



Laser Welding in Regulated Industries

Challenges and Opportunities for High Integrity Laser Welding

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Plan

Background

Rolls-Royce Business Areas

Examples of Laser Applications

Demands on Process Control

Challenges in control / understanding

RADICLE developing increase opportunity for control

Background

Industrial laser systems – the largest manufacturing category for photonics – was worth EUR 11.4 billion in 2016

Laser welding has been used in a range of high quality, highly regulated industries from its earliest days in the late 1980s enabling new products and improved existing products

The ability to automate laser welding makes it an attractive choice for high cost, high criticality applications.

Automation capability has developed dramatically over the past 20 years.

New laser sources have expanded that further.

Process control need to follow to fully benefit from the technology





Rolls-Royce Business

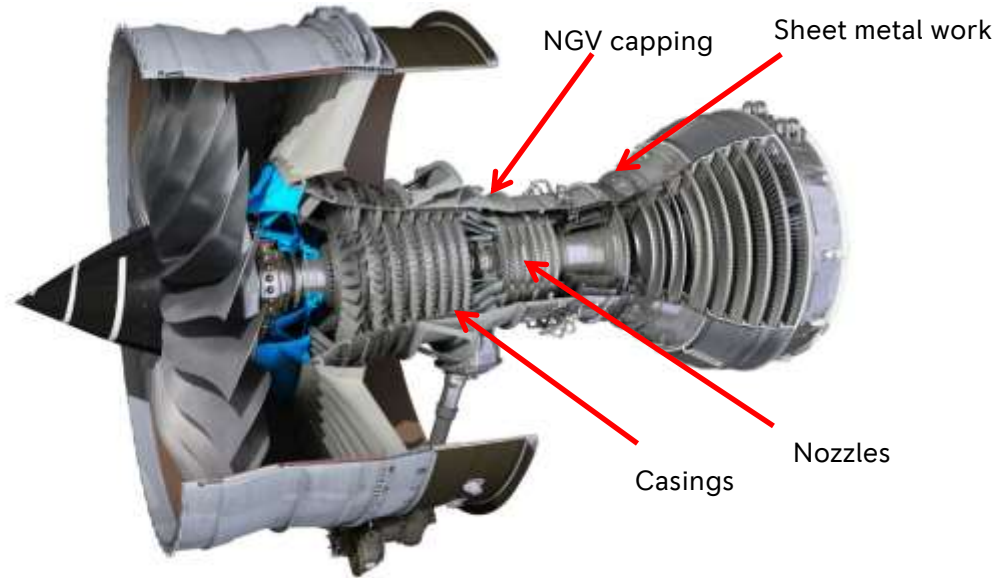
Rolls-Royce Operates in many highly regulated industries



Increasing range of Laser Welding Applications

Growing range of
applications as
power and control
develops

Examples of Aerospace Laser Welding



Increasing range of Laser Welding Applications

Growing range of
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Examples of Laser Welding



6mm_Box.mp4

Courtesy of Graham Engineering





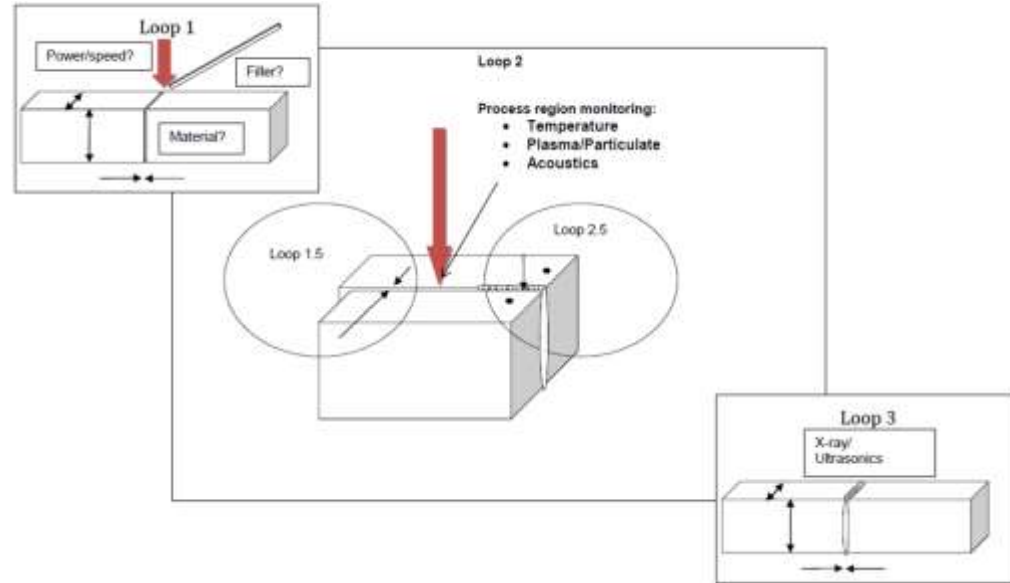
Demand for Greater Process Monitoring and Control

Product Integrity & Right First Time through increased process understanding

- Process Knowledge derived from broader process signal understanding offers routes to
 - More stable process window development
 - Extend range of application
 - Weld more complex materials
 - Eliminate process variation
 - Reduce post weld inspection

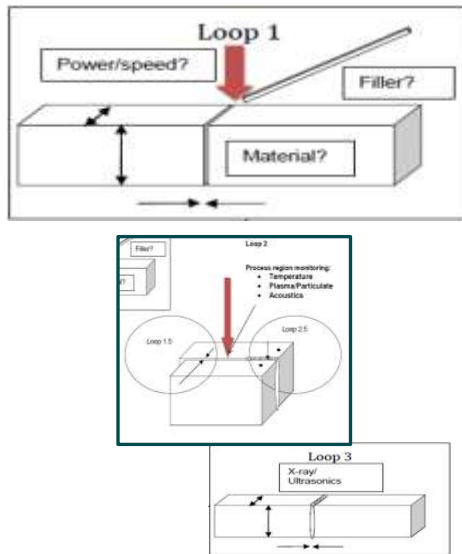
RADICLE Control Loops and Challenges

Current Challenges at in each loop



RADICLE Control Loops and challenges

Challenges at in each loop

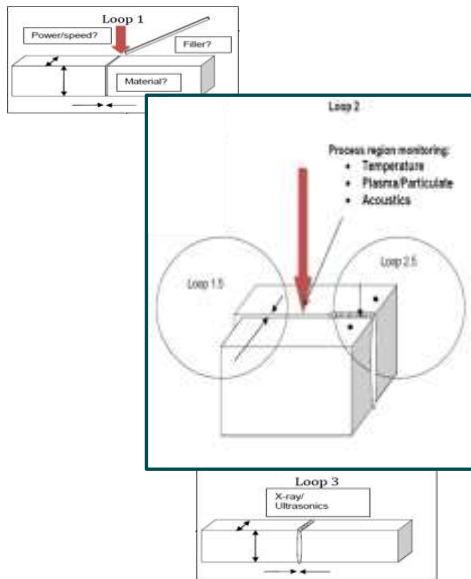


Loop 1

- Ensuring components are present & aligned within limits can reduced defects.
- Seam tracking developed for automotive industry struggles with closed butt welds
- Obtaining numeric values for gap, misalignment and vertical misalignment is valuable to feedback into preceding processes
- Flagging potential areas along the weld line could offer options to programming

RADICLE Control Loops and challenges

Challenges at in each loop



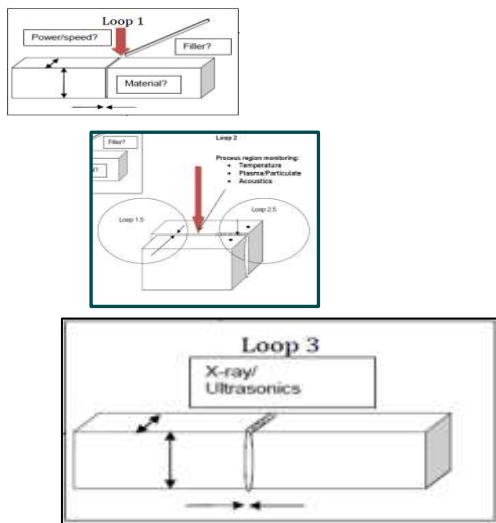
Loop 2

- Sensing and recording of process signal can be used for both closed loop and more basic empirical control.
- Matching process signatures to good welds offers route to pass/review/reject function in automated system- reducing manual inspection.
- Tagging positions where “exception” signals have been recorded offer route to reduce inspection.
- Using tagged positions from loop 1 can select signal output data to look for anomalies.
- Closed loop control from multi-sensor input can avoid false negatives and incorrect control action
- Closed loop control could adapt for part variability (thickness, misalignment, fit up) to reduce defects
- On board sensors can give quantitative results in process

RADICLE Control

Loops and challenges

Challenges at in each loop



Loop 3

- Tagging positions where “exception” signals have been recorded offer route to reduce inspection.
- Using tagged positions from loop 1 & 2 can select signal output data to look for anomalies.
- On-board camera system and scanners can provide confirmation of weld exterior is within specification
- Measurements from on board systems can quantify data to reinforce process knowledge.

