SAMULET II P5 - Advanced Fabrication

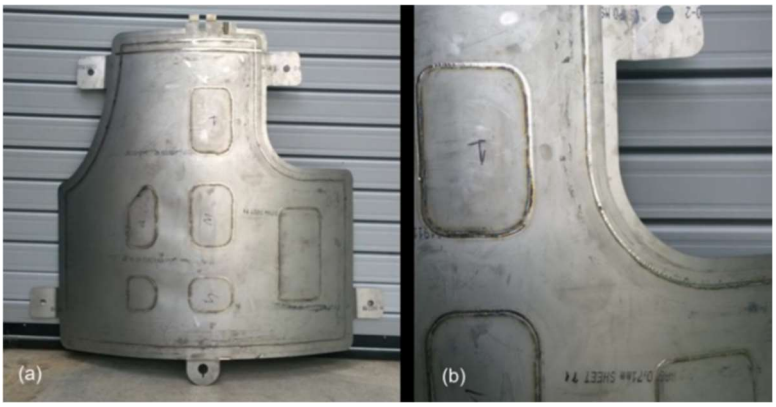
Rolls-Royce (Lead), Manufacturing Technology Centre (MTC)

Project details:

The current manufacturing process for cold complex structures involves joining cold-formed details by both mechanical and non-mechanical methods and is reliant on tacit skills inherent in skilled labour.

The main aim of this project was to develop novel technology to enhance the manufacture of fabricated components, to produce consistent competitive products. The project concentrated on advancing the understanding and utilisation of automated welding techniques, using robots to weld Outlet Guide Vane (OGV) components during assembly and fabrication. The project also focused on developing novel manufacturing technologies to significantly reduce cost, improved lead-time and enable more complex 3D designs for large static structures. This included the development of new laser welding techniques for joining various configurations of thin-walled aerospace materials and the laser drilling of combustion tiles, enabling the benefits of the early laser technology development to be applied onto critical aerospace components.

Collaboration with the MTC supported the aim of this project which included design, installation and development of an automated Tungsten Inert Gas (TIG) welding cell and a laser welding cell at the MTC.



The project touched a wide range of technologies and operated across different work packages. Technologies specifically addressed were robotic TIG welding, automated laser welding, novel welding fixtures, advanced welding torch designs, Laser and TIG welding predictive models.

Table 1: Summary of the project grant details

Project	Funding	Lead Partner	No. of Partners	Partner Composition	Duration
110104 Advanced Fabrications	Total: £3.8m Grant: £1.9m	Rolls-Royce	2	1 Large company, 1 Catapult	April 2012-Dec 2015

Table 2: Summary of the project focus areas

ATI Value Streams		ATI Enablers		ATI Attributes		Strategic Horizon	
Whole Aircraft		Aerodynamics		Safety		Secure	x
Structures		Manufacturing	x	Cost	x	Exploit	
Propulsion	x	Materials		Environment		Position	
Systems		Infrastructure		Fuel Burn			
		Process and Tools		Operational Needs			
				Passenger Experience			

Technology Achievements:

The project met the original expectations with a significant level of technology development during the course of this project.

A new method for laser welding the non–acoustic core faring was developed, reducing the cycle time by more than 80%. This is a significant step change in technology which not only simplifies the manufacturing of cold fabrications, but also offers designers an opportunity to maximise the technology though more complex fabrication designs, thereby advancing the technology of future engines.

A new method for automated welding of OGV components was developed to Manufacturing Capability Readiness Level (MCRL) 4. This involved a novel light-weight composite welding torch design that automatically scanned the components to be welded and adaptively offset the welding parameters to obtain the optimum weld geometry.

The process for laser machining advanced cooling hole geometry in combustor tiles was raised to MCRL 4. This has the potential to reduce NOx emissions, yielding a £120k per annum as a result of a more efficient manufacturing process.

A novel tooling system and prototype fixture was developed to weld elements of a non-acoustic core fairing. The successful development trials enabled the manufacture of a prototype Trent XWB 97 component which was used on on-wing trials of a development engine.

Table 3: Summary of the technology achievements

Project	Performance Improvements	TRL Progression
Laser welding of cold fabrications	Non–acoustic core faring cycle time reduced by >80%. Novel fixture with integrated gas shielding	MCRL 2 - MCRL 6
Automated TIG Welding	Novel torch design with integrated shield gas delivery. Adaptive robotic weld path technology	MCRL 2 - MCRL 4
Laser drilling of cooling holes	Demonstration of capability to laser drill advanced cooling hole geometries in combustion tiles.	MCRL 2 - MCRL 4

Economic Impact:

During the course of this project, Rolls-Royce employed around 15 staff focusing on industrial research. These staff represented a diverse range of disciplines, including but not limited to manufacturing engineering, operations, laser welding, TIG welding, automation, inspection, materials science and fixture design. This level of effort is expected to continue in future years as the technology continues to mature.

At the MTC 10 jobs were created due to the expansion of the team to deliver the project, and a further 5 jobs were safeguarded.

Rolls-Royce has procured a £2m automated laser cell which has now been installed in its Hucknall facility. This cell will initially be targeted at new engine components, however, there is an opportunity to maximise the benefits of the technology by applying it to legacy components. This technology also offers significant cost reduction over conventional fabrications.,

"Hucknall is now making a product that was probably going to go out onto our sub-contract network, or was going to be outsourced. This investment means Rolls-Royce is now not going to do that."

***Ian Wilson**, Rolls-Royce Trade Union Convenor*

A significant amount of technology and learning has been accumulated over the four years of this project. In addition to the Manufacturing Technology Centre, several other companies have been involved in various aspects of the work packages, assisting in fixture manufacture, materials testing, analysis, metrology and Non Destructive Testing (NDT). The learning and experience these companies have gained will be employed across many future manufacturing projects. The Manufacturing Technology Centre will also play a significant role in further disseminating the knowledge gained by application of their new skills to projects with other members, the High Value Manufacturing Catapult partners and wider industry.

Table 4: Summary of the economic impact

Project	Value created	Employment
110104 Advanced Fabrication	£2m capital investment in Rolls-Royce facility	20 jobs safeguarded 10 jobs created

Next Steps:

Rolls-Royce will incorporate the new Laser welding technologies into a new production cell in Hucknall. The technology will initially be targeted at new engine components, however there is an opportunity to maximise the benefits of the technology by applying it to large welded fabrications such as core fairings across the Rolls-Royce engine fleet. An investigation will be undertaken to evaluate if the business case justifies the investment to re-validate the components.

Rolls-Royce is planning to capture all of the learning in the laser welding work-package, the laser drilling work-package and the automate TIG welding work-packages on a software system termed the 'Rolls-Royce Commodity Desktop'. This is a knowledge management system for engineering and manufacturing data. It is accessible, via the standard computing platform, by all engineers and technologists with the United Kingdom and is designed as a 'first port of call' to ensure that best practice and learning is adopted and deployed in future work.

The laser welding and tooling technologies have opened up new areas of research for manufacturing various aerospace components and Rolls-Royce will conduct further research into these technologies working in conjunction with the research centres.

"Working with Rolls-Royce on this project has enabled the MTC to make significant advances in Laser drilling and welding technologies, while delivering novel state of the art laser processes which are now operational in Rolls-Royce factories in the UK. This joint collaboration has allowed us to grow our world class capabilities in industrial laser processing including understand the fundamental physics behind the behaviour of the materials, the machining processes and the laser equipment. This capability has opened up many opportunities for future collaboration projects with UK manufacturers in many different sectors."

Ken Young, Technical Director at the MTC

In addition to the MTC, there have been 15 other companies involved in various aspects of the work packages. The experience gained will be employed across many future UK manufacturing projects. One such company is Tec Systems:

"Tec have gained greatly from this project in terms of enhancing our profile in the market place. Due to the sheer size of the cell and the steady flow of visitors through the MTC, it has become a recognisable industrial piece of equipment. This has certainly benefited Tec in terms of the quality of new laser enquiries that we now receive on a regular basis and more importantly ones that turn into real orders.

From a technical standpoint it also helped us push and develop the systems required when dealing with high power lasers. Most companies never get the opportunity to work with anything more than 2 or 3 kW, this cell being 20kW moved the boundaries and demonstrated to people that Tec were capable of supplying this type of demanding automation. It has also shown that a UK based company can compete with the best of Europe and deliver a quality solution.

This project also acted as an important springboard for us to launch a range of standard laser machines, enhancing the bespoke part of the business. Over the next few years, we hope to see this part of the business continue to grow and offer employment opportunities for apprentices and the next generation of engineers."

Tony Jones, Managing Director, Tec Systems

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