

Smooth Operators

Investigating Bearing Systems for Linear Generators in submerged Wave Energy Converters

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Work stream 5: Electrical Power Take off and Power Conditioning

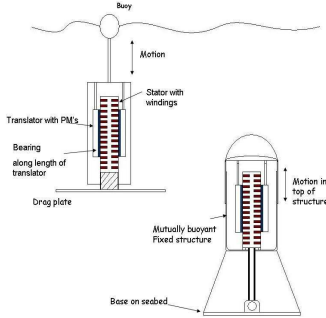
Bearings for the Offshore Environment

Developing a reliable bearing to operate over a long period of time in the harsh, unpredictable and corrosive environment inhabited by a submerged generator in a wave energy converter provides many design challenges.

The design will be based on survivability and low maintenance. Identifying materials and adapting construction to suit the environment without compromising efficiency involves fully integrating the bearing systems to the machines structure.

Direct Drive Linear Generators

WEC Schematic



- The position of the WEC will affect the structure and wave loading it experiences.

- Submerged structures experience lower loads but are difficult to monitor

- Bearings threaten reliability, experiencing heavy loading reduces life span, impedes motion

- Conventional Iron Cored generators are physically large & heavy due to the low speeds from direct drive.

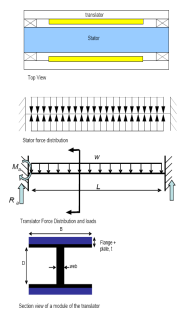
- Small air gaps give high shear stress, high normal stress

- F_n , normal attractive forces (radial loads) increase with area, straining the structure.

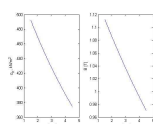
- Double sided machine aims to balance loads.

- Removing the iron from the stator removes the huge forces. Active material deals with loads.

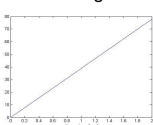
Iron cored Generator



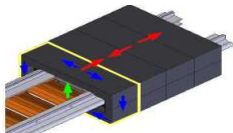
Normal Stress, σ_n



Net changes



Air cored Generator



Ref (Mc Donald 07)

Expected Operating life

Analysing wave exceedence charts indicate 5000hrs sea activity over a year, equating to 18,000km travel.

7m strokes at average speed of 1m/s. Yearly maintenance intervals are the design aim.

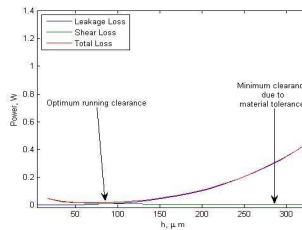
Bearings; Limitations and Wear Mechanisms



Rollers ; Linear ball; profile rail bearing [3] IGUS UW[4] DPFB [5] Thordon SXL[5]

Bearings for the C-Core	Failure mechanisms	Re lubrication
Graphite Sliding surfaces	Adhesive & Abrasive	Bio Grease, 12 days
Linear ball bearing	Fatigue, fretting inadequate stiffness	Monthly
Linear Profile rail	Fatigue, corrosive wear	2-3 months
Thordon SXL Marine	Expects 0.5mm wear/yr	Flooded operation
Hydrostatic pads	Pumping power loss Abrasive contact	Oil – 4 months Water – filtered supply

Hydrostatic Operation...Optimum vs. Possible



Variation of operating points at minimum h_{01} of 280 μ m.

	Iron Cored	Air cored
Pad Load, N	2693	5
Optimum h	18	88
Pad loss at h_{01}	939	0.287

What it's all leading to

Bearings with

- Low maintenance operation
- Water as lubricant
- A Structural Analysis of bearing integrated with support
- A benefit to the Optimisation of Generators for WEC's

References

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