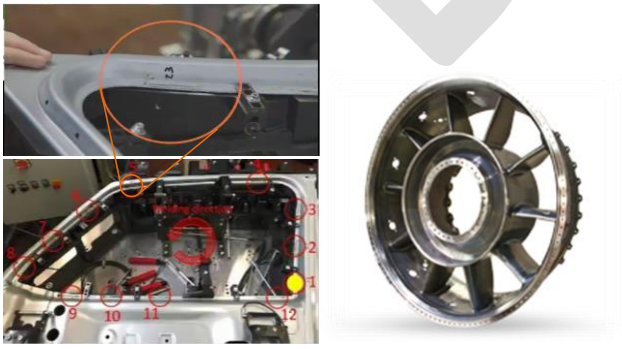
RADICLE
Real-Time Dynamic Control System for Laser Welding

TWI is working for CRF (Italy), GE (Switzerland), GKN Aerospace (Sweden) and Rolls-Royce (UK), in collaboration with The MTC (UK), Bit Addict (Sweden), Laser Optical Engineering (LOE) (UK), Permanova Lasersystem (Sweden), VTT Technical Research Centre (Finland) and The European Federation for Welding, Joining and Cutting, in the EC Horizon 2020 supported RADICLE project, to design, build and test a new prototype multi-sensor system for real-time monitoring and predictive control of laser beam welding.

The system itself will help to minimise defects in laser welds across a range of materials and joint configurations of immediate relevance to the aerospace and automotive industry, as well as being able to be used in conjunction with existing technologies for pre- and post-weld inspection. Overall, successful implementation will allow an increase in product quality and productivity, and a reduction in rework and/or scrap, with the ensuing cost reductions that will come with these advances.

Project background

Laser welding can be a high productivity and high performance joining process offering significant benefits over conventional joining methods. These advantages have already been practically realised by the automotive industry, and the aerospace industry and other fabrication sectors have also set along the path of uptake of this joining process, for components ranging from aircraft engine parts to ship hull panels.

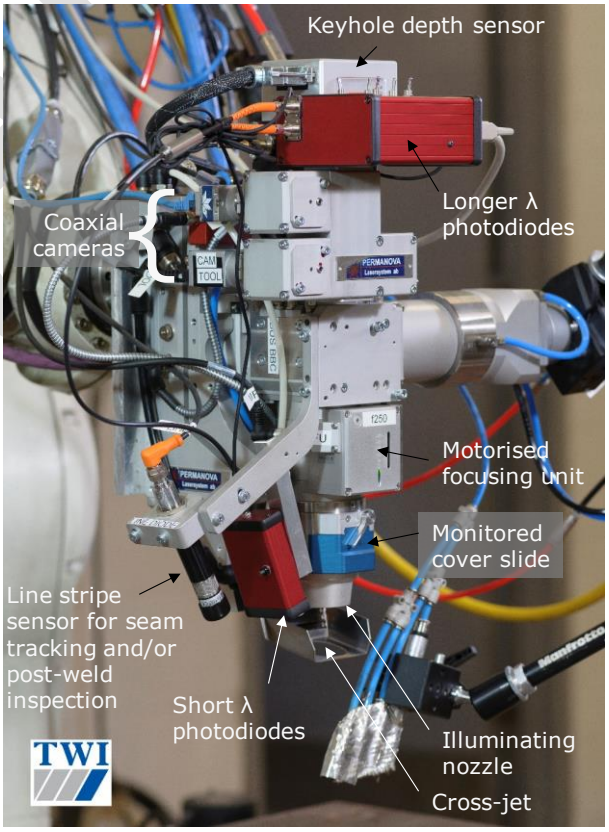


Examples of laser welded automotive (left) and aerospace (right) structures (images reproduced courtesy of CRF and GKN Aerospace)

After welding, such structures undergo some form of inspection and/or testing, to a greater or lesser extent, depending on the component, as one means of quality assurance. Nevertheless, this can be time- and cost-consuming, and the development of improved automated techniques around in-process monitoring and, ultimately, real-time control, is widely recognised as a key enabler to help reduce the costs, and improve the quality and performance, of welded manufactured parts.

With this in mind, the RADICLE project is developing a new multi-sensor system for real-time monitoring and intelligent control of the laser welding process, based on a range of different process measurements and signals detected during welding, using a bank of distinct sensors.

Work programme



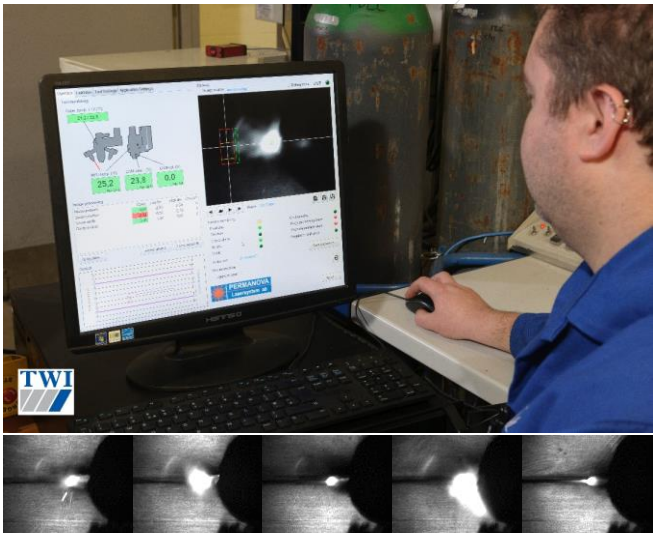
Prototype RADICLE multi-sensing laser welding head

Building from the state of the art, one example of a selected combination of sensors selected by the project for this task comprises:

- Photodiodes (detecting different key photo-emissions from the process across a range of wavelengths from UV to IR, as well as any back-reflected proportion of the incident laser beam). These photodiodes are arranged both off-axis and coaxially.
- Coaxial cameras (taking different images of the process at different wavelengths).
- A microphone (for airborne acoustic monitoring).
- Compatibility with interferometric laser keyhole depth measurements, e.g. to enhance the detection capabilities of the overall system for those users where precise penetration depth control is essential.

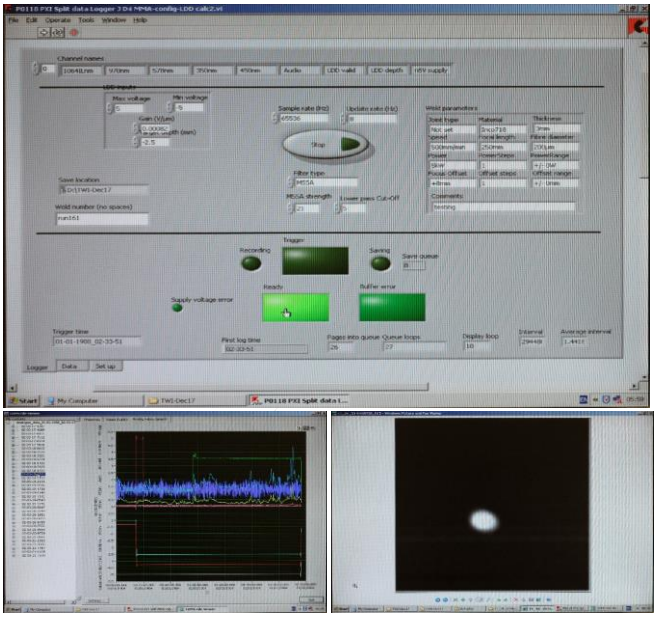
In the project, VTT, LOE, CRF and BitAddict are developing real-time data handling and analysis routines to extract useful process- and defect-related information from these signals. This extracted information will then ultimately be used in combination with specific background materials/joint configuration welding knowhow (e.g. extent of processing envelope), derived from welding trials performed by TWI and the MTC, to predict the imminent probability of defects occurring, and identify smart changes in key welding parameters to avoid that from happening.

This advance is being delivered through the testing of a modified version of Permanova's existing seam finding, inspection and tracking welding head system, combined with in-built coaxial LED illumination and camera imaging of the seam and weld zone, with software support from Bit Addict.



Examples of Permanova.BitAddict in-process imaging

LOE are further enhancing the capabilities of this head with associated weld zone imaging at a second wavelength, photodiode measurements over a range of wavelengths, acoustic monitoring and additional hardware and software support.



Screenshots of LOE monitoring system developments

The whole system has also already been proven to also be compatible with third-party keyhole depth interferometers (e.g. as available from LaserDepthDynamics (IPG) or Precitec), for additional sensing capabilities.

RADICLE head in action during coupon trials

TWI and the MTC are currently carrying out trials with the system, on materials and material thicknesses pertinent to Fiat, GKN and Rolls-Royce, to determine its performance, ascertain the data that can be collected, and help to define how that data can be put to best use for both process monitoring and control.

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