reduces but does not eliminate the need for manual inspection
- Takes qualified personnel to set up alarm windows and to maintain the process



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Manual Weld Inspection Supporting Technologies

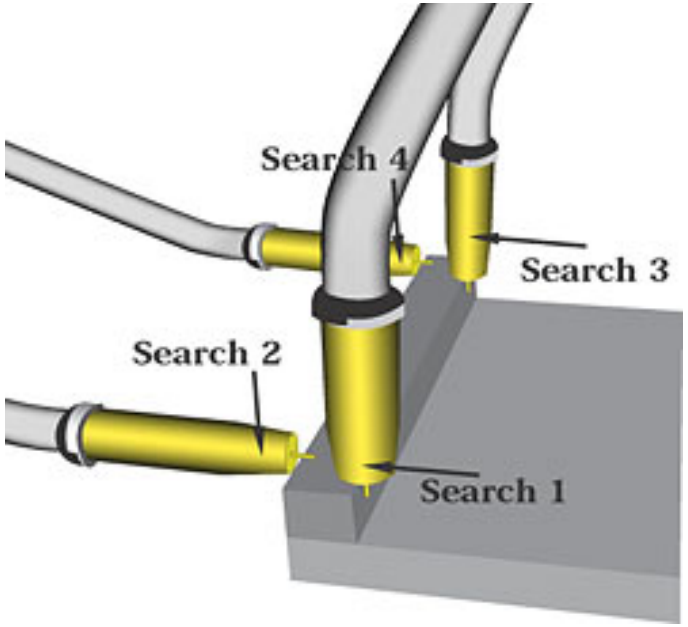
Touch Sensing and Through the Arc Seam Tracking

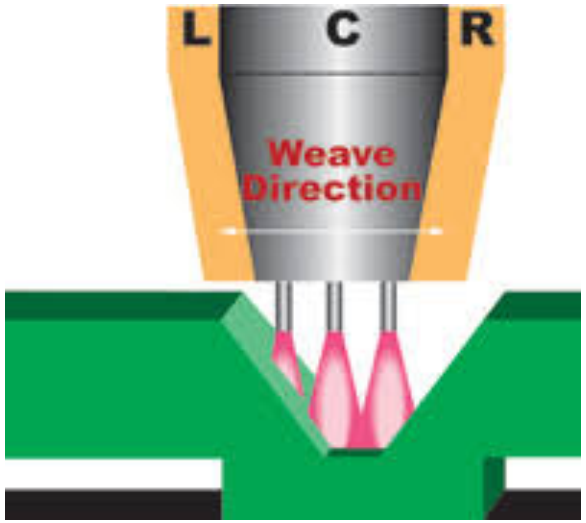
Pros

- Ability to keep weld on seam when joint is not repeatable
- Helps maintain weld quality
- Reduces weld repair
- No extra hardware to purchase

Cons

- Needs a minimal material thickness to work properly
- Not useable for most automotive applications
- Can increase cycle time
- Does not replace weld inspection





Manual Weld Inspection Supporting Technologies

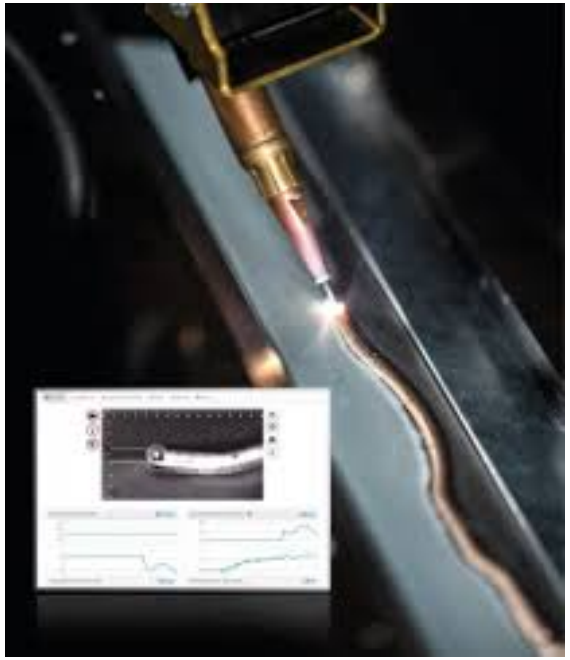
Tactile Seam Tracking

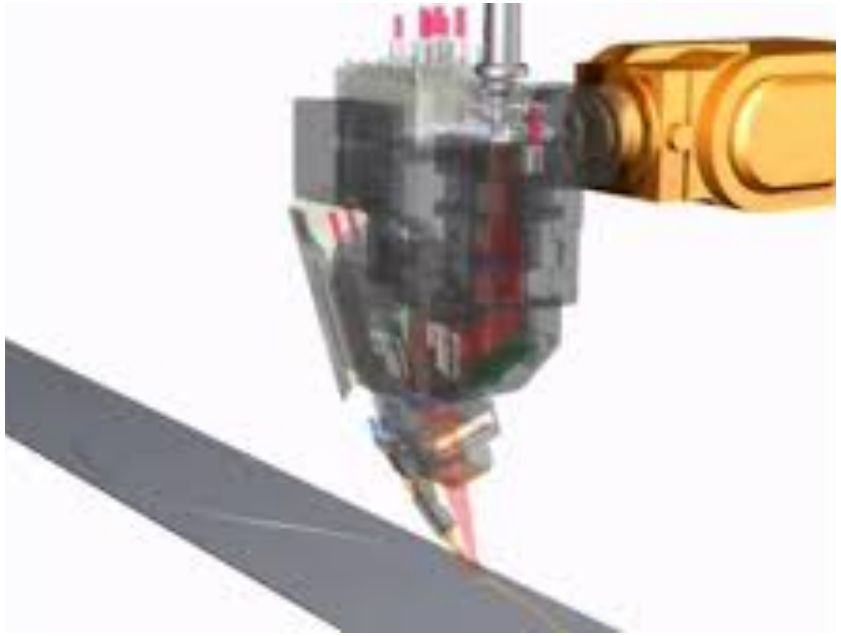
Pros

- Ability to keep weld/braze on seam when joint is not repeatable
- Helps maintain Laser weld/braze quality
- Reduces weld/braze repair
- Uses filler wire to track weld joint in real time

Cons

- Not applicable for MIG/MAG applications
- Special Laser Weld needed to work
- Limited usability on joint configurations
- Does not replace weld inspection





Manual Weld Inspection Supporting Technologies

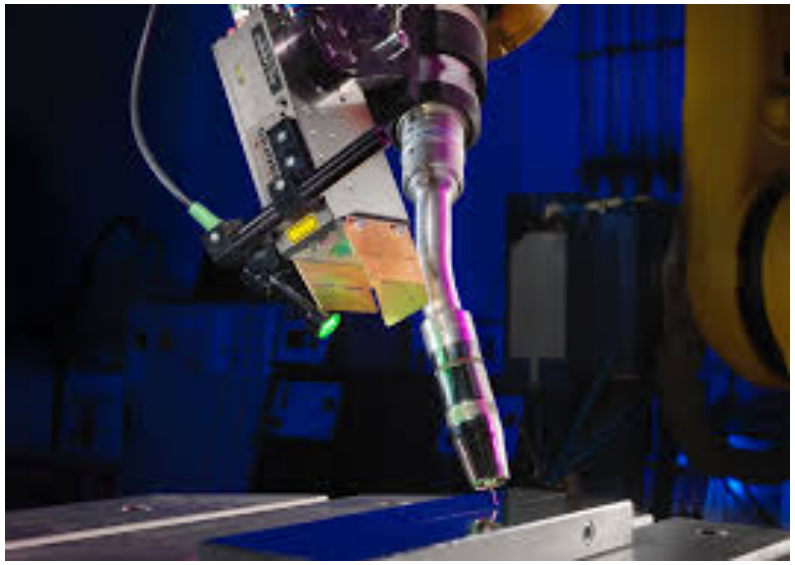
Optical Seam Tracking

Pros

- Ability to keep weld on seam when joint is not repeatable
- Helps maintain weld quality
- Reduces weld repair

Cons

- Increases size of torch
- Limited reach in tight spaces
- Can increase cycle time
- Does not replace weld inspection



Weld Inspection

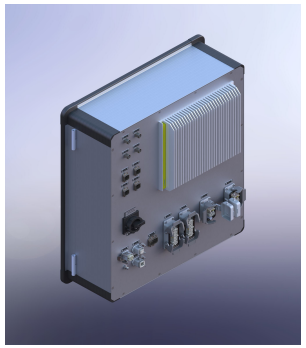
How Does it Work?

- The 3D weld inspection sensor is integrated onto a robot or stand in-line

- The sensor uses a laser and analyzes the laser reflection to create a 3D model of the weld

- The sensor has a scan rate of up to 8K
  - Fast data collection, high travel speeds

- Data analyzation happens in the controller
  - Uses an algorithm to compare specification to defects identified in the weld
  - Projects scan results onto a monitor for review
  - Operator administers repairs to part with the defect



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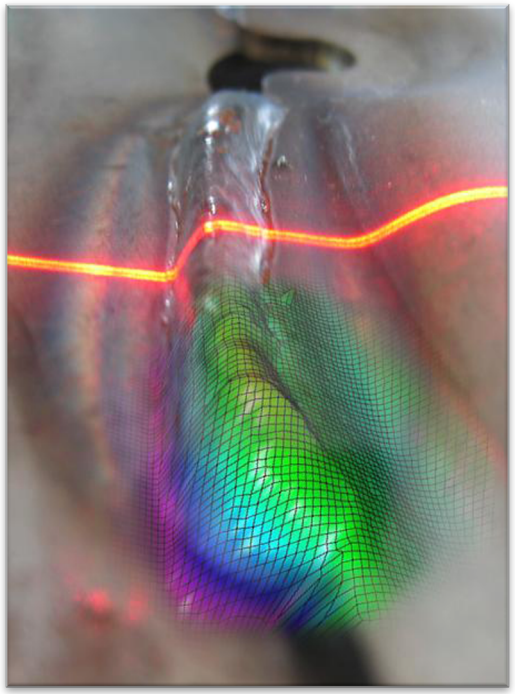
Weld Inspection

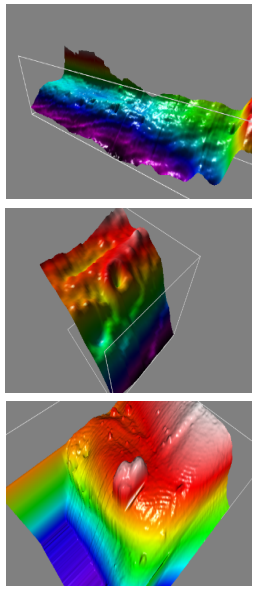
What Are We Looking At?

Weld Dimensions



- Length
- Width
- Throat thickness
- Cross sectional area / volume
- Toe
- Position
- Asymmetry
- Reinforcement
- Distance to edge
- Overlap length

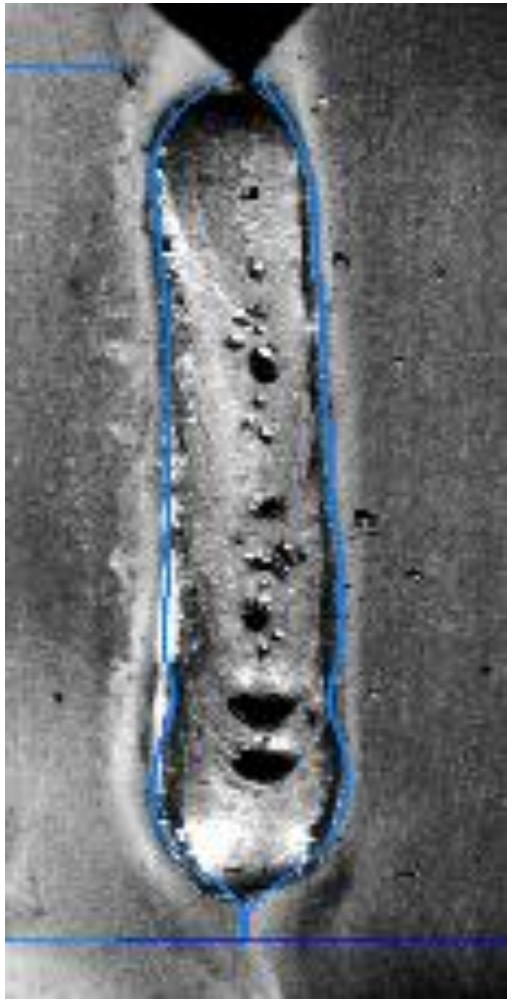
Weld Defects

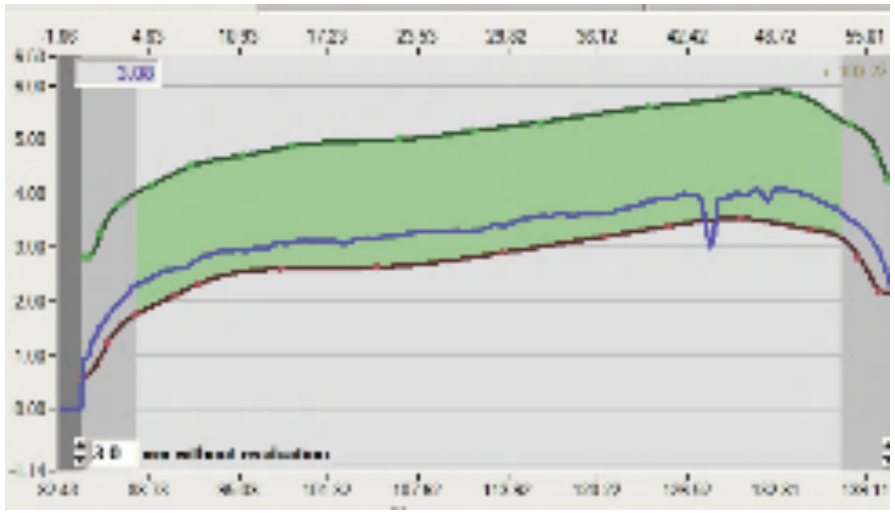


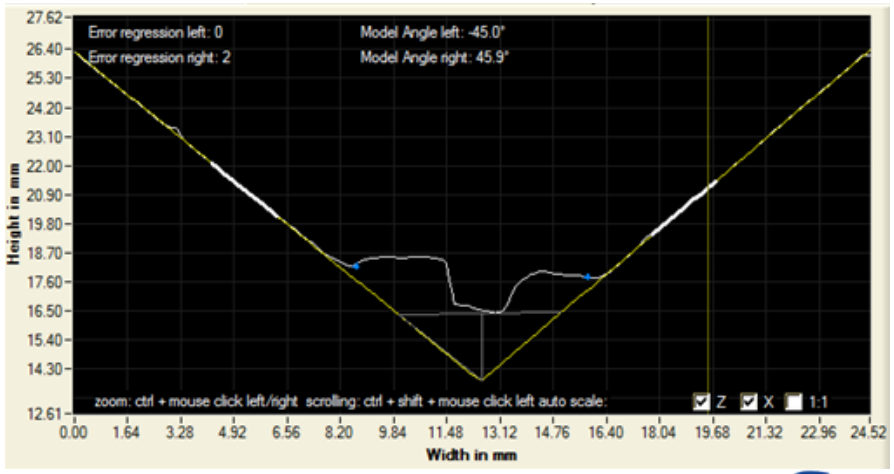
- Missing welds
- Incomplete welds
- Pores
- Skips
- Incompletely filled groove
- Undercut
- Spatter

Software Function

Throat Thickness







- Inline 3D weld inspection has the capability to estimate throat thickness
  - Looks at weld surface and unwelded joint to estimate throat
  - Software creates a cross-section of the weld from its algorithm
  - Set up pass/fail windows to alarm when a measurement goes out of range

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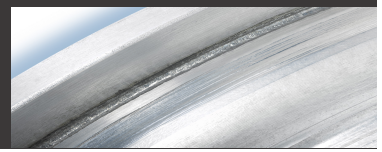
Process Application Overview

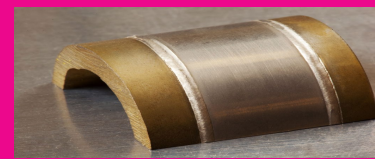
MIG/MAG

LASER WELDING

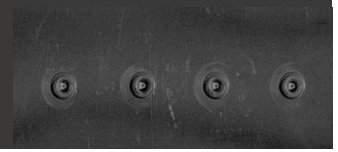


LASER BRAZING

ELECTRONIC BEAM WELDING



MECHANICAL JOINING



RESISTANCE WELDING

SPOT WELDING

PVC SEALING

GLUE BEAD

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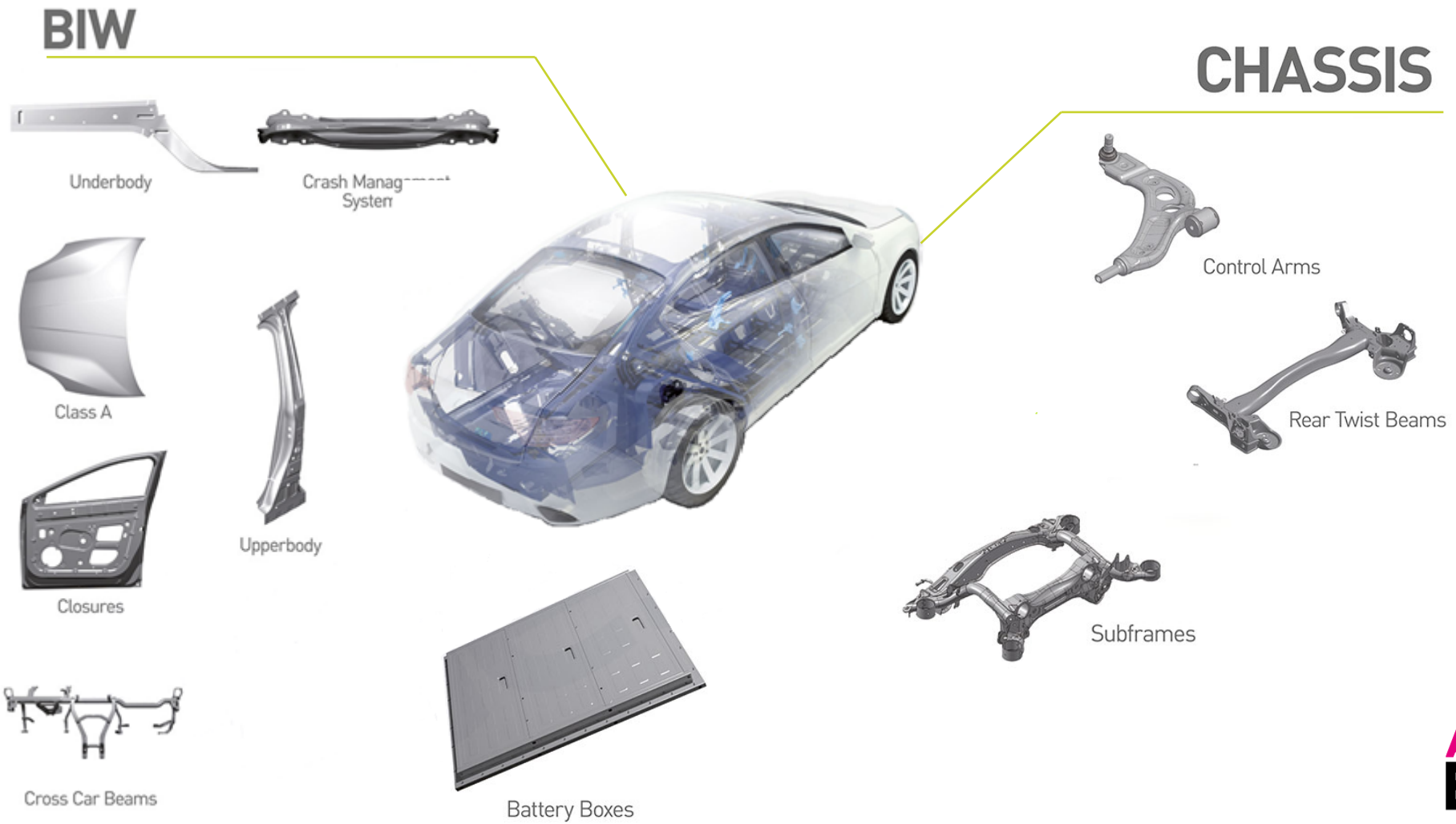
High Speed 3D Inline Inspection



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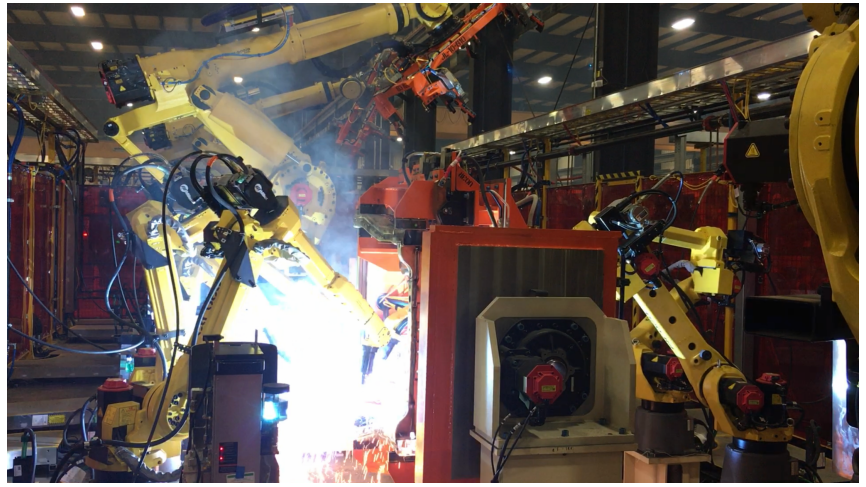
Truck Frame Inspection



- 3D Weld inspection is quickly becoming a must have when manufacturing Truck Frames

- Truck Frame OEMs are starting to require data records regarding weld quality
  - For quality tracing purposes
  - To ensure the safest and highest quality product for their end user

- Automated Inspection will help insure weld quality
  - Less need for destructive testing of welds
  - Less scrap cost from testing
  - Less Post OP repair after the frame has left the production line

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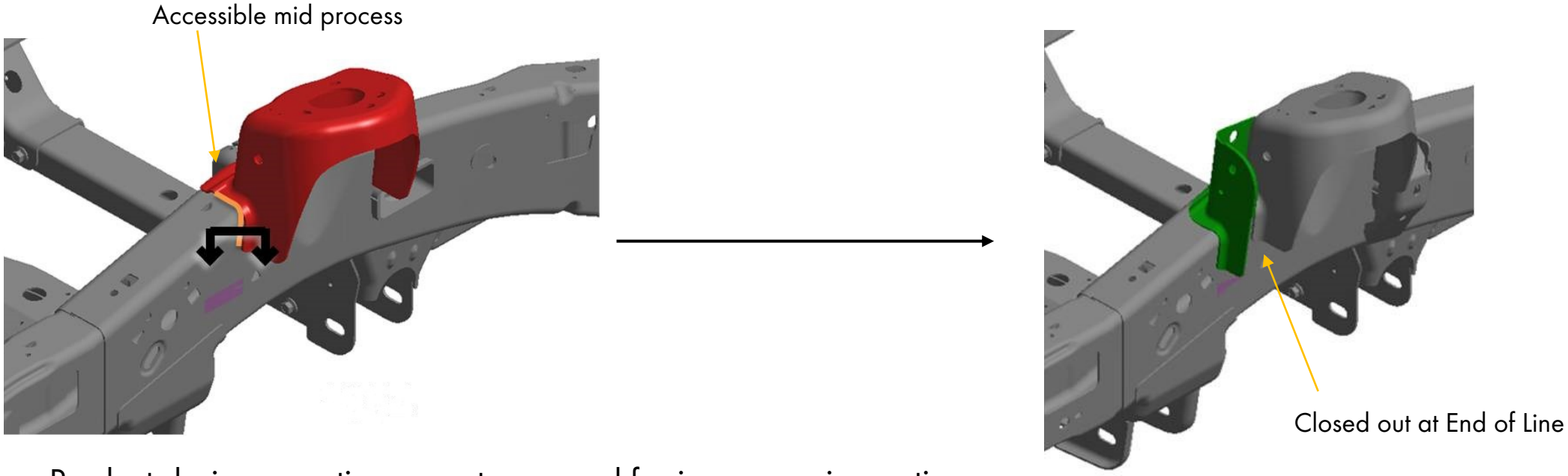
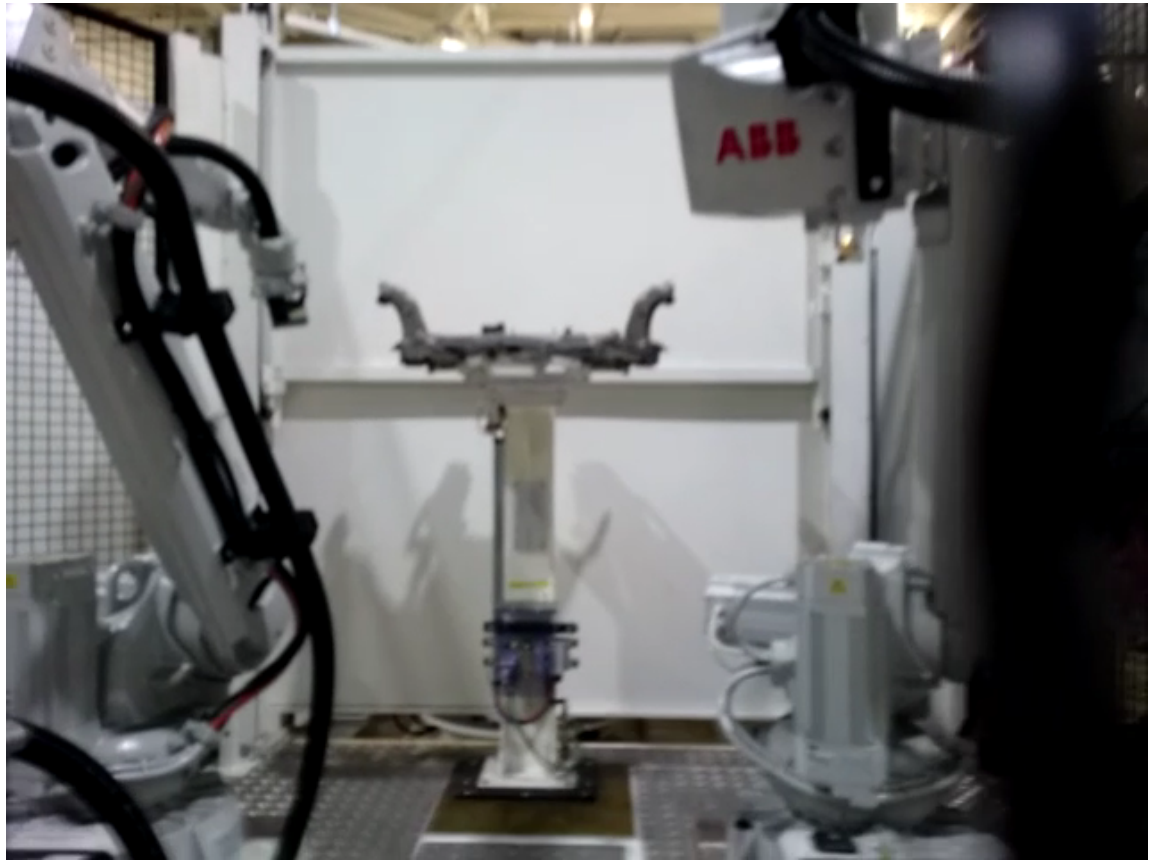
Close-out Welds



- Product design sometimes creates a need for in process inspection
- Welds can not be accessed at the End of Line inspection and repair process
- An automated inspection process can eliminate the need for an extra operator station and labor head
- Cuts down cycle time needed for inspection
- Avoid costly rework or scrap by repairing welds before they are closed out

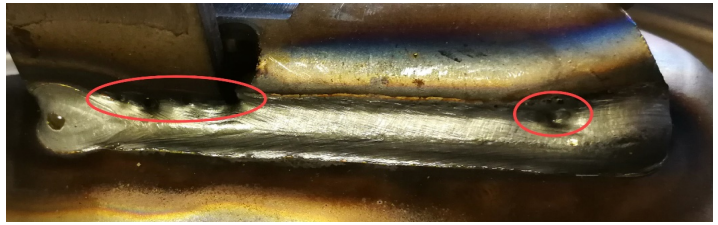
Application Example

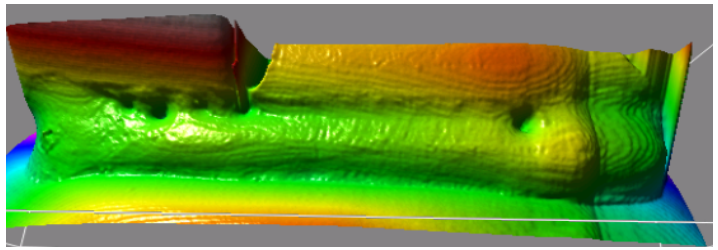
MIG/MAG – Cradle & Structural Parts Inspection



- Aluminum and Steel applications
- Reachability of welds on complex areas
- High Speed inspection up to 400 mm/s

- > 50 Systems installed worldwide





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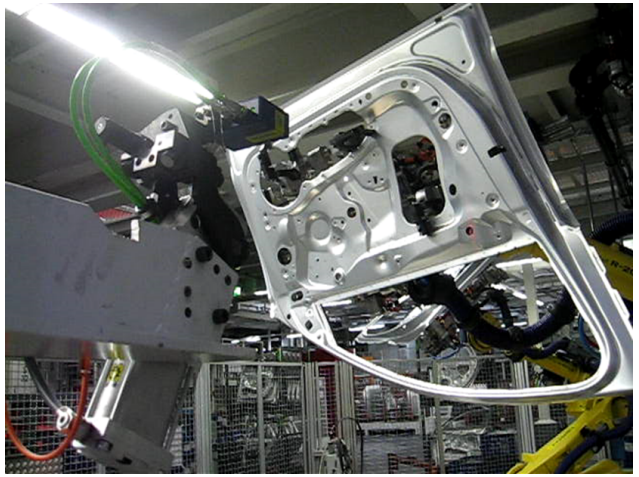
Application Example

Laser Brazing/Welding of Closures

- Aluminum and Steel
- Detection of pores > 0.1mm
- High Speed Measurement 200mm/s

- > 20 Systems installed worldwide

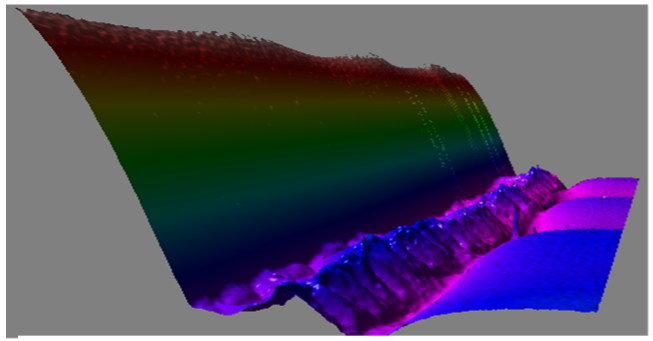


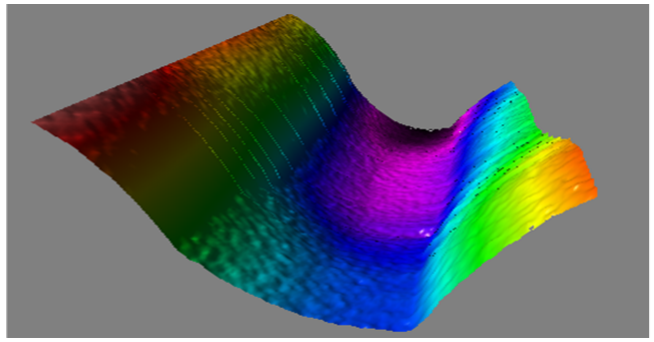
Application Example

Laser Brazing Inspection – Roof Brazing

- Aluminum and Steel
- Detection of pores > 0.1mm
- High Speed Measurement

- > 20 Systems installed worldwide

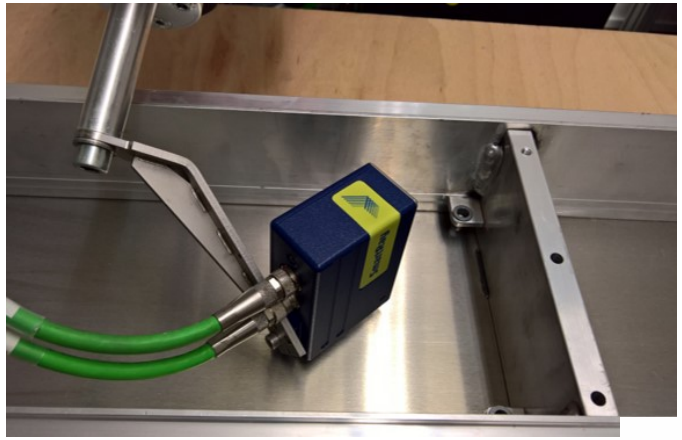


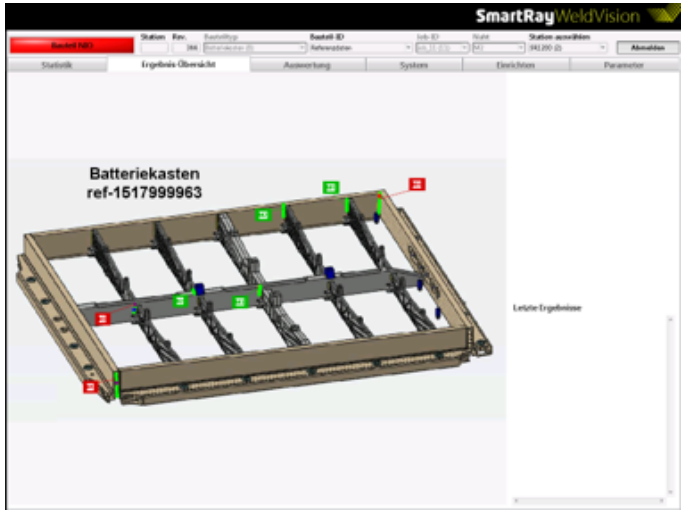


3D-View of elevated weld

Application Example

Battery Boxes – EV Production





- Almost all Automotive OEMs are now building electric vehicles
- Battery Boxes are required equipment
- The need arises for 100% quality inspection
  - Laser and MIG welds are Safety Critical in these assemblies
  - Welds must be Water Tight to ensure safety and reliability
- Automated weld inspection can help guarantee quality to the customer and reduce costly recalls

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Your Benefit

With High Speed 3D Inline Inspection

- Full control of inspection process
  - zero-error production
  - Faster inspection time
  - Reduce other additional checks (microsections)
- Reduce risks (e.g. liability issues / product recalls)
- Minimize qualtiy and rework costs
- Optimized joining processes for a fast ROI

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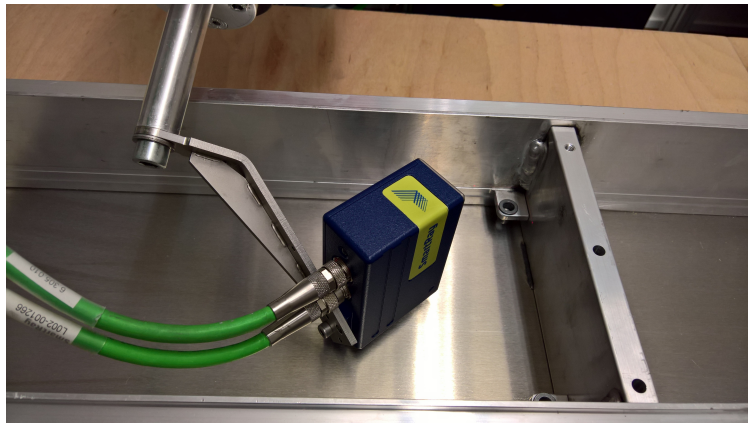
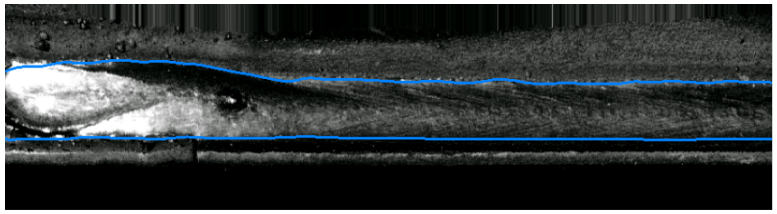
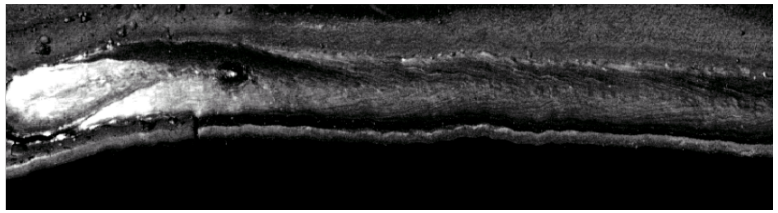
3D Weld Inspection

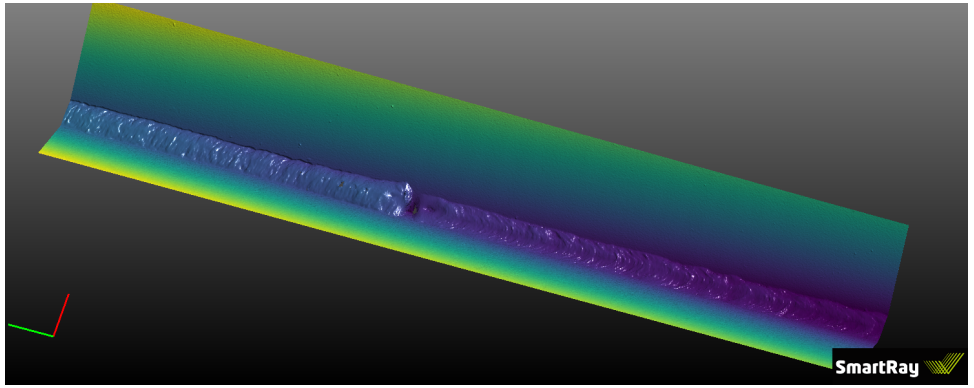
Key Highlights







- Profile Based Alignment
  → Vibration Elimination
- Robot Track Speed Calibration
  → Accurate Length Measurement
- High Accurate Sensor
  → Precise Inspection
- High Accuracy 3D Inspection Independent of Robot
- High-Speed Inspection Up to 400mm/s



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3D Weld Inspection

What Does it Take to Get Started?

	Project Services		Support Services	
	Pre-Sales	**Installation & Commissioning**	**After-Sales**	**Training**
Basic	Customer demo (in-house)	Controller setup	Phone support	Basic operator training
	Feasibility studies	Interface adjustment	Remote support	Maintenance
Advanced	Test installation (on-site)	Parameterization	Annual system validation	Expert Level 1 System Containment
		Optimization	On-site support	Expert Level 2 Advanced Configuration
		Final acceptance test	Optimization	Data Analysis Process Optimization
			Individual service contracts	

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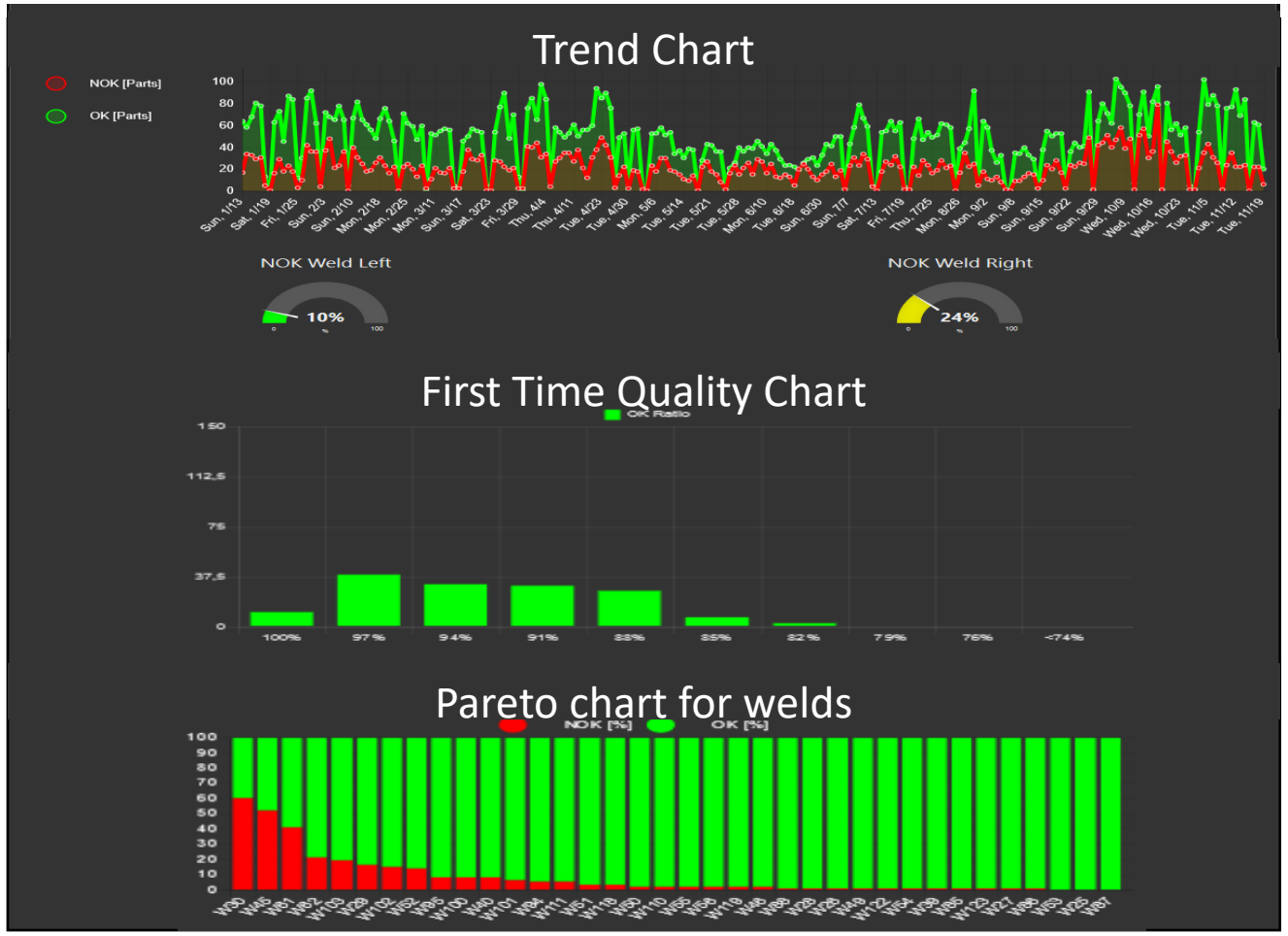
3D Weld Inspection

Data Records

- Less risks for customers' claims
- Efficiency increase through ...
  - Continuous improvement
  - Fast feedback on welding process
  - Preventive maintenance



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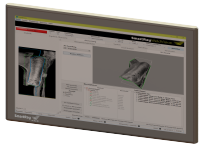
System Concept

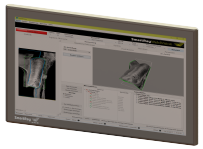
Sensor

- 20+ different sensor models
- Up to 8 kHz
- Up to 400 mm/s
- Resolution (z-Axis) down to 0.5 microns
- Resolution (y-Axis) down to 6 microns
- Variable field of view
- Compact size
- IP65 protection
- HDR acquisition mode
- Advanced reflection filter

3D Weld Inspection

System Concept (Two Sensors)





Intelligent Visualization Module (optional)
- Visualization of results
- Advanced configuration system
- Advanced visualization for re-work stations

Statistics Module (optional)
- Integrated database
- Advanced, user configurable statistical analysis
- System validation features
- Visualization of measured values and trends

Controller Unit
- Consistent of:
  - IPC for inspection
  - PLC
  - Flexible field bus interface
  - Power Supply
- Plug & Play exchangable
- Active backup
- Remote access

TCP/IP Communication Interface for MES/ERP

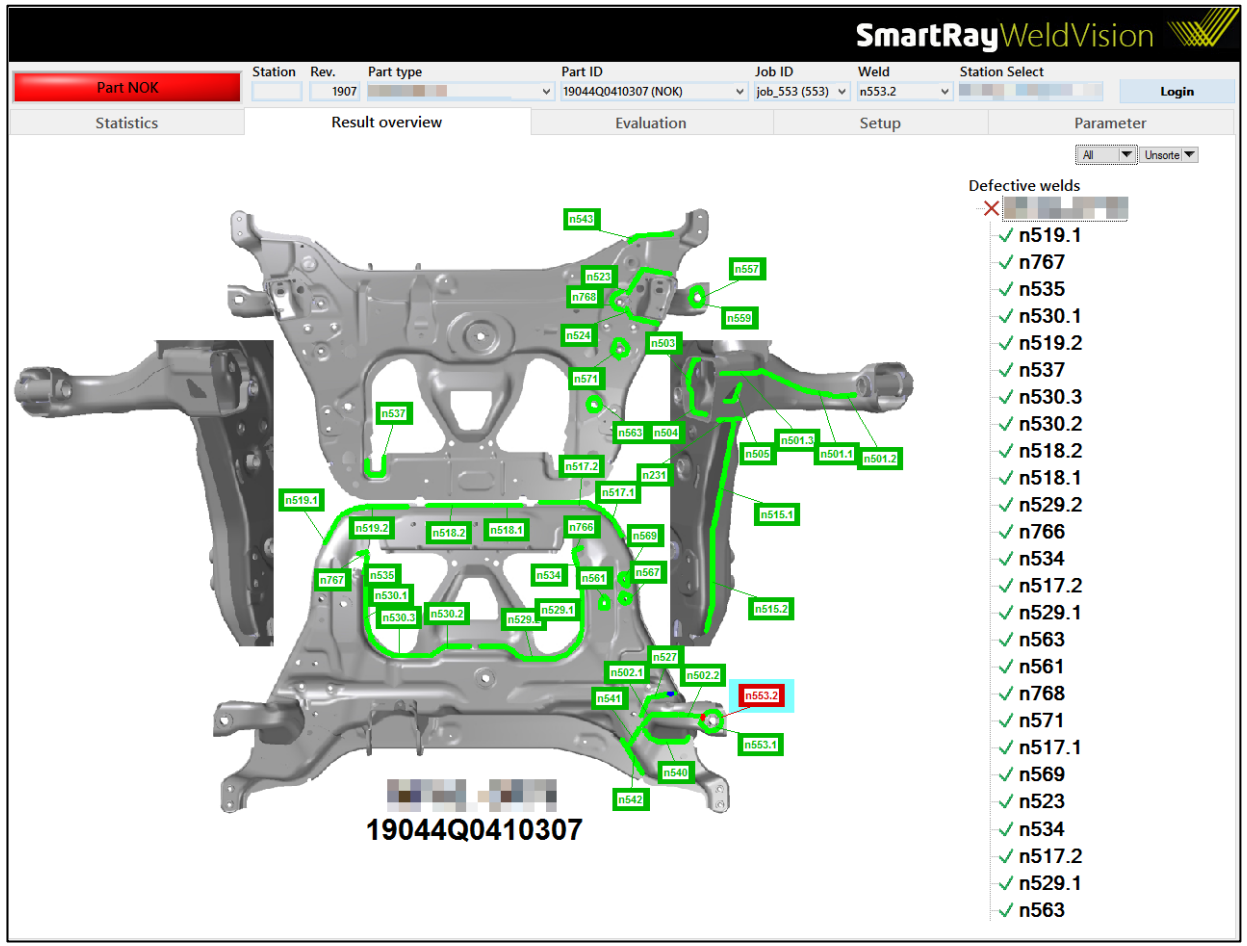
3D sensor
- High resolution down to 6 microns
- High speed up to 400 mm / s
- Multiple models for best customer experience

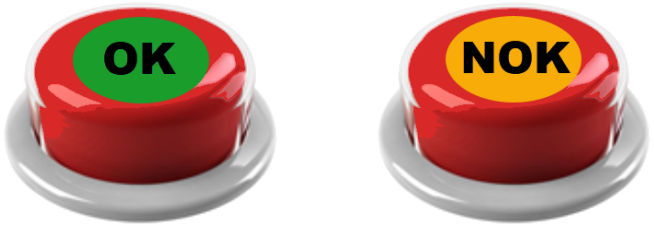
3D Weld Inspection

Key Highlights

Operator/Repair Stations

- Set up a visual aid to help repair workers to fix and keep track of repaired welds
- Remote push button control to complete weld repair
- Gives the ability to record failures and find line problem areas





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What does the Market Need when it comes to 3D weld inspection?

Reliability of output

a. Plenty of good sensors on the market to do this. Plenty of good software companies to provide back end support to sensor.
b. Lacking is full-scale support around entire process. Choose the right supplier who is capable of providing high-level service.
c. User required 99%+ success rate. No "false" negatives.
d. Statistics packages which help encapsulate data collection can help guide corrective actions to improve overall operations.

Ease of use

a. Ability to make changes to algorithms in the field as part conditions change.
b. Simplistic troubleshooting of system
c. Exchange of hardware (including calibration / set up) should be able to be done in the field.

Front line support

a. Ability to easily get support to your location when not able to address issues internally
b. Remote dial in capabilities.
c. Having knowledgeable team behind product capable of providing turnkey support.

Types of Weld Inspection/Supporting Technologies

Manual Inspection:
- Most readily available
- Not the most reliable system
- Costly training
- Defects still make it to the customer

Ultrasound/Dye Pen/X-Ray
- Very effective at finding defects
- Costly training and/or equipment
- Adds an offline process and can create a bottle neck
- Slow inspection processes, can't get 100% of parts

Seam Tracking Arc and Laser
- Greatly reduces weld defects and repairs
- Can not replace inspection for weld quality

Automated 3D Weld Inspection
- Systems are expensive
- Added capitol in line
- Adds complexity in the automated line
- Fast inspection times
- Can inspect 100% of parts
- 99.9% effective at finding weld defects
- In-line, no need for an offline process and eliminates bottleneck
- Ease of use
    - Defects are displayed for the operator to repair
- Data collection can be utilized to find line Hotspots and help with continuous improvement
- Helps in customer mandated data reporting

Summary

The need for post process weld inspection has never been more important

- Reduces defects getting out to customer
- Reduces risk of recall or customer fines
- Most OEMs require some sort of weld inspection and some are starting to require data records of welds too
- Can save money by reducing scrap
- **Question to ask yourself:** Not whether you can afford 3D Inline Weld Inspection, but can you afford not to have it?

QUESTIONS?

Weld Inspection

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