SAMULET II P3 - Affordable Blisks

Rolls-Royce (Lead), Manufacturing Technology Centre (MTC), University of Sheffield (Advanced Manufacturing Research Centre)

Project details:

The main aim of the Affordable Blisk project was to develop technologies to significantly reduce manufacturing lead time and cost for these complex aerospace components. A blisk (bladed disc) is created as single part by the joining of a blade to a disc using solid state joining techniques, enabling substantial weight and performance benefits, when compared to conventional disc/blades arrangements.

In addition, the project aimed to develop a Titanium Metal Matrix Composite (TiMMC) process to coat "ceramic fibres" with a metallic sheath, followed by winding and assembly. This technology enables a significant improvement in the strength and stiffness of components, while reducing their weight. The project improved process capability and automation, to drive down product cost, which will enable wider use of the technology across Rolls-Royce products and the wider supply chain.

A collaboration between Rolls-Royce, the AMRC and the MTC supported the aim of this project to reduce the manufacturing cycle times by 30%. This reduction in cost helps to ensure these new technologies are available for civil applications, supporting future engine designs and confirming our competitiveness in this market.

Table 1: Summary of the project grant details

Project	Funding	Lead Partner	No. of Partners	Partner Composition	Duration
110102 Affordable Blisks	Total: £8.5m Grant: £1.7m	Roll-Royce	3	1 Large company, 2 Catapults	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	
Structures		Manufacturing	x	Cost	x	Exploit	x
Propulsion	x	Materials	x	Environment		Position	
Systems		Infrastructure		Fuel Burn			
		Process and Tools	x	Operational Needs			
				Passenger Experience			

Technology Achievements:

This project successfully developed a multitude of novel blisk technologies including novel fixture design, advanced machining programmes, optimised cutter paths, novel tooling, rapid Coordinate Measuring Machine (CMM) programmes (programmable inspection machine for automatically measuring components) and novel surface finishing processes. Collectively, these technologies have generated improvements in blisk manufacture in excess of 30%. The cost of manufacturing titanium-coated silicon carbide fibre is very expensive, being impacted by long cycle times and high consumable costs of manufacture. The team successfully developed novel fibre coating technologies which exceeded all the project targets with 100% increase in rate of coating fibre, 100% increase in fibre length coated in a single run, 45% decrease in coated fibre cost and 100% productivity increase for the Rotherham facility.

The first use of the blisk technologies is aimed for a Trent XWB-97 engine flying test bed. Some successful examples of blisk development exceeded our expectations with significant business benefits so far:

- The lead-time to validate Linear Friction Welded components is a limiting factor on the lead time to implement new blisks into production. This project carried out a multitude of Linear Friction Welds (LFW), followed by extensive testing to compile a database of information which has already reduced the cost of testing and analysis by 45%. In addition, the generic validation methodology has the potential to reduce the product introduction lead-time by 70%.
- It was recognised during the project that the current method of repairing aerofoils could not be applied to current LFW blisks. To mitigate this risk, work was undertaken to develop repair technology for blisk aerofoils, using material addition and finishing processes. The development of blisk repair technologies has successfully raised the manufacturing readiness level to Manufacturing Capability Readiness Level (MCRL) 4, and Rolls-Royce will continue to develop this technology to deliver a robust production process.
- The TiMMC work package has made significant progress in reducing the cost of coated fibre, however, the current rate still needs to be increased to meet cost targets and Rolls-Royce has launched a further development project, in collaboration with the AMRC, to continue this development, to optimise the cost opportunity and enable this technology to be used on future aerospace components.

Table 3: Summary of the technology achievements

Project	Performance Improvements	TRL Progression
RR3.1 Competitive LFW Blisk	• Process database compiled and analysed for increased LFW understanding. • Reduced the cost of testing and analysis by 45%. • Improvements in blisk manufacture >30%.	Progressed to MCRL 4
RR3.2 Titanium Metal Matrix Composite	• 100% increase in rate of coating fibre. • 100% increase in fibre run length. • 45% decrease in coated fibre cost. • 100% productivity increase at Rotherham facility.	100% rate increase maintaining current capability level

Economic Impact:

During the course of this project, Rolls-Royce employed around 20 staff who were engaged in industrial research. These staff represented a diverse range of disciplines, including but not limited to Linear Friction Welding, inspection, materials science and fixture design. This level of effort is expected to continue in future years as the technology continues to mature. The equivalent of three people full-time worked on this project from the MTC.

This project combined a number of blisk technologies to enable the on time delivery of a finished blisk for the Trent XWB flying test bed. This is a significant milestone for Rolls-Royce and for the UK aerospace industry.

This project has significantly moved blisk technology forward across a number of different technologies enabling more accurate predictions of the future development time, scope and benefits. The Linear Friction welding work package has successfully demonstrated the manufacture of a large civil blisk. Rolls-Royce is currently in the process of developing the capacity and capability to enable volume production of these complex components, with new Linear Friction Welding processes and capital equipment currently being installed in Rolls-Royce's Compressor Rotor Facility in Annesley, near Nottingham. The learning and understanding from this project will be used to support future engine programmes, enabling engineering to design more complex blisks, including the linear friction welding of dissimilar materials.

Table 4: Summary of the economic impact

Project	Value created	Employment
110102 Affordable Blisks	An enabler for improving the competitiveness of UK manufacturing sites.	Jobs safeguarded: 23

Next Steps:

This project was instrumental in building strong relationships between the partners. These relationships will be fundamental to tackling the future technology programmes and this interface will continue well beyond the end of SAMULETII.

Many of the sub-contracted companies involved in the project (including Renishaw, Stresscraft Ltd, Atlas Engineering LTD and TICISC Ltd) are planning to further develop their technology to meet the requirements of other UK manufacturing organisations, further growing their capability and that of the UK manufacturing sector.

"The programme has facilitated the maintenance and further development of the team of Researchers and Engineers specialising in the area of Titanium Metal Matrix Composites, ensuring that the UK maintains its leading position in this field. The technology developed has enabled the broadening of skills and experience as the manufacturing process has been matured. A number of the techniques developed have found application in other technology areas.

The development of this team has enabled the provision of technical support and assistance to other MMC development areas, without compromise of IP developed on the programme. This is enabling the UK to continue its development of MMC technologies in Aluminium matrix composites in addition to Titanium Matrix composites."

Richard Scaife, Head of Composites, AMRC Composite Centre

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