University of Sheffield /AMRC Advanced Manufacturing Research Centre

High-speed Rotor Development and Testing at the AMRC

Future Propulsion Conference 2025

CATAPULT High Value Manufacturing

UKRI Innovate UK

TOMORROW. DONE BETTER.

Agenda

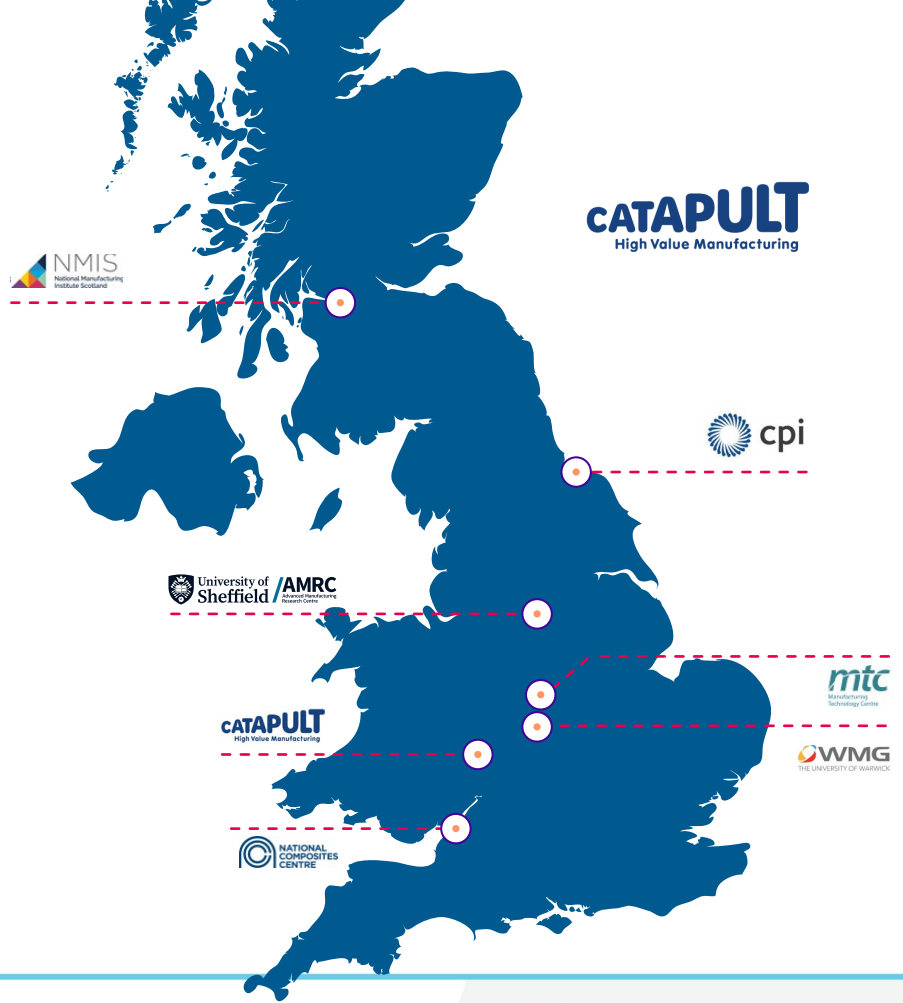
- The University of Sheffield AMRC
- Motivation
- Rotor development
- New testing capability
- Future direction

High Value Manufacturing Catapult

The AMRC is a core part of the High Value Manufacturing (HVM) Catapult, a group of leading manufacturing research centres backed by the UK's innovation agency, Innovate UK.

The HVM Catapult is a thriving alliance that works with companies of all sizes to bridge the gap in – and accelerate the activity between – technology concept and commercialisation.

Being part of the HVM Catapult ensures that we play a core role in the revival of the national manufacturing sector.



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DER

Driving the Electric Revolution Industrialisation Centres

The Driving the Electric Revolution Industrialisation Centre (DER-IC) network provides open access to expertise and state-of-the-art manufacturing, test and validation equipment in PEMD.

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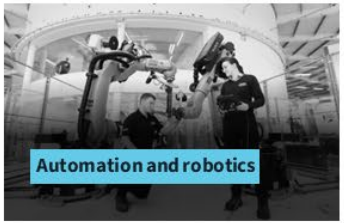

Capabilities

Our research is organised into a number of key capabilities.

Our capabilities span our sites in Rotherham, Sheffield, Broughton and Preston.

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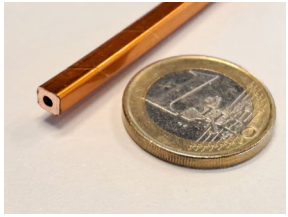
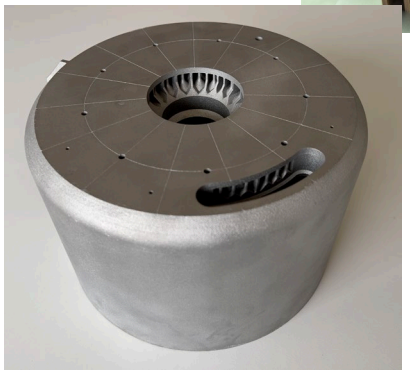
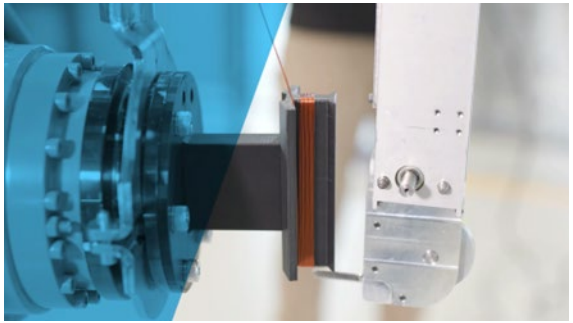
Electrical machines manufacturing





TECHNOLOGY INDICATORS

		2026	2030	Target 2050
Electric motor	Power Density (kW/kg)	13	23	25
Power electronics (Inverter)	Power Density (kW/kg)	22	40	60
Power electronics (DC-DC)	Power Density (kW/kg)	15	40	60
Fuel cell stack	Power Density (kW/kg)	7	9	16
Thermal management system*	Power Density (kW/kg)	6	7	20
Air-supply system*	Power Density (kW/kg)	1	1	3
Electrical propulsion system	Power Density (kW/kg)	1.0-1.5	1.5-2.0	3.0-3.5

**For thermal management system and air supply system the power used to calculate power density refers to amount of heat dissipated, and compression power required to support the system.*

Electrical Propulsion Systems – Roadmap Report (FZO-PPN-COM-0030) Aerospace Technology Institute 2022

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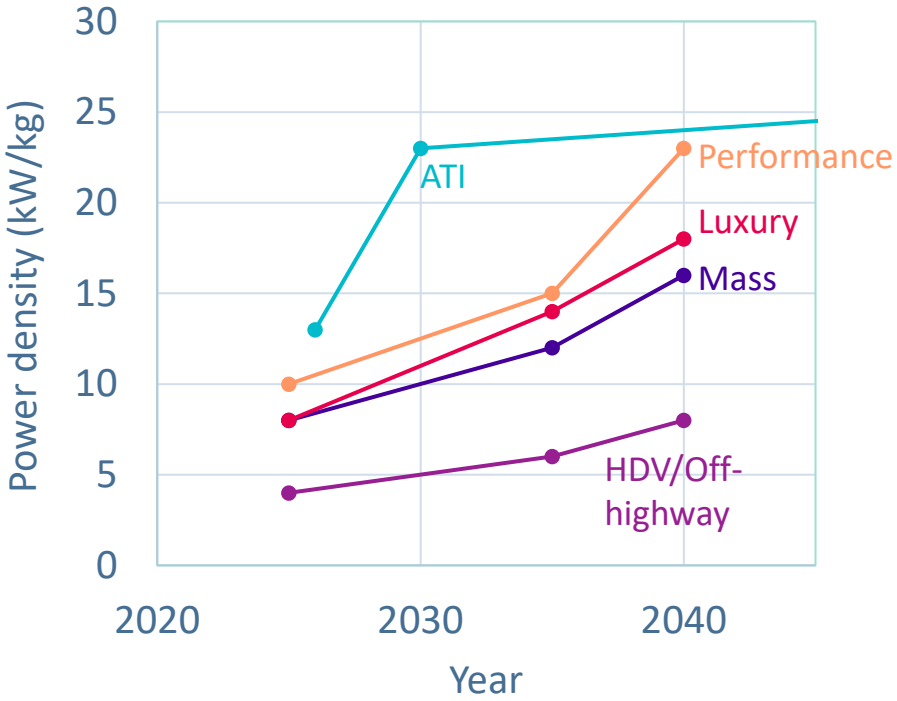
Technology indicator – power density

$$Power\ density = \frac{Power}{Mass}$$

$$= \frac{Torque \times Speed}{Mass}$$



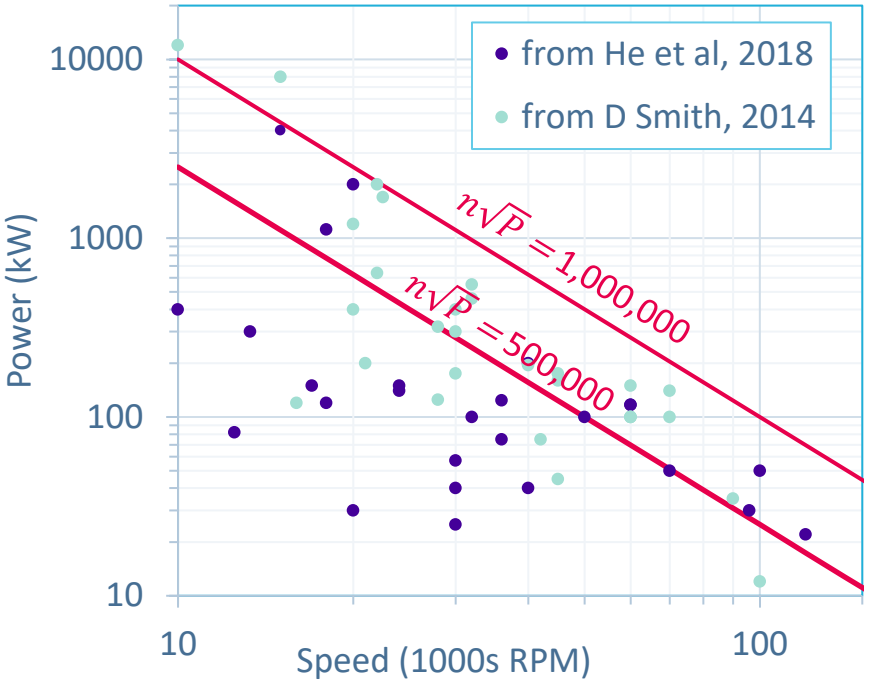
APC Electrical Machines Technology Roadmap 2024
ATI Electrical Propulsion Systems Roadmap 2022

High speed machines

With some assumptions can derive figure of merit $n\sqrt{P}$

n – Speed (1000 RPM)

P – Power (kW)



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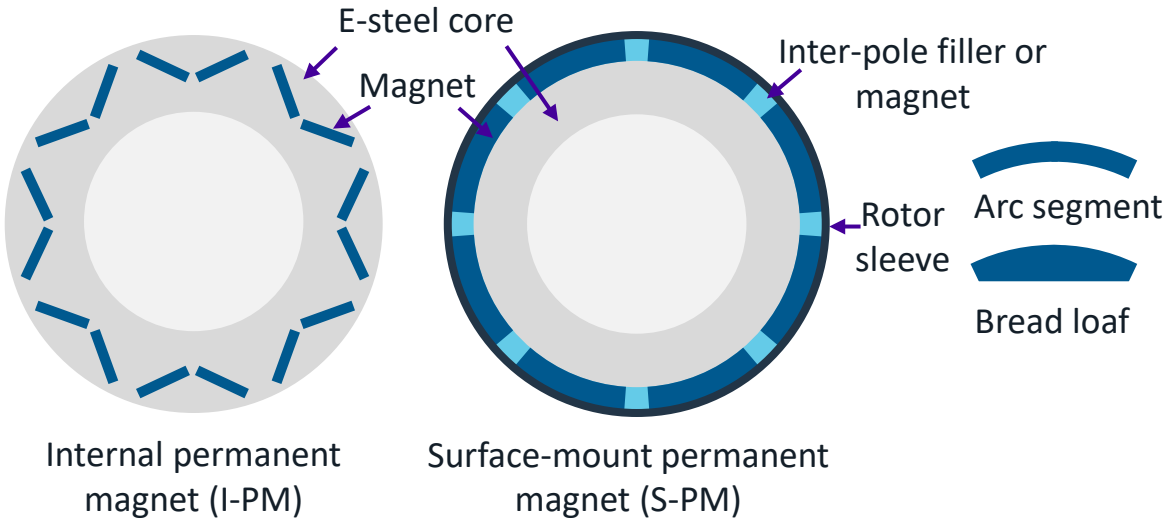
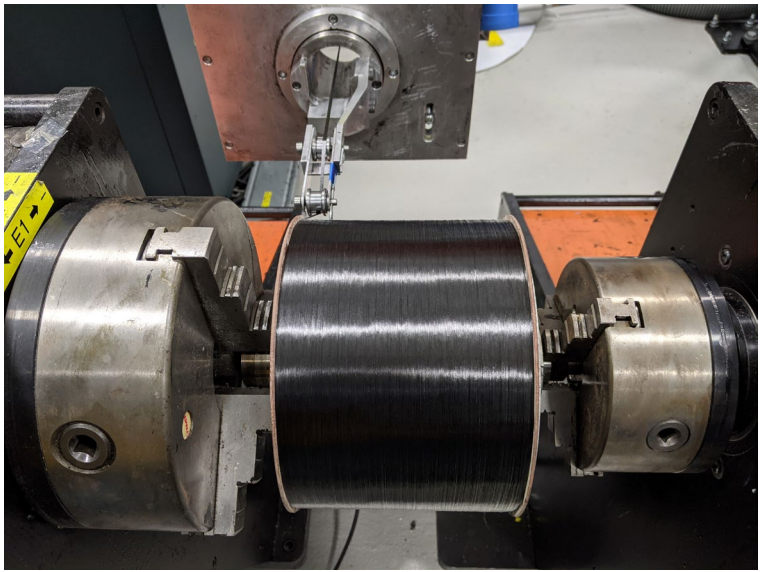
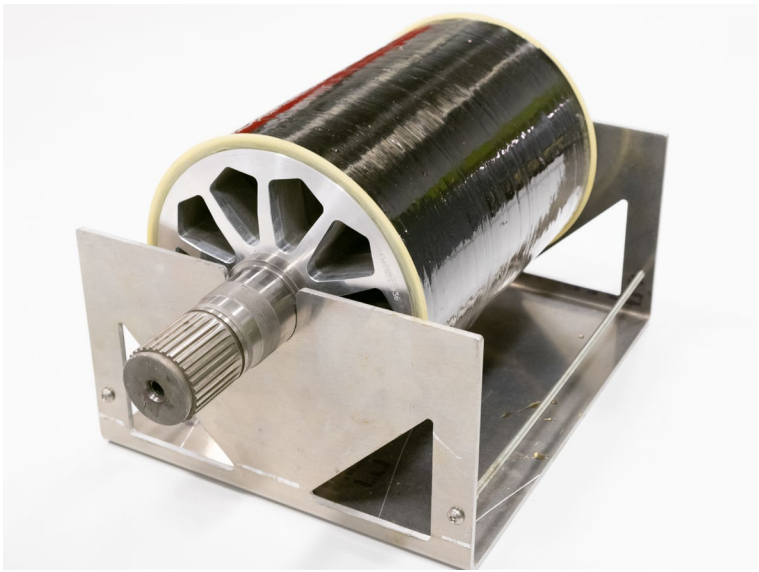
Rotor sleeves



Rotor sleeves

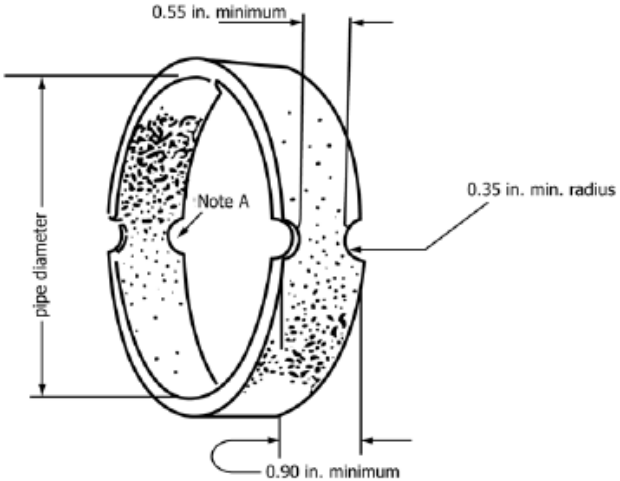


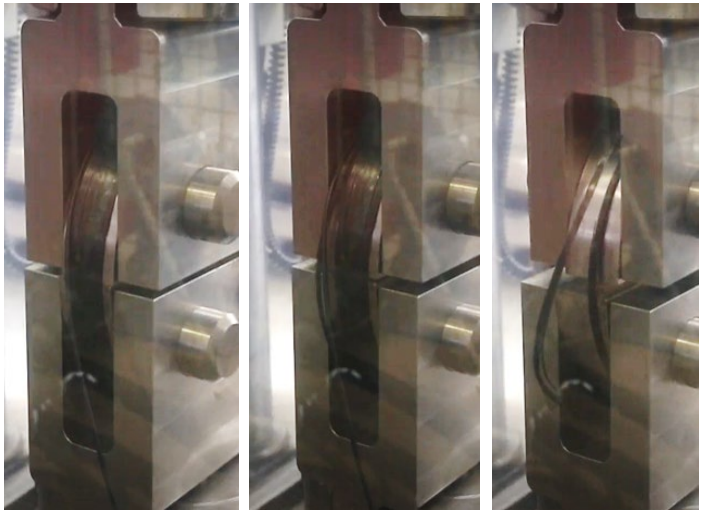


933 mins → 495 mins (47% reduction). Cleaner, safer and more consistent process.

Rotor sleeves

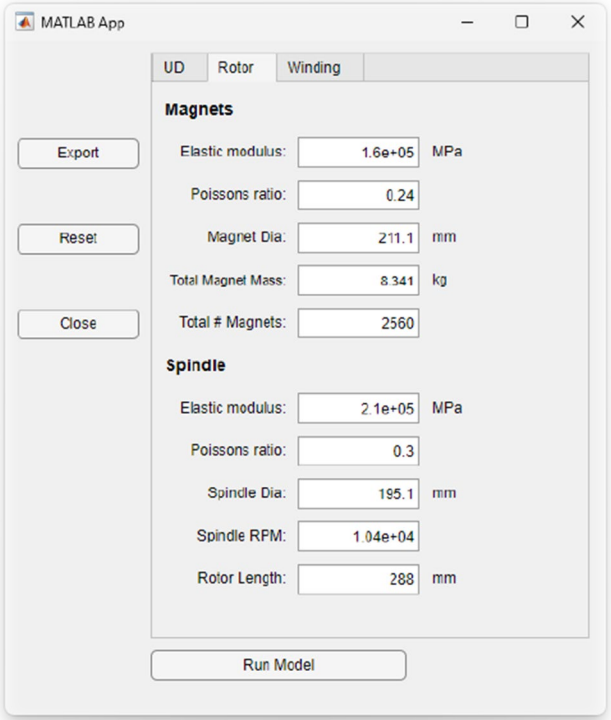
ASTM D2290 to measure apparent hoop strength.





2038 ± 58 MPa (datasheet 2860 MPa) but in-line with literature.

Rotor sleeves



Rotor sleeves

- Relaxation during curing?
- Filament wound vs press-fit?
- Lifetime of the sleeve?
- Size and speed limitations?

Rotor spin tester

£1.27 million investment from the UKRI DER-IC to provide a unique UK open-access facility to support industry in developing net zero technologies.

Max. speed 63,000 rpm

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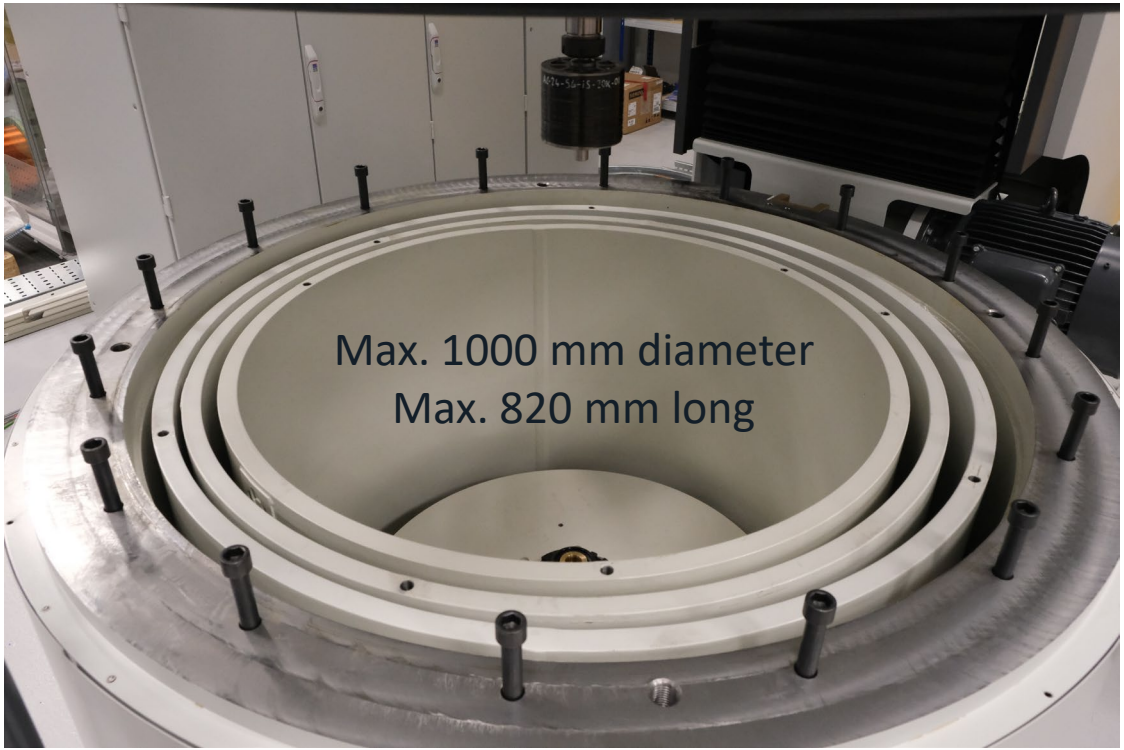
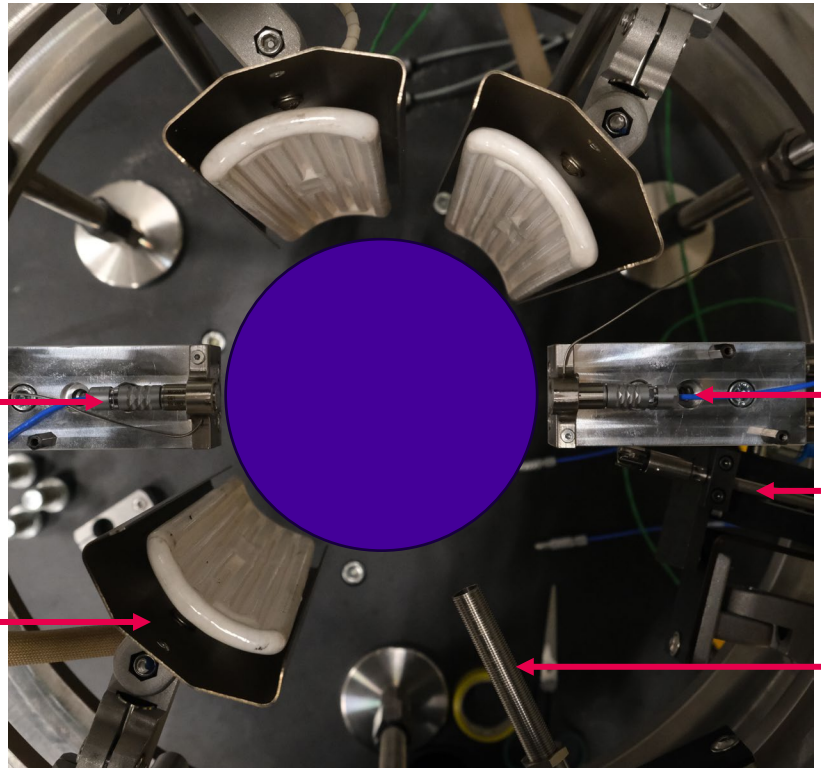
Sense of scale



Radial growth and heating



Capacitive sensor

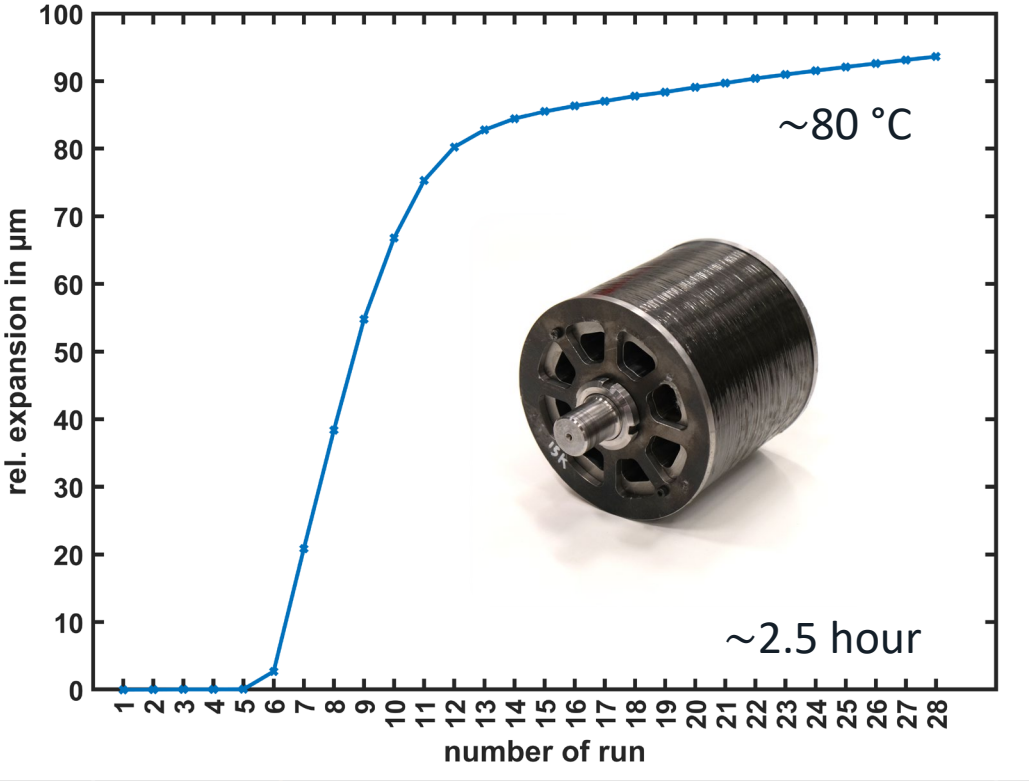
Capacitive sensor

Thermocouple probe

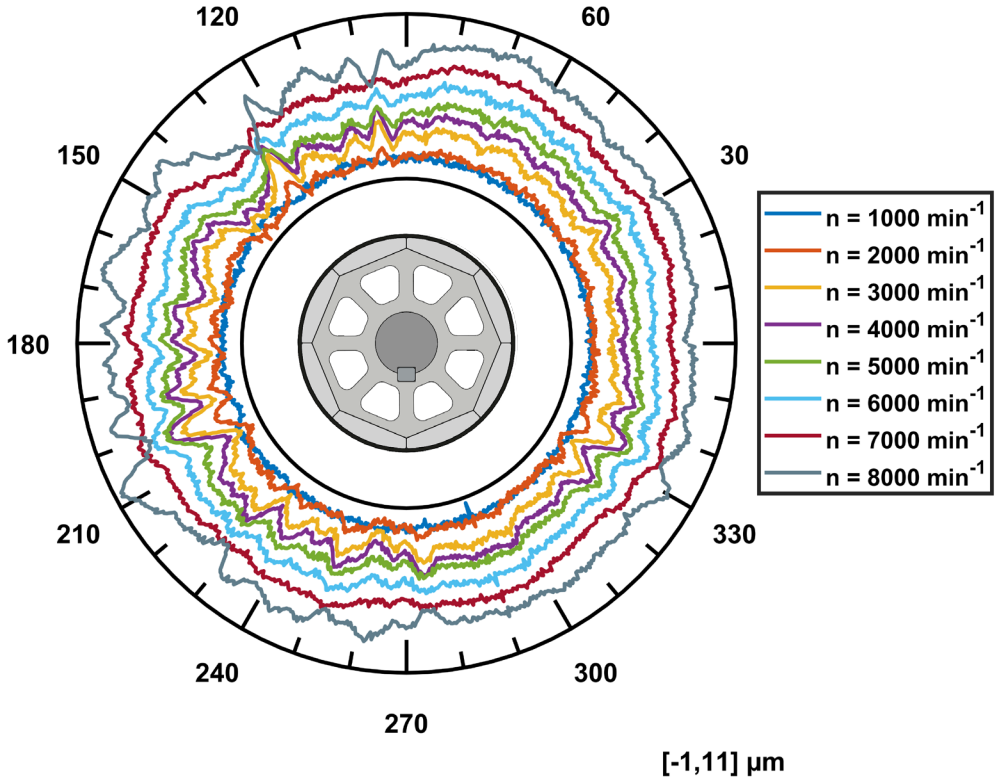
Heating elements
Max. rotor temp 250 °C

Pyrometer

Radial growth with temperature



Radial expansion with speed

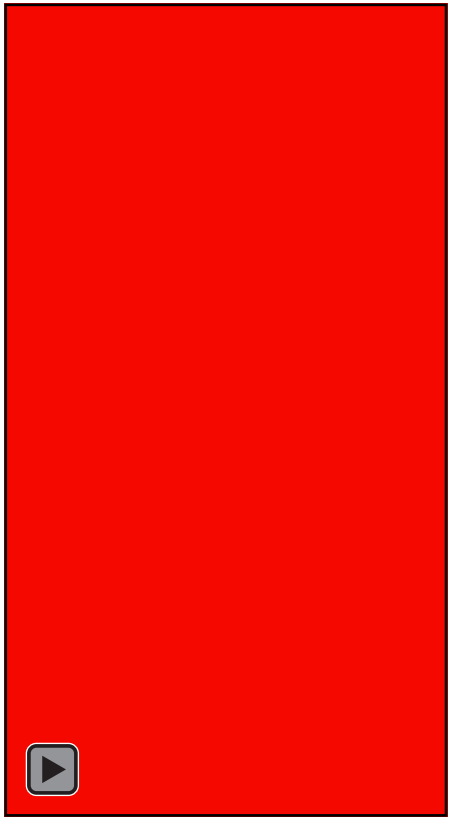


High speed camera

Can be triggered manually or by burst sensor to capture rotor breakup.

Frame rate and resolution:

- 2,000 fps (1280 x 1024 pixels)
- 160,000 fps (1280 x 8 pixels)



Summary and next steps

New experimental test capability to support industry in developing better and more robust products.

Co-location with capability at AMRC affords opportunity for rapid make and test, and innovations in manufacturing processes.

Acknowledgements:

DER Driving the Electric Revolution Industrialisation Centres

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Thank you.

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