SAMULET – Manufacturing R&D Programmes

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Programme Manager – Research & Technology

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Agenda

- Introduction to the SAMULET Programme
- Examples of technology delivery
  - Product Definition
  - High Performance Disc Machining
  - Precision Forging Die Life
  - Automated Smoke Chute Welding
  - Filmless x-ray
  - Adhesive & Pro-Laser Fixturing
  - Machine Tool Metrology
- SAMULET II Programme
  - Content & Engine Exploitation
- HVM Catapult – Rationale & Capability
Aims and Objectives

To significantly increase competitiveness of UK high value manufacturers and reduce environmental impact

- **Product definition technology**
  - Develop next generation core gas turbine technology with increased efficiency and reduced emissions (Key measures: SFC, ACARE targets)

- **Manufacturing technology**
  - Develop manufacturing capability to significantly improve productivity while supporting increasing product complexity and volume (Key measures: Buy-to-fly ratios, output/m² & energy consumption/m²)
SAMULET I Programme

£80m running 2009-2013
£31m from industry, £28.5m from TSB, £11.2m from EPSRC & £8m from RDAs

Industrials

Academics

Working collaboratively on 6 projects – 3 relating to product definition and 3 relating to manufacturing
Product Definition

High Efficiency Turbomachinery
• Wide range of technology from blade casting and coating to advanced cooling and novel architectures.

Combustion Systems
• Studies of both rich and lean burn technologies; cooling methodologies (air and fuel) and advanced analytical techniques.

Advanced Transmission Systems
• Technology development relating to engine structures; gear, oil and sealing systems. Also composite externals raft.
Case Study: High Performance Disc Machining
System of technologies deployed into a competitive Method of Manufacture

- A family of complex, high precision gas turbine components
- Previous method of manufacture uncompetitive in UK context

### Modelling
- Distortion
- Fixtures

### Monitoring
- Process
- In Cycle

### Integration
- Mill-turn, deburr
- Less setup
- Less Ops

### Green Button

- Half the current value added time
- Double the productivity
- Zero consumable cost difference
- 6-sigma process capability
Case Study: Precision Forging Die Life
Scientific understanding in established forging techniques

- High volume production of precision nickel forged aerofoils
- Die life impacted by thermal and mechanical stresses

Short life tools

**Die coatings & substrate**

FE Analysis

**Die geometry optimised**

Failure analysis

Dimensional & thermal

**Die material change**

New surface treatment

- Improvements led to doubling of die life
- Reduced manufacturing cost and increased capacity
- Benefits integrated into process at Rolls-Royce Compressor Facility in Glasgow
Case Study: Automated Smoke Chute Welding

- Combustor casings contain around 200 smoke chutes, each secured to the casing via 2-3 small and highly toleranced welds.
- The welding is a manual process leading to inherent variation, inconsistent fit and distortion resulting in rework.
- Automated Smoke Chute Welding aims to reduce variation and improve rate through introducing hard automation with an orbital welding TIG process.
- The orbital welding head centralises on the ID of each smoke chute giving accurate positional control reducing geometric variability in the weld and halving the process time.
Case Study: Filmless X-ray

Conventional Film inspection
Lengths of film are positioned behind the joint by hand. The shot is taken and film removed. This is repeated 10 times/weld. Takes 45min/part.

Through drive arm shot
Not possible as sensitivity cannot be achieved due to excess metal thickness.

Miniature detector solution
The SAMULET miniature detector solves this and opens up
• Automation of inspection process (R-R perform 20,000 x-rays/yr drums)
• Opportunity for automated detection by combining digital x-ray image and ‘No defects’ x-ray created using weld bead shapes + x-ray computer model.

Included in filmless conversion plan for compressor drums

Detector was developed with CIT Ltd, an SME based in Milton Keynes.
Case Study: Adhesive Fixturing System

- Technology developed in conjunction with Nottingham University with subsequent application at AMRC.
- Securely retains components avoiding clamping forces which may lead to distortion.
- Prototype fixture designed and manufactured and used in compressor blade grinding trial.
- UV curable adhesive (Dymax 6-621) is applied to the component locating feature which is loaded into the fixture.
- An intense integrated UV light source cures the adhesive constraining the component.
- Post machining the adhesive bond is broken mechanically and can be completely removed by heating.
- 6 patents covering adhesive fixturing filed by Rolls-Royce.
Case Study: Pro-Laser Fixturing

- Affordable precision fixtures and tooling with shorter manufacturing lead times through intelligent design and construction from laser cut sheet metal.
- Typical cost reductions of 50%.
- Construction techniques that do not require any welded joints – patented joining features are laser-profiled into the flat-sheet elements creating patented Pro-Laser clamping and locking mechanisms. Fully finished plates are mechanically assembled with simple hand tools.
- Various sheet materials can be used, exploiting unique properties (e.g. titanium springs).
Case Study: Machine Tool Metrology

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SAMULET 6.3.1

Calibration Workstream
- University of Huddersfield
- MTT Ltd.

Verification Workstream
- University of Bath

Supporting Organisations
- RENISHAW
- NPL
- Advanced Manufacturing Research Centre

Technology
Advice and Approval
Lab trials
Case Study: Machine Tool Metrology - Results

Objective: Calibrate a 5-axis machine in less than 1 hour

- Previously 3 - 5 days
- Now 1hr 40mins

Verify a 5-axis machine in less than 1 minute

- Previously 30 mins (3-axis)
- Now 2 mins (3-axis)

Ensure that best-practice calibration and verification methods are available to Rolls-Royce manufacturing facilities
SAMULET II Programme
£65m running 2012-2015
£40m from industry and £25m from TSB

Industrials

Academics/ HVM Catapult

Rolls-Royce
GKN Aerospace
Aero Engine Controls
The University of Sheffield
Advanced Manufacturing Research Centre
Manufacturing Technology Centre
Boeing
The University of Birmingham
AFRC
Advanced Forming Research Centre
University of Strathclyde

Working collaboratively on 8 manufacturing projects. Supported by £15m capital investment from HVM Catapult
Exploitation in an Engine

- High performance SPF
- EB Powder technology (EB) for TS&D parts
- Advanced fabrication of large structures (Fans)
- Competitive blisk
- Tighter tolerance compressor aerofoils
- High temperature material processing
- Advanced fabrication of large structures (TS&D)

- Composite Fan System
- TiMMCs
- MIM stator vanes
- Advanced fabrication of cold structures
- Powder HIP casings
- FlowForm / Radial forge shafts
- High Performance Shaft manufacture
Questions?