EDRIVE - MEC

Integrated Design

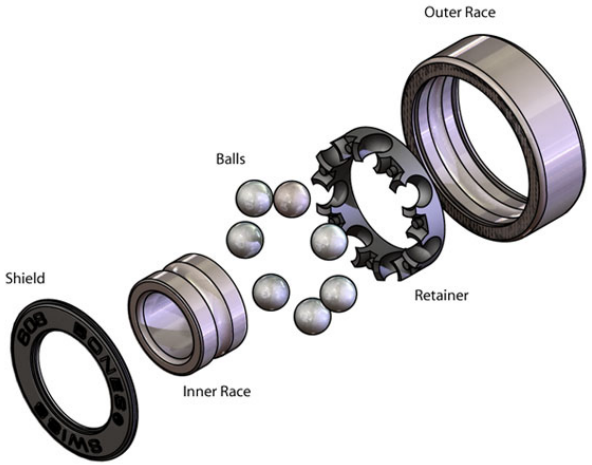
Prof Markus Mueller

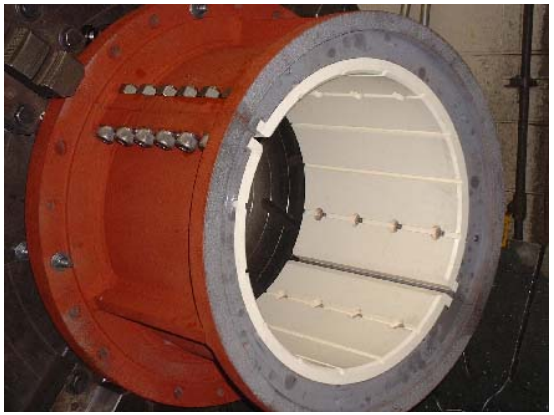
Integrated Electro-Mechanical Design

- Design for Survivability & Reliability
  - Structural design
  - Bearing system
  - Thermal performance
- Wave Energy Scotland Project

Bearing System

- Bearings are a critical component.
- Conventional bearing technology
  - challenging for marine applications
  - require sealing
  - lubrication requires maintenance
- Polymeric Bearing Materials
  - Used in ship propulsion systems
  - Do not require seals
  - Operate in a flooded environment



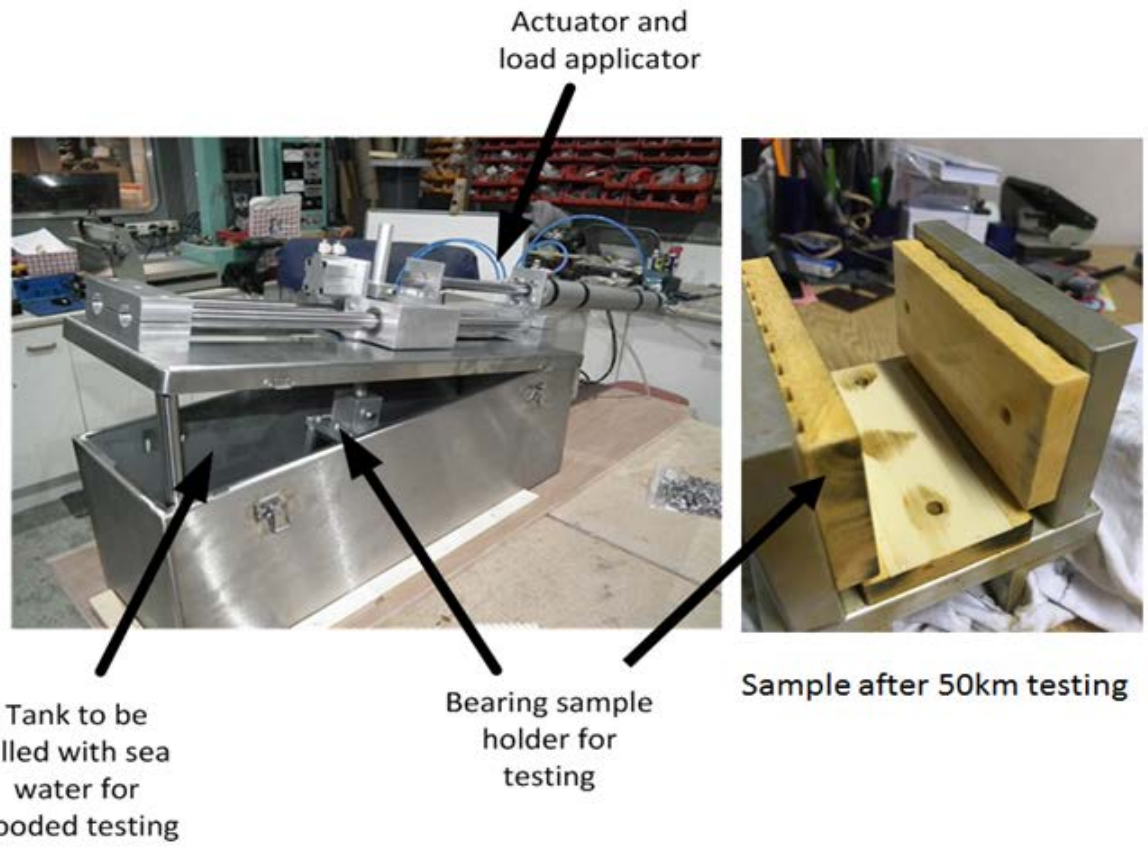


Polymeric Bearings

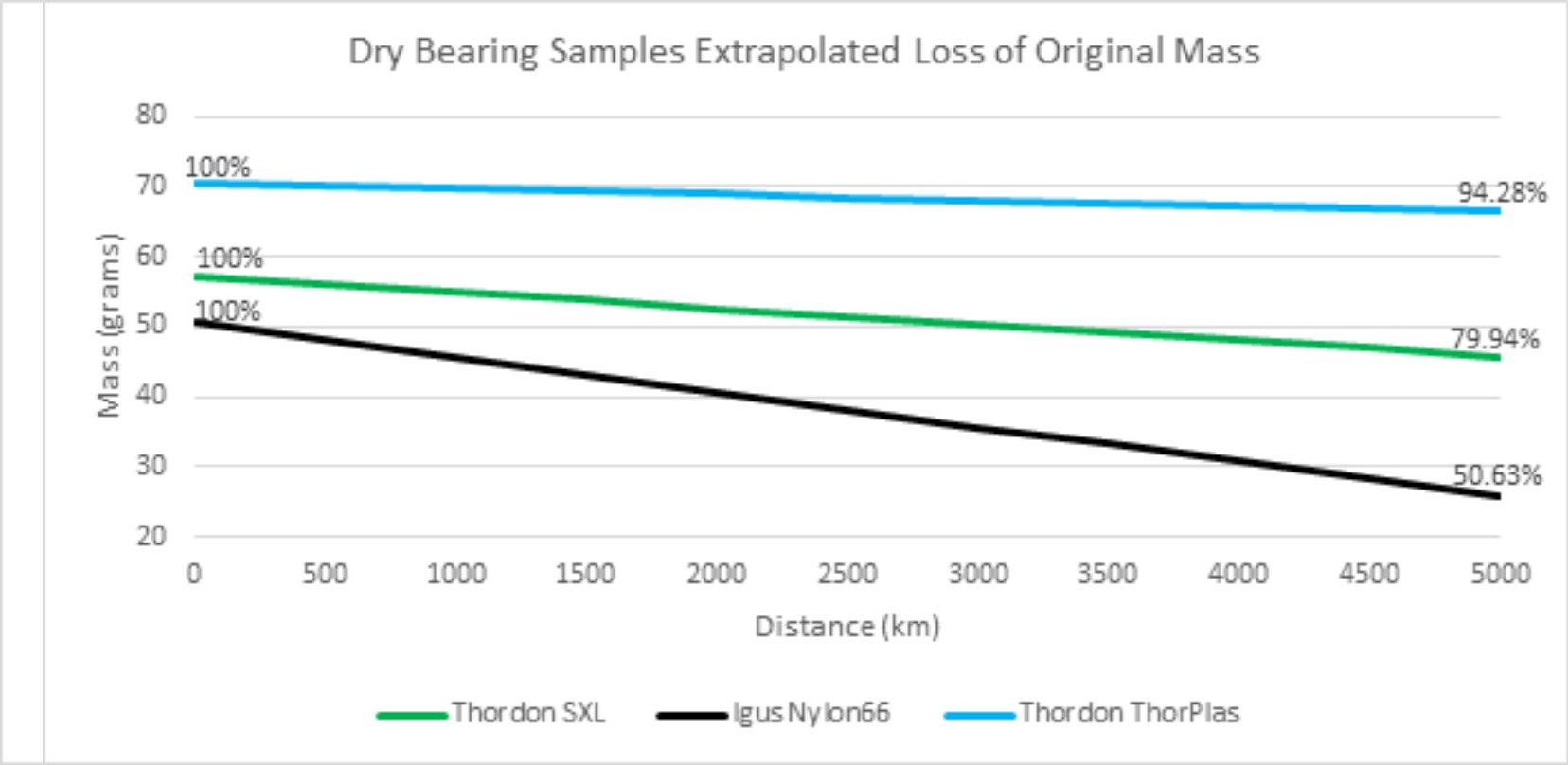
- Polymeric bearings used in marine propulsion systems, flooded with seawater
- Samples:
  - Thordon SXL, for wet testing
  - Thordon SXL+, for wet testing
  - ThorPlas Blue, for both wet and dry testing
  - Igus bearing samples, wet and dry

Bearing Test rig

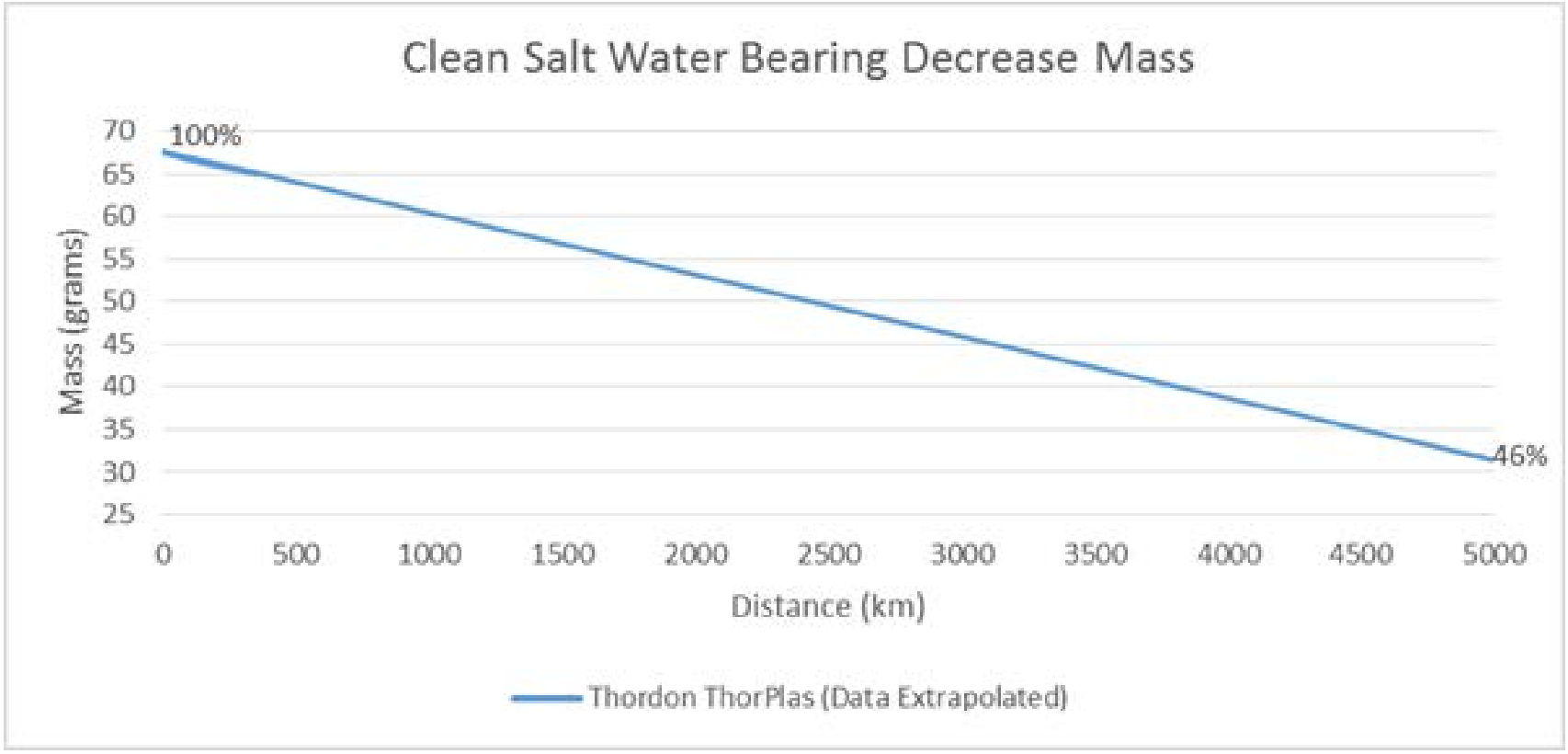
- Stroke = 0.5m
- Velocity = 0.75m/s
- Test interval = 500km
- Loads applied
- Dry and Wet tests (seawater)
- Measure wear rates
- Microscopic measurements



Dry Test Extrapolated

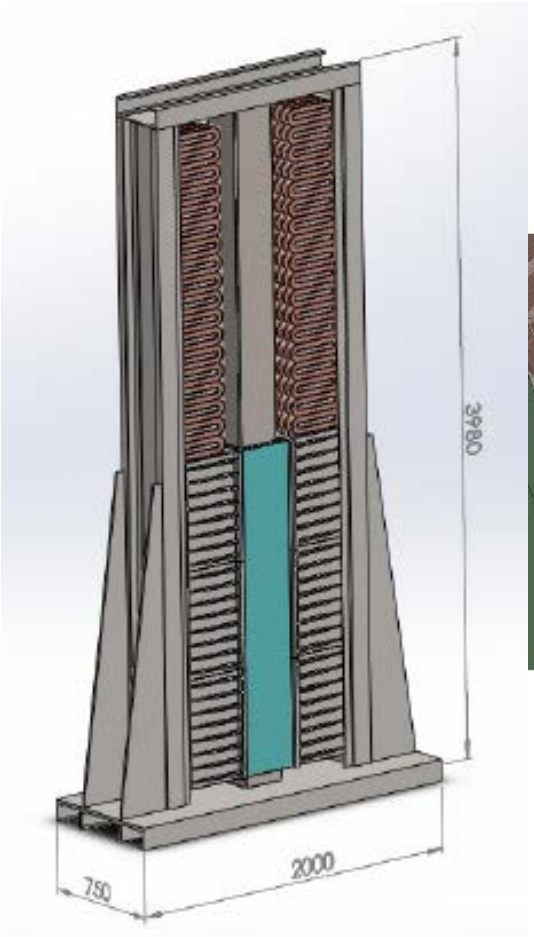


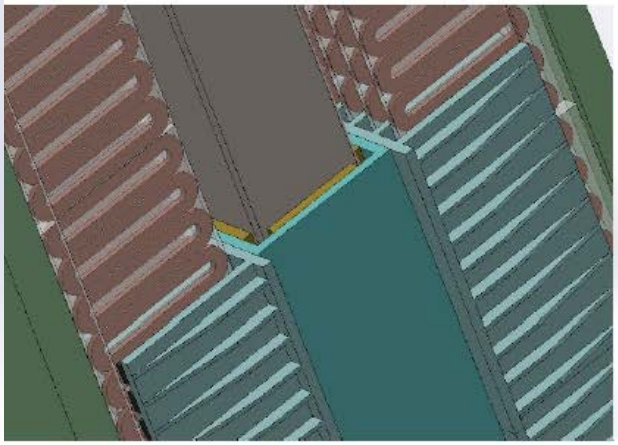
Wet Bearing Tests

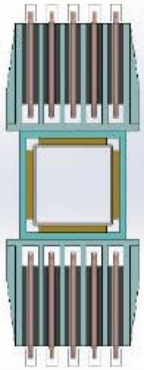


Wet Bearing Tests

Integration of Bearings into Generator



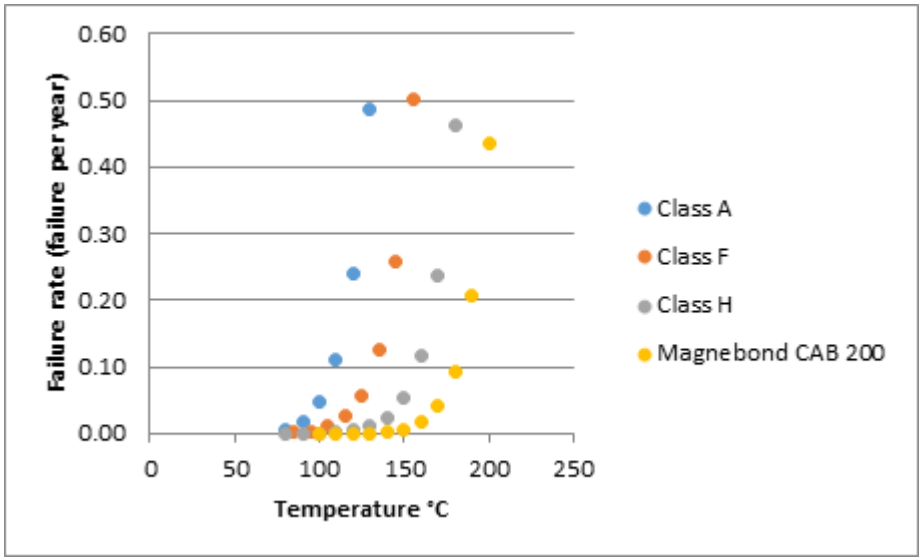




THE UNIVERSITY of EDINBURGH
School of Engineering
Institute for Energy Systems
Newcastle University

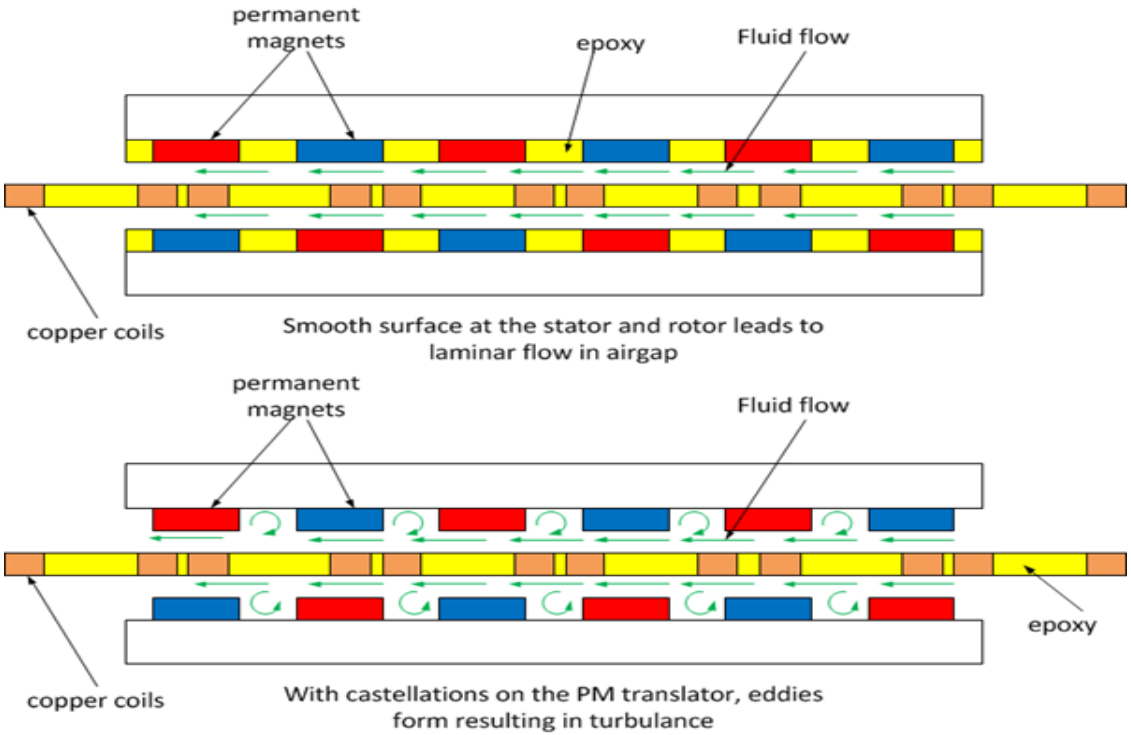
Thermal Performance

- Natural air cooling not effective – low velocity
- Forced cooling requires auxiliary fans and pumps
  - Reliability issue
- Winding temperature linked to insulation life
  - Each 10degC rise above the rating may reduce the motor lifetime by half.
- Passive cooling is preferred
  - Flooded operation



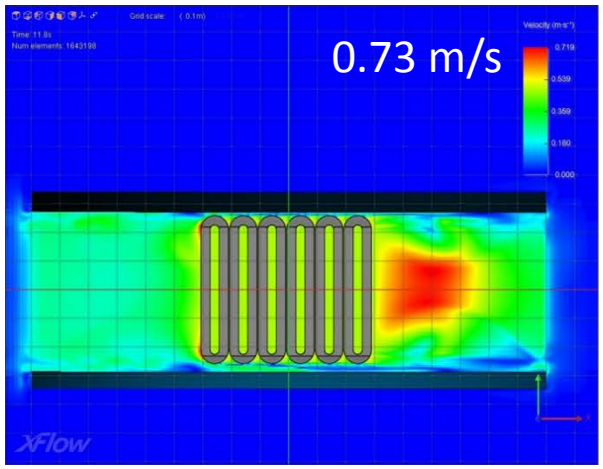
Airgap Topology

- Smooth surfaces or salient surface

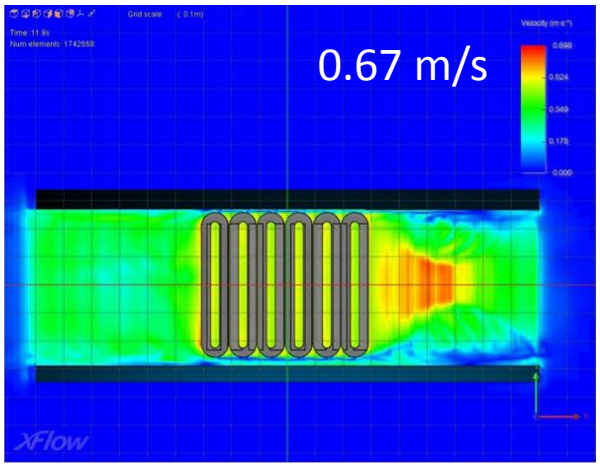


CFD modelling

AIR

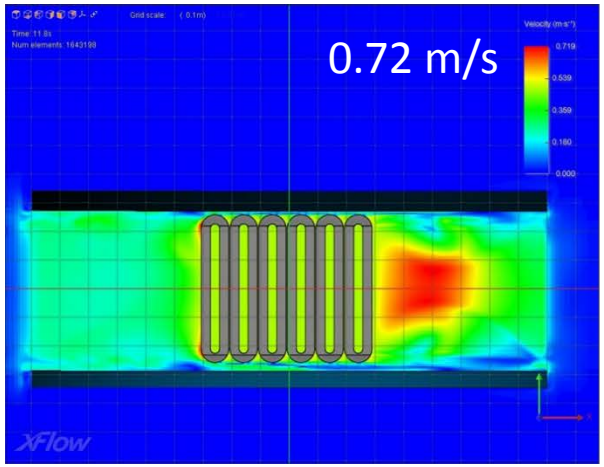


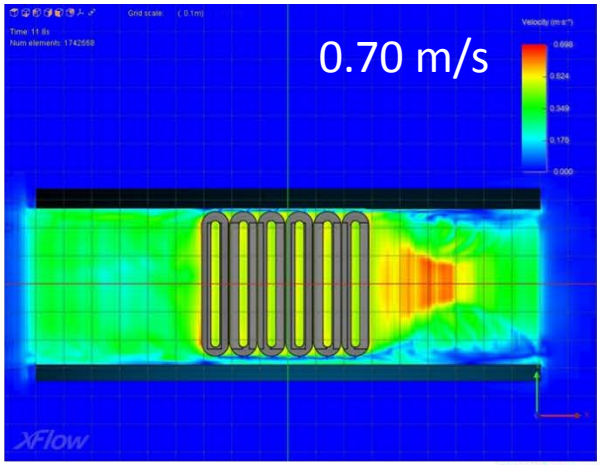
Smooth Surface



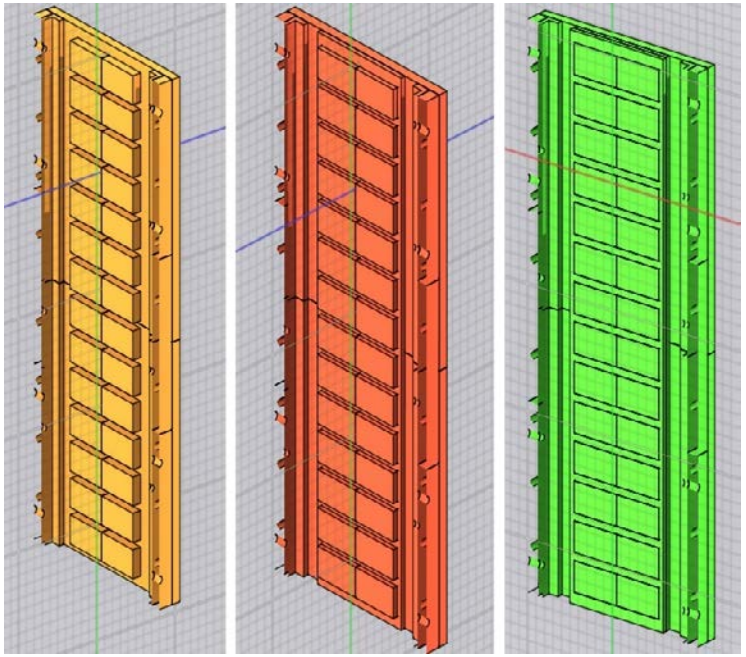
PM salient surface

WATER

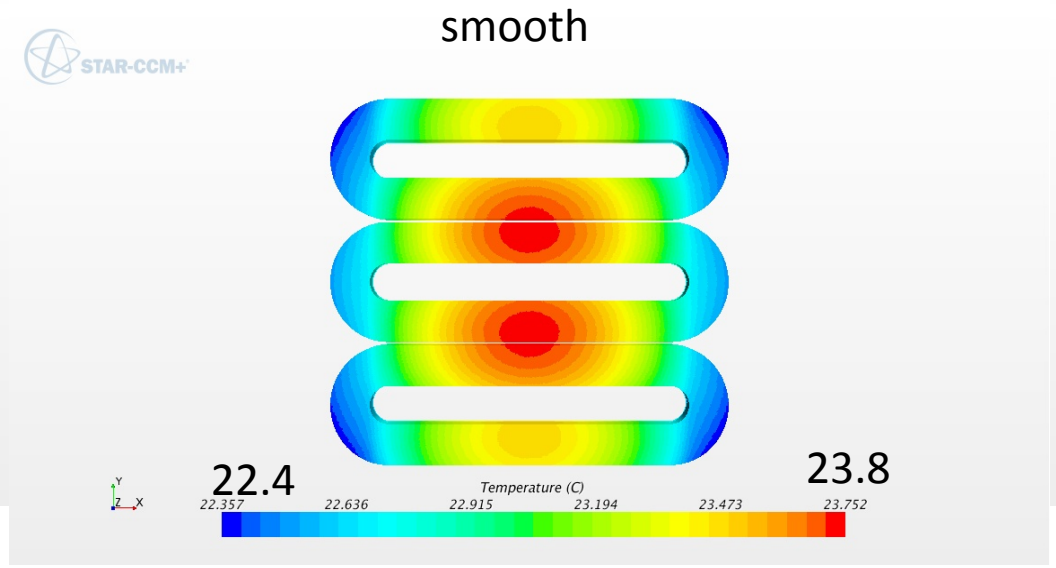




Modelling



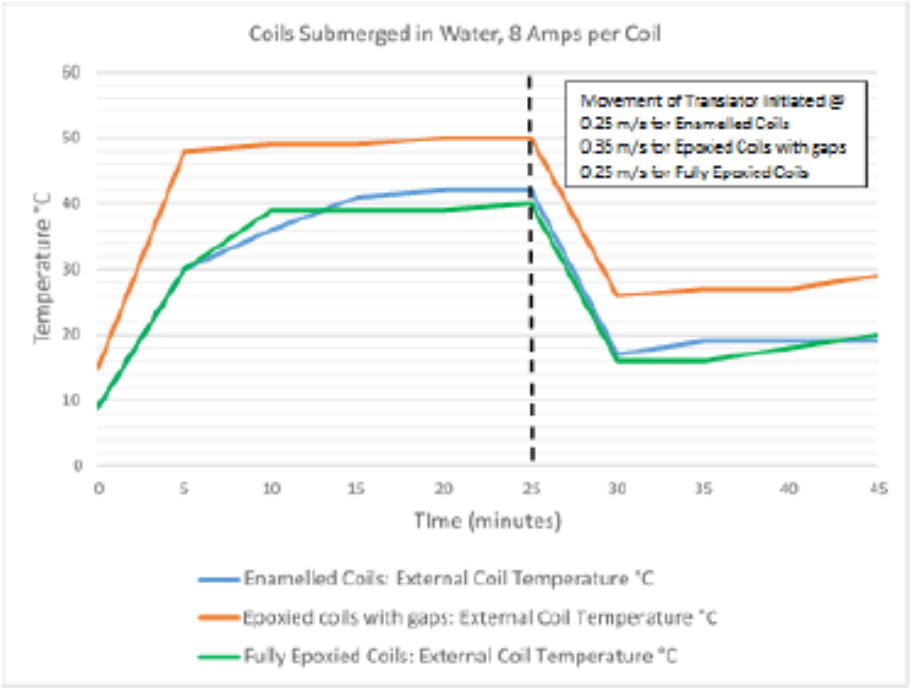
salient semi -salient smooth



Thermal Testing

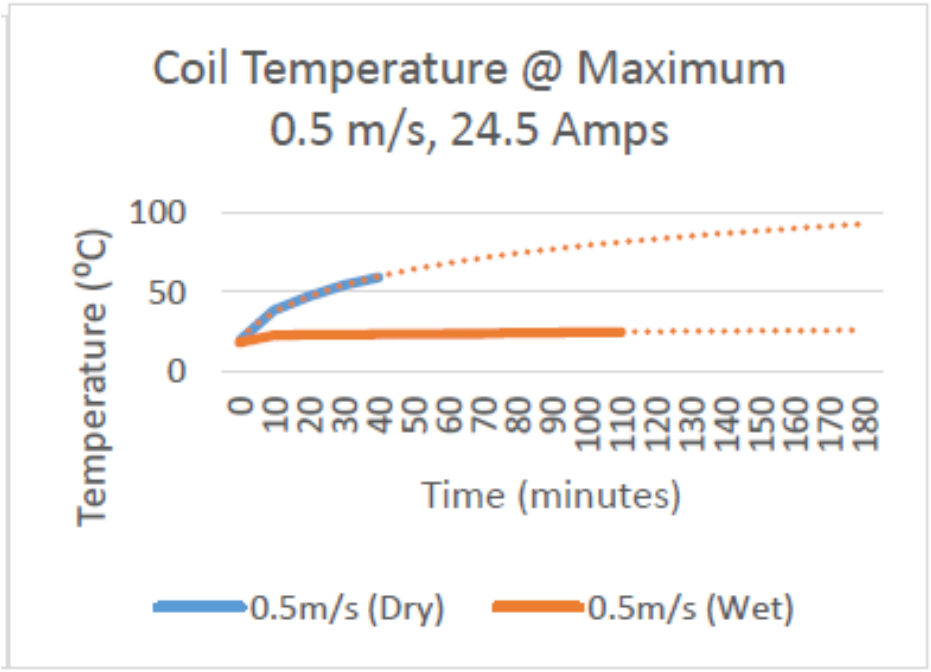
Thermal Testing

- Current density – 18 A/mm^2



- 3 different coil surfaces.
- Motion assists cooling.
- Castellated surface causes turbulence aiding cooling, verifying CFD results

Thermal Testing



- Current density – 31 A/mm^2
- Six times greater than normal.
- Continuous overload capability
  - Survivability

Conclusion

- Polymeric Bearings
  - Robust.
  - Wear rates can be estimated.
  - Flooded operation.
  - No lubrication.
  - Linear and rotary motion.
- Windings
  - Flooded operation provides excellent cooling.
  - High overload capability
    - Current density > 20 A/mm^2
  - Absorb extreme loads.
  - Design for normal current density to maintain efficiency.

Acknowledgements

- Funding from wave energy SCOTLAND

- Test rigs built by Fountain Design Ltd