Industrialising Additive Manufacturing of metal parts

Prof David Wimpenny
Chief Technologist
Component Manufacturing Technology
MANUFACTURING TECHNOLOGY CENTRE

FOUNDING IN 2010

Independent RTO
Company limited by guarantee (profit re-invested in MTC)

Purpose built facility - to allow industry & academia to perform industrial scale projects

FOUNDING BY LEADING RESEARCH ORGANISATIONS:

University of Birmingham
Loughborough University
University of Nottingham
TWI

With support of industry
BRIDGING THE VALLEY OF DEATH

Experimental research

Applied research

Technology implementation

TRL 1  TRL 2  TRL 3  TRL 4  TRL 5  TRL 6  TRL 7  TRL 8  TRL 9

MTC FOCUS
Innovate UK

VALLEY OF DEATH

UNIVERSITIES
RESEARCH ORGANISATIONS
RESEARCH COUNCILS

INDUSTRY AND COMPANIES
PRIVATE SECTOR FUNDS
MTC MEMBERS

TIER 1
- AIRBUS
- Rolls-Royce
- Renishaw
- DMG MORI
- Hexagon
- BAE Systems
- Amey
- AWE

TIER 2
- KUKA
- +GF+
- Renishaw
- Nikon
- Delcam
- London Underground
- Siemens
- Autodesk
- Thales

TIER 3
- Guidel
- Omron
- Prodtex
- ABB
- Segromesh
- Witte
- Mahr
- Europlascer
- SGS
- Aerotech
- HumSeal
- Holovis
- Metrosage
- National Instruments
- VFE
- Höganäs
- Law
- DBK
- TIT
- Alicona
- Edgecam
- Crown
- Thommons
- Beckhoff
- Univesa
- Capvidia
- Blundell
- Makita
- Accelouis
- OKE
- Virto
- Altair

+ several others recently joined
NATIONAL CENTRE FOR ADDITIVE MANUFACTURING

- Demonstration factory taking raw material and part designs and producing fully finished parts where every stage of the process is carefully monitored and controlled
NATIONAL CENTRE FOR AM

- Design for AM
- Feedstock Control
- AM Process Chain Production Readiness
- Inspection & Validation
- Process Simulation

Pilot Production & Factory Implementation

Integrated Digital Engineering Systems
The challenge

- Research
- Rapid Prototyping

Is NOT production
Our aim......

“Rapidly develop AM through to industrialisation by developing the technology and systems required to address the key challenges within the AM value chain.”
Design

- Which software?
  - Evaluation and selection of software
  - Optimisation of workflow

- Lack of identified applications
  - Product line assessment and down-select
  - Re-designing to benefit from AM process

- Lack of DfAM knowledge
  - Workshops and training courses + knowledge transfer
Manufacture

- Low production rates
- Lack of process heritage
- Varying part quality and aesthetics
- High cost
- Lack of process understanding
- System development
- System assessment and suitable part selection
- Years of AM experience across multiple technologies
- Workshops and training courses + knowledge transfer
- Cost modelling and analysis
- Process development and optimisation to part specs
- Process development and optimisation to part specs
Materials

- Limited material availability
- New supply chain required
- Varying material quality
- Material development
- Material assessment and optimisation
- Supply chain assessment and engagement
Inspection

Part qualification

Lack of functional testing

Rate capability

Work undertaken to industry qualification requirements

Wide range of testing capabilities

Development of rate capable systems

Rate capability
Roadmaps

**GRAND CHALLENGES**

- Improved component performance
- Zero defect components
- Low cost production
- Right first time design
- Rate capable production

**AM Roadmaps**

- Improved quality and reduced time / cost
- Improved / Reduced post processing
- Factory-Ready AM
- Improved AM quality through simulation
- Design for AM
- Improved AM quality through inspection
MTC Projects

- **Universities (fundamental research)**
- **Industrial and research partners**
- **External Collaborative Projects (large scale)**
- **Direct Funded Projects (confidential)**
- **Internal Capability Building Projects (MTC only)**
- **Core Research Projects (members only)**
- **Impact (end user, supply chain)**
AMAZE

(Additive Manufacturing Aiming Towards Zero Waste and Efficient Production of High–Tech Metal Parts)

Grant Agreement 313781

• FP7 (FoF-NMP.2012-4 high performance manufacturing technologies in terms of efficiency)
• €18m project (€10mEU funding plus partner contribution)
• 4.5 year duration
• Commenced 1st January 2013
• 28 Partners
AMAZE Partnership
Aim

Develop and demonstrate metal AM process chains for industrial production

• Robust AM process chain for small to large parts

• Industrial scale parts which have been tested

• Demonstration AM production factories
Entire Process Chain…….

- Materials development (including feed-stock characterization)
- Design for AM
- AM process development
- Process monitoring
- In-process and post process NDT and inspection
- Process modelling
- Part finishing
- Process automation and streamlining production
- Production and testing of industrial demonstration parts
- Supporting the development of standards
AM process technologies

Powder bed fusion
• Laser melting (EOS, Concept Laser, SLM Solutions, Renishaw machines)
• Electron beam melting (Arcam)

Directed energy deposition
• Laser+powder
• Laser+wire
• Arc+wire
Powder Bed Fusion

Increasing the build rate by;

• Higher laser power
• Multiple laser sources
• Improved build strategies
• Optimised process parameters
Directed Energy Deposition

- Improved hardware and process strategies enabling complex parts to be built quickly, with lower distortion, defects and waste

- Norsk Titanium: PTA + wire
- FhG ILT: Laser + powder
- IREPA: Laser + powder
- Trumpf: Laser + powder
- Technalia: Thermal monitoring
Feed-stock quality is critical

• A key part of the early stages of the AMAZE project was to set an agree specification for both powder and wire feed-stocks

• ALL material used in the project was checked against this specification
Controlling Powder Quality

• Conformance to chemical composition
  Alloyning elements
  Interstitial elements
• Free from foreign particulate contamination
• Correct particle size fraction
  SLM – 15-45 µm, EBM – 45-106 µm, BP – 45-90/150 µm
• Ability to spread evenly across build platform
• Maintain a consistent bulk packing density – higher is better
• Spherical particle Morphology
Powder Characterisation

• MTC powder testing lab
New Powder Quality

Excessive amount of fines (<15microns)

Porous/shell particles

Contamination
Contamination when powder is reused

EDS shows this irregular particle is Fe-based powder, containing Ti, Cr, Ni, Al, Si, and Mn (stainless steel?)
Part Post processing

• Part fixturing

• Finishing methods (Laser polishing, machining etc)
Demonstration AM Factories
AM Factory of the Future
Demonstration Parts

• Designed for AM
• Best process(es) selected
• Manufactured to match current production requirements
• Parts evaluated;
• Performance
• Economic / environmental benefits
TAS Cannes : Sun sensors and antenna support

Observation and science satellite application

Material : aluminium alloy

Current process: 3 parts Machined and bonded
Original and new design

Weight: 550g
7075 T7351

Weight: 260g
AlSi10Mg

Weight reduction 52%
Parts Made by Laser Melting Powder Bed Fusion

- Renishaw
- Concept Laser
- University of Birmingham (SLM Solutions)

Testing: Static and Fatigue testing at Thales
Not covered in the presentation …. 

80% of the AMAZE project including:

• Process modelling
• In process and post process NDT
• Life cycle analysis
• Development of new auxetic structures
• New AM materials….vanadium, tantalum, tungsten, etc
• Standard development
To find out more....

Date for the Diary:

7th of June 2017
AMAZE EU Project Forum
MTC

http://www.amaze-project.eu/
Thank you for listening

Any questions?
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