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Engineering and Physical Sciences
Research Council

Introduction to the FEMM hub

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The University of Sheffield

The University Of Sheffield.

Newcastle University

University of Strathclyde

AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

AFRC
ADVANCED FORMING RESEARCH CENTRE
UNIVERSITY OF STRATHCLYDE

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£28M Future Manufacturing Hub -
£10.3M EPSRC, £13.0M from industry and £4.7M from institutions

Our vision:

- To put UK manufacturing at the forefront of the electrification revolution in aerospace, energy, high value automotive and premium consumer sectors.
- Address key manufacturing challenges for high integrity and high value electrical machines.
- Assist UK manufacturing to capture significant value in the supply chain, improve productivity and deliver the cleaner growth at the heart of the UK's industrial strategy.

www.electricalmachineshub.ac.uk

Timelines

- 7 year programme
- Start date 1st April 2019
- Official launch event 12th June 2019
- ~80% of research staff roles populated (8 staff in post)
- Recruitment of first cohort of 6 studentships on-going for September 2019 start
- Work-plan laid out for first 2-3 years only

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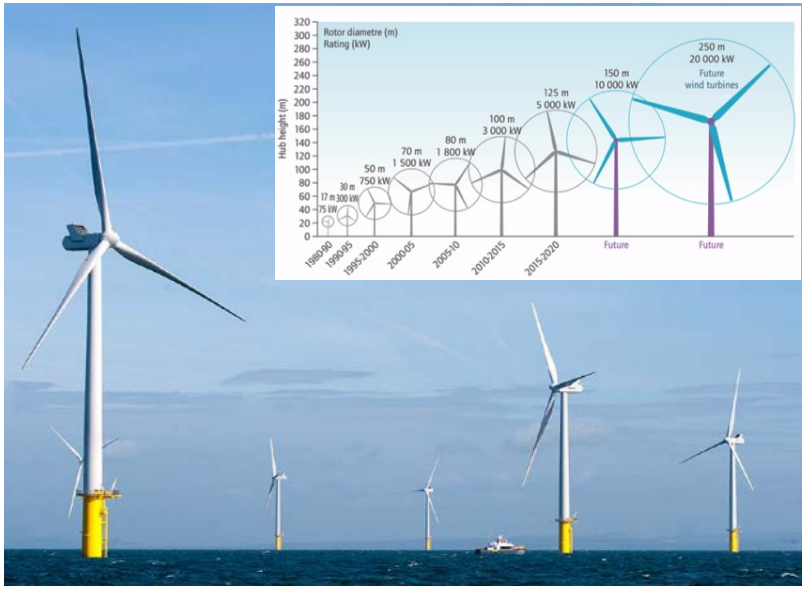
Electrification



Many sectors demanding machine with higher power density going forward

Moving from 5-10 kW/kg to projection of 20-30kW/kg in some applications while maintaining efficiencies of >95%

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Hub focus

- Manufacture of high-value, high integrity and low to medium volume electrical machines for several key UK sectors (e.g aerospace, renewables, premium automotive)
- Anticipate spill-over to mass-market, high volume manufacture (e.g. mainstream automotive) but not primary focus of the Hub.
- Reflected in our starting group of partners.

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Our Industry Partners

AIRBUS

SIEMENS Gamesa

Rolls-Royce

GKN AEROSPACE

ZF

dyson

Höganäs

UTC Aerospace
Systems

Protean
ELECTRIC

McLaren
APPLIED TECHNOLOGIES

Romax
TECHNOLOGY

Lanner

CATAPULT
High Value Manufacturing

NPL
National Physical Laboratory

AEROSPACE
TECHNOLOGY
INSTITUTE

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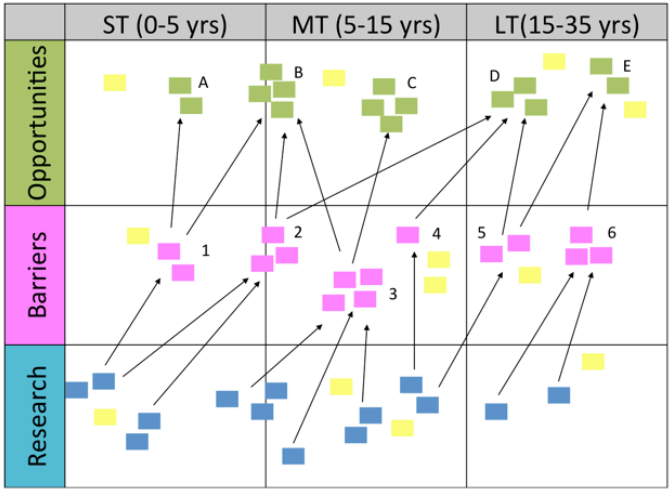
Industry input to initial themes

Facilitated workshop 14th March 2018 attended by 14 companies



Identified manufacturing challenges and barriers:

- Need for in-process support for manual operations to improve productivity and provide quality assurance
- Sensitivity of high value and high integrity machines to small changes in tolerance – need for high precision in manufacturing for safety critical applications
- Increasing drive to low batch size, flexibility and customisation
- Need to train the next generation of manufacturing scientists and engineers

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Grand Challenges Themes – Precompetitive - focus on TRL1-3

GC1 - Manufacturing-led Innovation in EM

- Realising novel machine designs from innovative manufacture
- Manufacturing of features for in-service performance
- Manufacture of light-weight and multi-functional components

GC2 - Process Innovation, Monitoring and Simulation

- Form nominal core properties to in-service performance
- Manufacturing high performance coils with ultimate control
- Manufacturing technologies for flexibility and customisation
- In-process tracking & traceability for zero defect manufacture

Lower TRL & Fundamental R

Hub PhD studentships

EPSRC projects

Higher TRL & Applied R&D

Industry funded PhD studentships

Direct industry funded projects

HVM Catapult projects

UK Gov. / Industry funded projects (ATI, APC, IUK, ISCF Stephenson & Made Smarter)

A-priori defined R (first 2-3yrs)

Emerging R

Core hub & partner funding

New funding

Platform Research

Feasibility projects with new university partners (£800k funding)

- Proof of concept
- Secondments

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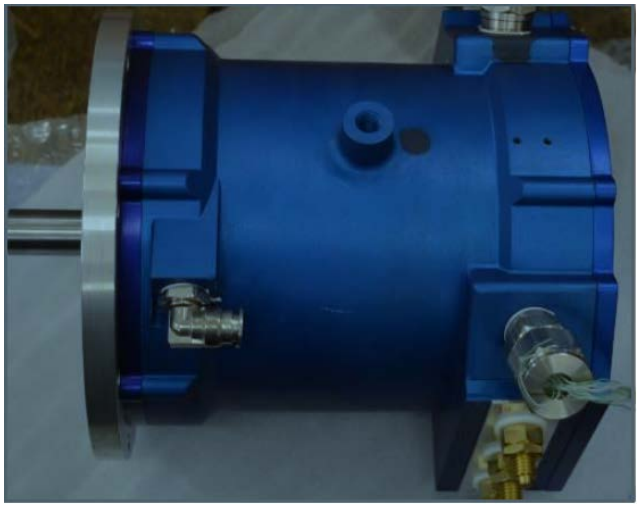
Power density challenge - role of manufacturing



Very mature palette of active materials

- Stator core – Vacoflux 50 Cobalt Iron – essentially tweaks on Permendur (1932)
- Rotor magnets Sm_2Co_{17} – early 1970s
- Drawn copper wire – Theophilus the Monk in 12th century
- Insulation coatings of wire – Polyimides 1990s

100kW continuous, 135kW peak in generator mode
22.75kg - 3.96kW/kg
47% of mass contributed by non-active elements

Power density increases will come from improved heat transfer and light-weighting of structural components

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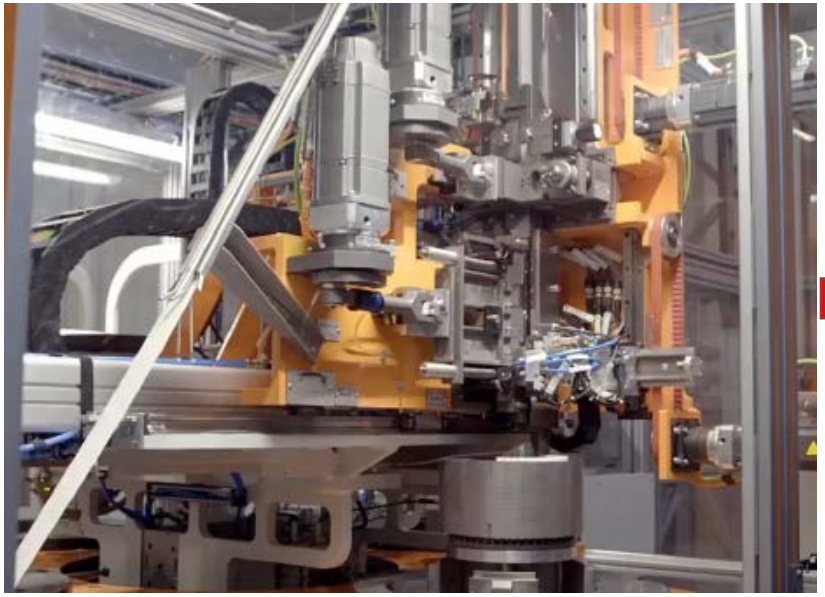
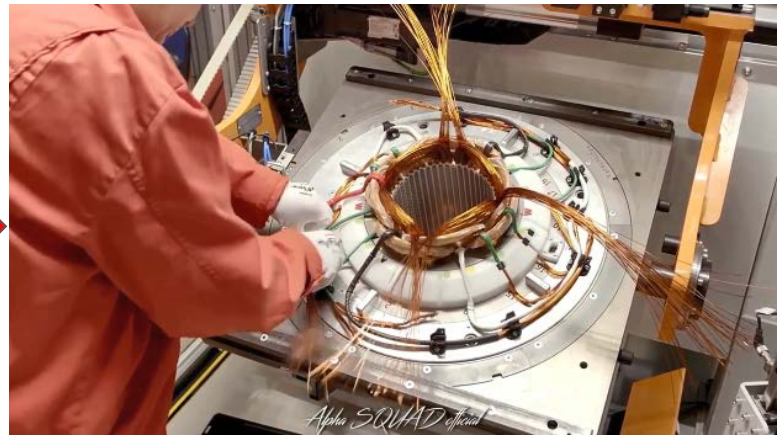
In-Process Inspection

- **Vision:** Zero-defect manufacturing of Electrical Machines (EM) through inspection, verification and digital certification at the point of manufacture
- **Opportunity:** Potential to "reshape current assembly research" by addressing the unique features of EM manufacture, such as coil windings, insertions and terminations that all involve skill-intensive tasks with deformable materials

Manual processes

Not just an issue for small batch manufacture - many highly automated production facilities employ some manual interventions





Source: https://www.youtube.com/watch?v=MSxgFs1FXps

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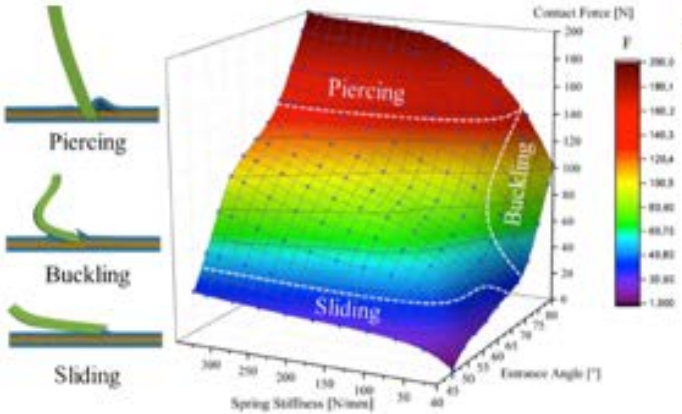
State of the Art: Termination Endings

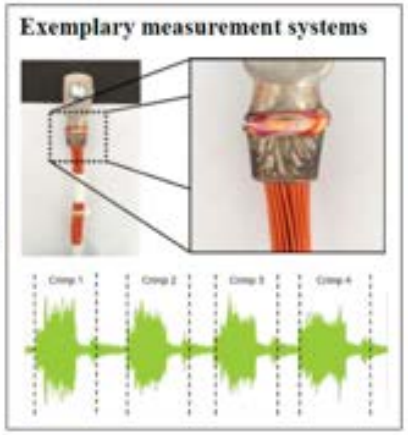


FEM Modelling

"Explicit FEM Analysis of a New Contacting Method for Electronic Devices with Novel Wiring Harnesses" 2015

"Conceptual Design of an Ultrasonic Crimping Process using Machine Learning Algorithms" 2018

Acoustic Sensing



"Potentials of Machine Learning in Electric Drives Production Using the Example of Contacting Processes and Selective Magnet Assembly" 2017

Computer Vision

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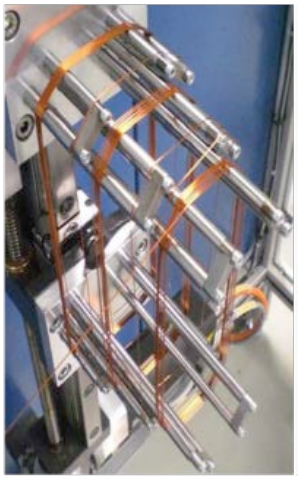
In-Process Inspection for Electrical machines: Stage 1

Development of a ‘sensorised workbench’ for capturing manufacturing data

- Capture process characteristics using networked sensors
- Map defects with process characteristics
- Develop a workbench for real-time spatio-temporal data capture: coil winding, terminations, wiring, insertions and connections



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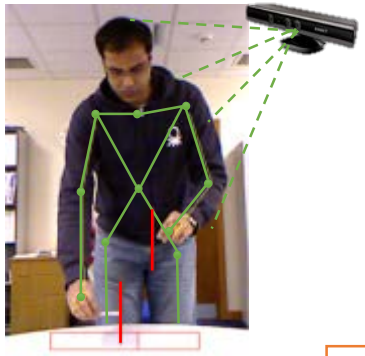
Digitisation of Human-Workpiece Interactions



Digitisation of Human Actions

Digitisation of Objects and Environments

Digitisation of Manufacturing Processes

In-Process Inspection and Verification

Intelligent Automation

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