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Reduction of cogging forces in a double sided tubular linear permanent magnet generator used for ocean wave energy conversion

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Abstract

An increased awareness of the environment and the growing energy needs of countries like China and India have accelerated the search for sustainable alternatives to fossil fuel energy sources. Generating electricity from ocean waves is a viable alternative. This is because energy densities are sufficient to supplement the grid and thus make it economically viable. The seasonal supply profile also matches the demand profile. There are currently many different devices operating on different principles, the most promising of these is the oscillating body device using a linear generator.

Linear generators are able to convert linear motion into electrical energy without the need for intermediate gears, screws or crank shafts. This increases the overall efficiency and makes the device more reliable. Static force simulations were done on a novel linear generator design. The generator combines the duel air-gap of a double sided topology with the encapsulation of the magnetic field in a tubular topology. This results in an increased force density, but also large cogging forces. The cogging forces consist of end-effects cogging forces that are caused by the interaction of the Permanent Magnets (PMs) with the stator ends, as well as cogging forces which are due to the interaction of the PMs and stator slots. The topic of this thesis is to find suitable methods of reducing the cogging forces.

The end-effect forces were reduced by changing the stator length and altering the stator ends shape. Creating a quadratic b'ezier curve end shape and optimising the stator length reduced the end-effect cogging force from 630 N to 7 N. The slot cogging forces were reduced by dividing the PMs into two sections and to shift the outer PMs by one slot pitch relative to the inner PMs. This resulted in a decrease from 663 N to 25 N. However, a compromise needs to be made between reducing the cogging forces and not reducing the machine performance. Increasing the stator length increases the machine volume and dividing the magnets reduces the thrust force. This needs to be taken into account when designing a new machine.