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Energy

Integrated Design of Linear Generators

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Introduction

One promising technology for power take-off in Wave Energy Converters (WECs) is direct drive linear electrical machines. The principle is identical to a conventional rotary generator but 'unrolled' into a straight line. Many possible generator topologies exist and the object of this research is to optimise and compare several of these options, such as the generators shown here.

Objectives

1. Develop integrated structural and electrical models of the linear generators shown in Figure 1.
2. Use these models create an optimisation tool for each generator type.
3. Compare and contrast the generator types under different conditions.

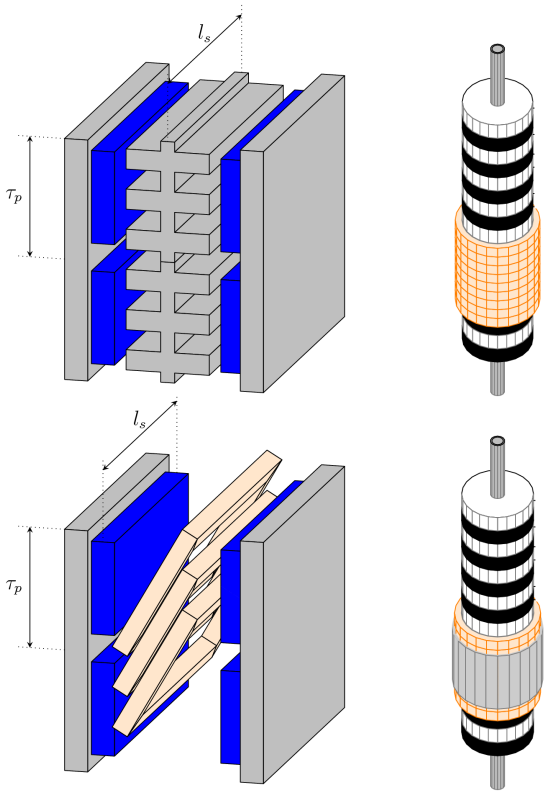

Figure 1. Clockwise from top left: The Linear Permanent Magnet Synchronous Machine, The Air-Cored Tubular Machine, The Slottless Tubular Machine, The Air-Cored Permanent Magnet Machine.

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Electromagnetic Analysis

The machines are analysed using a combination of classical analytical techniques and finite element analysis. From this, we calculate electrical properties such as predicted voltages etc. and also calculate the internal machine forces.

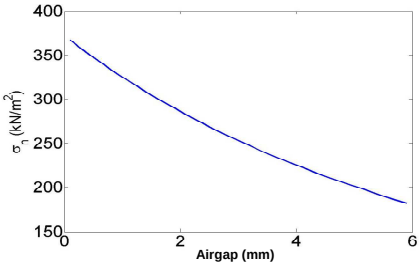

Figure 2. Air-Gap closing stress for the linear permanent magnet synchronous machine for varying air-gap sizes.

Structural Analysis

The large internal forces must be withstood by an appropriate structure. The minimum structure required can be estimated using classical structural analysis, such as beam theory.

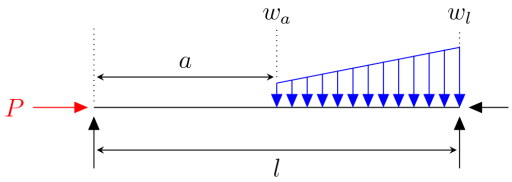

Figure 3. A typical structural loading case for the tubular machines, multiple cases are superimposed.

Optimisation

When the models are fully integrated, they can easily be optimised using a genetic algorithm, provided a suitable scoring mechanism is available. Suitable genetic algorithms have been identified and tested. Appropriate scoring mechanisms have also been investigated based on the cost of energy produced

Progress

- Structural analysis completed for all four machines
- Electromagnetic analysis completed for all four machines
- Integration of models underway