Direct-Drive Power Take Off

R. Crozier, M. Mueller

Work stream 5: Electrical Power Take-Off and Power Conditioning

Introduction

Linear permanent magnet machines are a potential alternative to the mechanical and hydraulic linkages currently employed in wave energy applications. One promising technology is the linear Air-Cored Tubular permanent magnet Machine (ACTM). The ACTM consists of a series of permanent magnet discs, alternating in polarity, separated by steel spacers and mounted on a moving shaft.

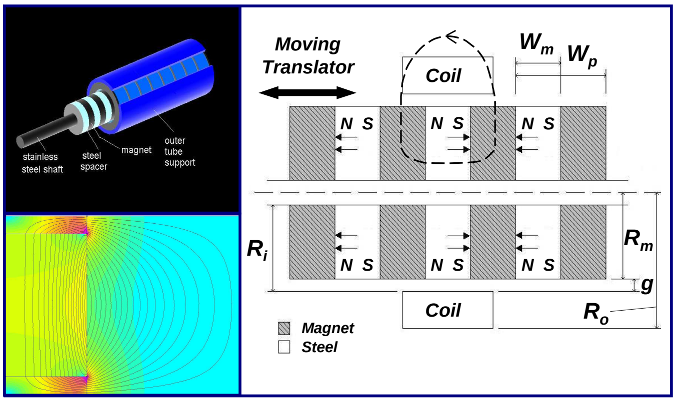

Figure 1. A 3D representation of the general configuration of the machine is shown top-left, above a 2D flux density plot of a single pole of the machine, generated using FEA. A cross-section of the machine is shown to the right.

Characterise and Normalise

The machine geometry is redefined in terms of unitless ratios, and the distance from the translator surface normalised to allow easy scaling and direct comparison of any configuration. The following ratios were chosen for the ACTM:

- ***W_m / W_p:*** ***The Magnet Width to Pole Width***
- ***W_p / R_m:*** ***The Pole Width to Translator Radius***
- ***r / R_m:*** ***The Distance From the Translator Surface to Translator Radius***

For each variable, a range of possible values is chosen, and sets of variables generated using a uniform random distribution. These sets are then decoded and the machines modelled using Finite Element Analysis (FEA).

Polynomial Approximation to FEA

Traditionally, FEA is employed for accurate simulation of machines, but can be computationally intensive. Polynomial approximation [1] allows us to rapidly generate simulations with an accuracy close to FEA. This is achieved by fitting a polynomial to the output of the precomputed FEA simulations. Here, this technique has been used to model the magnetic field in the ACTM using 100 polynomials.

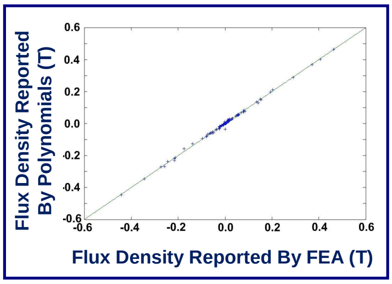

Figure 2. Comparison of flux density values at random positions above the translator for 100 randomly chosen machine configurations reported by FEA and polynomial approximation.

Rapid Optimisation Results

Using a polynomial based simulation, an initial optimisation of the machine operating in a sinusoidal motion to mimic real sea conditions has been performed. In this case, a W_m / W_p ratio in the region of 0.75 and W_p / R_m ratio of approximately 0.6 was found to be optimal.

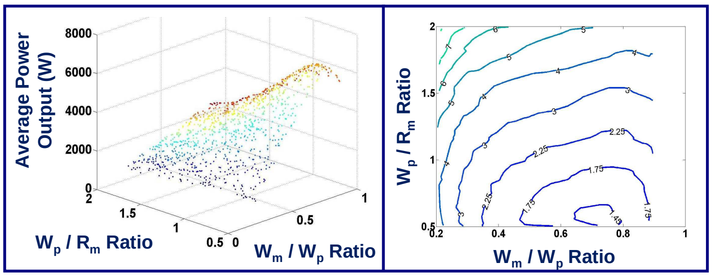

*Figure 3. **Left:** Average power produced by 1m translator in a 3m stator for varying machine parameters moving with a sinusoidal motion of amplitude 1m and freq. 0.28 Hz. **Right:** Contour plot of the results of an initial attempt at optimisation based on capital cost per unit average power produced.*

References

1. M.N. Hamlaoui, M.A. Mueller, J.R. Bumby, E. Spooner, "Polynomial modelling of electromechanical devices: an efficient alternative to look-up tables", Electric Power Applications, IEE Proceedings, Vol. 151, Issue 6, Nov. 2004 Page(s):758 – 768.

Institute for Energy Systems
The University of Edinburgh

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