RADICLE project leads advances on the development of control systems for all stages of laser welding

Ensuring highly demanding welds from leading industries are met with leading-edge monitoring and control

Laser welding is a high-performance joining technology of critical relevance in manufacturing industries where complex and highly demanding welds are commonplace or where fabrication throughput is very high. This is why the search for welds with the fewest possible defects from the welding process is fundamental for both security and competitiveness motives. For the last four years, the RADICLE project ('Real-time Dynamic Control System for Laser Welding') has been pursuing an effective real-time control system for laser welding, using a set of application-specific sensors, in combination with intelligent and predictive control technologies. The project's aim was to develop an in-process monitoring and control system that could identify and minimize defects for a range of key materials and geometries typical in the aerospace, automotive, power generation and general engineering sectors industries, amongst others.

On a broader perspective, the RADICLE project contributes to Europe 2020 targets by:

- Reducing energy usage and greenhouse gas emissions;
- Increasing employment for 20-64 year olds;
- Increasing R&D spend;
- Increasing education, particularly third level education.

The project is the result of an industry requirement identified by leading manufacturing companies, such as the consortium members CRF, GE Power, GKN Aerospace and Rolls Royce, for welding processes that deliver highly efficient and cost-effective alternatives to conventional technologies whilst meeting stringent quality standards. The uniqueness of the project lies in the combination of welding, materials, optical measurement, laser systems and software/ICT. The RADICLE system can also potentially be linked into the surrounding IT infrastructure and Manufacturing Execution Systems [MES], supporting the objectives of Industry 4.0. As a result, it is expected that the results from use of the system and the system itself, will have a positive impact and wider adoption within the industry.

RADICLE goals and benefits

The global market for using laser equipment for material processes has grown 50% since 2004 and is valued in excess of €10 billion per annum. The automotive sector has been a leader in the implementation of laser welding for applications such as BIW (Body in White) structures and power train welding. The aerospace sector is also now adopting this process for various applications including the joining of reactive metals such as aluminium and titanium alloys for critical structures. Across the aerospace sector, fabrications will undergo 100% post-weld inspection using X-ray and penetrant technologies and non-conforming welds have to, then, undergo rework, which can severely impact the economic benefits of laser welding processes.

RADICLE started in February 2015 and finished in October 2018. Its achievements, beyond the development of the laser welding adaptive control systems, has been to increase the scientific understanding of the signals generated in a range of commercially available sensors applicable to laser welding, to investigate acoustic monitoring and interferometry measurement as means for detecting process instability, and relating all this to at least three different weld defect types. The current project has laid the foundations for the longer-term goal to create a high-speed adaptive control algorithm capable of multitask processing of data from the sensors and providing rapid

feedback to the laser welding system being able to simultaneously control at least three laser welding parameters.

RADICLE brings academic and industrial partners from across Europe together, benefitting the partners and the project as a whole, including 4 large end-user partners – CRF (FIAT), GE, GKN and Rolls-Royce, with TWI and MTC as welding experts, who have identified a gap in market for laser process maps and suitable sensing tools. Laser Optical Engineering (LOE), BitAddict and Permanova have collaborated for the development of a laser processing head with integrated sensing in order to provide the relevant signals for process control. This process started by identifying the relevant and practical signals and the existing commercial sensors that could be used. Permanova then identified the components requiring modification and redesigned them to enable the integration of the sensor arrays selected by the RADICLE consortium. The development of the required control outputs was led by BitAddict and VTT, allowing an understanding of the information gathered by the sensors and then how best to make use of that understanding.

Ensuring that project partners upskill their workforce and train other people working in the sector is paramount to the project's success, to guarantee that professionals are capable of leveraging this new technology. As well as hardware and software, training and education are key components of RADICLE, increasing the project's visibility as it will become a sustainable training/educational program included in the EWF training system. In turn, this will create new and highly qualified employment opportunities within the laser systems supply chain, as the new systems become mainstream.

Preeminent industrial groups and associations ensure the project's success

The project had a lifespan of three and a half years and was coordinated by the Manufacturing Technology Centre (UK). Industrial companies partnering with MTC include CRF (Italy), GE (Switzerland), GKN Aerospace (Sweden), and Rolls-Royce (UK). These companies have significant market share in the critical markets of automotive, aerospace and power generation. Providing the process and sensor knowledge are Laser Optical Engineering (UK), Permanova and Bit Addict (Sweden), with TWI (UK) and VTT (Finland), each contributing their unique skills and competencies on the specific fields of laser welding and data analysis respectively, necessary for the development of this project. The European Federation for Welding, Joining and Cutting (EWF) led the project's training, dissemination and business planning activities as well as representing the needs of the general engineering and fabrications sector.

The project provides a sound base to develop upon, with all partners looking forward to working together to advance the state of the art on laser welding and ensure its broader utilization.