Multiphysics 3D Modelling of Ironless Permanent Magnet Generators

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Abstract

A multiphysics design strategy is developed in the work to address the design and optimization need of ironless PMG. This approach has following features:

- Both magnetic and thermal analyses are considered;
- 3D FEM is used for the field and inductance calculation;
- Genetic algorithm coupled with numerical method is used for machine optimizaiton;
- Only open source codes are used, which enables the possibility of using super computer for machine optimization.

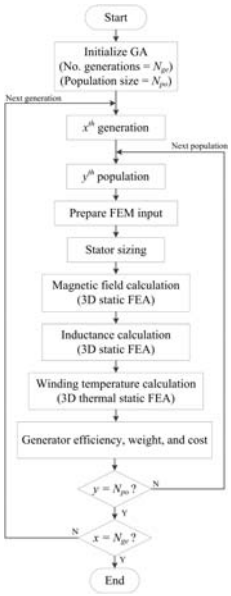
1. Introduction

Numerical method is normally avoided in the optimization of electrical machines because of long calculation time and the high codes cost if the optimiztion parallelized.

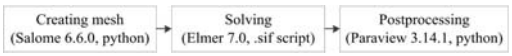
Ironless PMGs are reported for being lightweight. This is attractive for offshore wind turbine. Ironless PMGs are normally designed at large diameter and small aspect ratio, 3D multiphysics design approach is therefore demanded.

2. Developed Design Strategy

A. Design flow chart



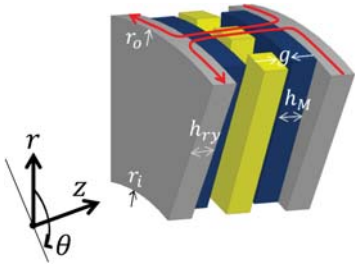
B. Only open source codes are used



3. A design example

A 10 MW axial-flux ironless PMG is optimized to demonstrate the capability of this design strategy.

A. Generator geometry



B. Optimization results

The objective is to find the optimal design that gives the best efficiency. The calculation was run with NTNU super computer Vilje, but only eight cores were used at the moment.

Parameters	Value
Rated frequency	43.2 Hz
Ratio of inner diameter to outer diameter	0.696
Ratio of PM width to pole pitch	0.795
Current density	2.25 A/mm2
PM thickness	20.25 mm
Rotor yoke thickness	19.15 mm
Number of turns per coil	4
Fundamental flux density in air gap	0.442 T
Winding temperature rise	88.64 ℃
Power factor	0.997
Active weight	75.2 ton
Active cost	3.29 €
Efficiency	98.1%
Total calculated cases	3000
Total calculation time	156.32 hours

For more details, please refer to the paper.

4. Conclusion

To enable the use of super computer for optimizing electrical machines with numerical method, open source codes have to be used. In addition, it should be possible to parallelize the FEA codes, and it is preferred that the GA code can handle parallel processes.