Technical University of Denmark



Wind Turbine Generators with Reduced Reliance on Rare Earth Magnets

Henriksen, Matthew Lee; Jensen, Bogi Bech

Publication date: 2012

Document Version Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA): Henriksen, M. L., & Jensen, B. B. (2012). Wind Turbine Generators with Reduced Reliance on Rare Earth Magnets. Poster session presented at Energieffektivisering for fremtiden, Kgs.Lyngby, Denmark.

DTU Library Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.

- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Technical University of Denmark

Wind Turbine Generators with Reduced Reliance on Rare Earth Magnets

Matthew L Henriksen, Bogi B Jensen

DTU Electrical Engineering Department of Electrical Engineering

Center for Electric Power and Energy, Technical University of Denmark

Introduction

Motivation and goal

- ▷ Recent volatile trends in the rare earth supply chain have been observed.
- Powerful rare earth permanent magnets (REPM) are the key ingredients to many modern, highly-efficient wind turbine generators (WTG).
- In this three-year project, finding the best wind turbine topology to use in the event that REPM usage becomes impractical is the ultimate goal.

Strategy

- ▷ Establish the baseline performance of wind turbines employing REPM.
- > Optimize some alternative generators and compare to the baseline results.
- Pick a winner, and verify the concept through design and construction of a scaled prototype.

Wind turbine drivetrains: to gear, or not to gear?

- Many drivetrain configurations are currently being marketed:
 High-speed gearing (classic solution)
 Direct-drive (newer)
 "Hybrid" drivetrain (newest)
- Wind turbine gearboxes can be very reliable, however reducing the
- A "hidden cost" associated with the direct-drive concept is the need
- Air gap deformation should be limited to 10-20%, which presents

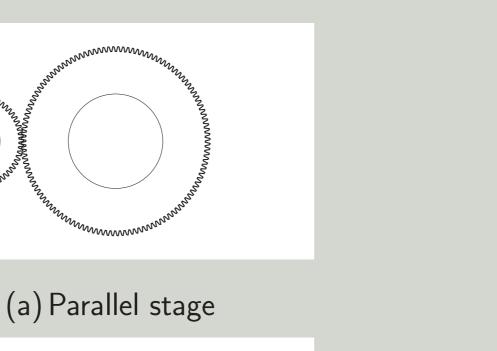
Decreasing gearing ratio High Gearbox cost, mass, losses Generator cost, mass, losses Reliability Rare earth usage

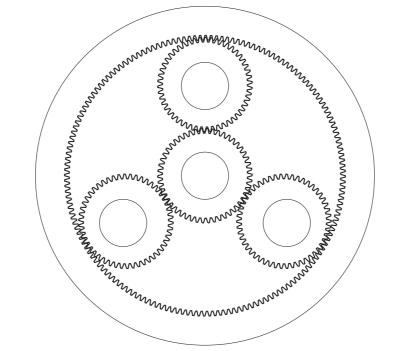
Figure 1 : Generalized trends. Note that little information on reliability of modern commercial wind turbines is available.

number of stages or removing the gearbox may increase the overall system reliability.

for a robust support structure to maintain the air gap.

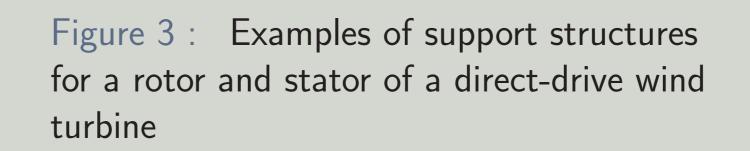
a significant challenge.





(b) Planetary stage

Figure 2 : Wind turbine gearboxes are composed of one or more planetary or parallel stages.



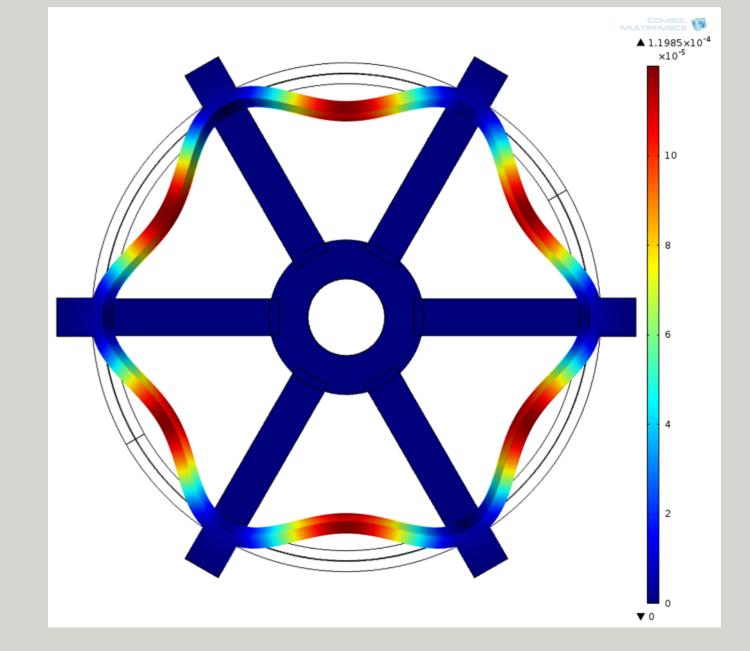


Figure 4 : Estimated displacement (m) due to attractive force between rotor and stator of a direct-drive wind turbine

Baseline study: synchronous machines with REPM

Advantages:
 Torque density
 High efficiency at partial load

Disadvantages:
 Rare earth prices
 Demagnetization can occur.

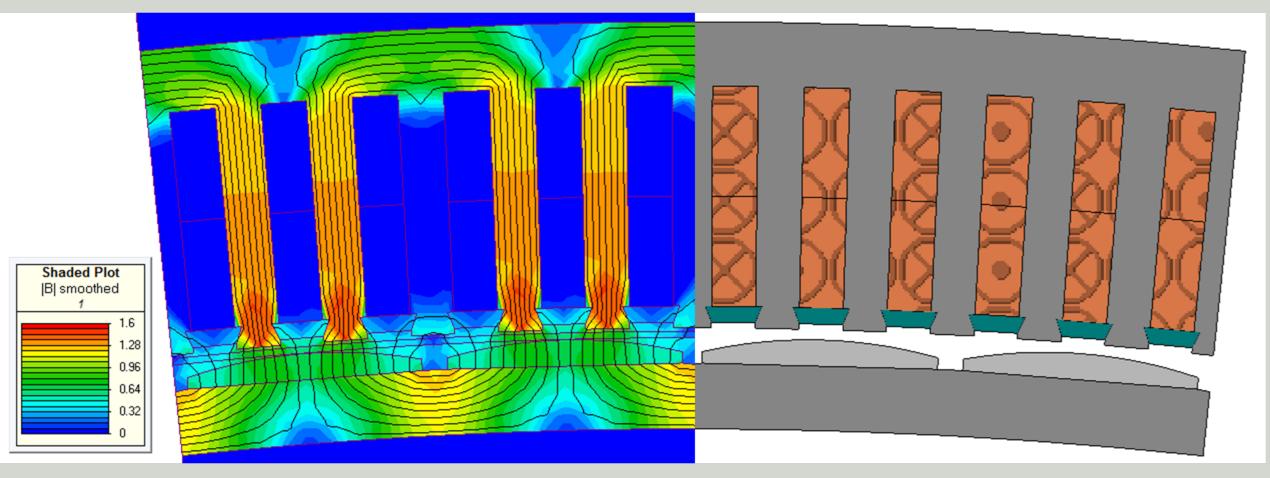


Figure 5 : Cross sectional view of a 3MW DDPMSG. Radius at air gap is 2.3m, length is 1.6m, rated torque is 1.9MNm. Plot on left shows flux lines and flux density at no-load.

Synchronous machines with ferrite magnets

- Advantages:
 - Ferrite magnets are low in cost.
 - Flux concentrating arrangements can be
- Disadvantages:
 - Machine is likely to be heavier.
 May be more sensitive to

Synchronous reluctance machines

Advantages:

No magnets
 Potentially a robust construction

Disadvantages:
 Poor power factor
 Torque ripple may be an issue.

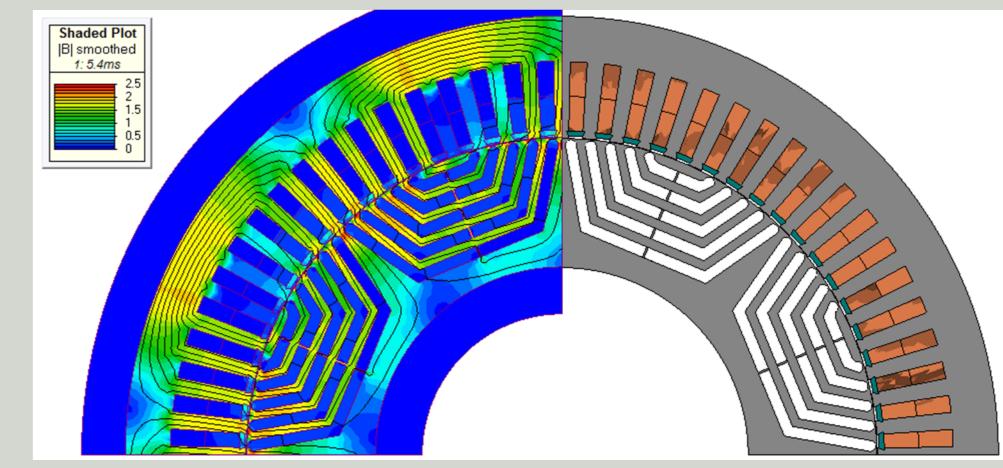


Figure 6 : Cross sectional view of a 3MW SynRM. Radius at air gap is 0.7m, length is 0.8m, rated torque is 28kNm. Plot on left shows flux lines and flux density at full-load.

Future Work

- Consider additional generator concepts:
 - Induction machines
 - Electrically-excited synchronous machines

used to generate a high flux density in the air gap.

demagnetization currents

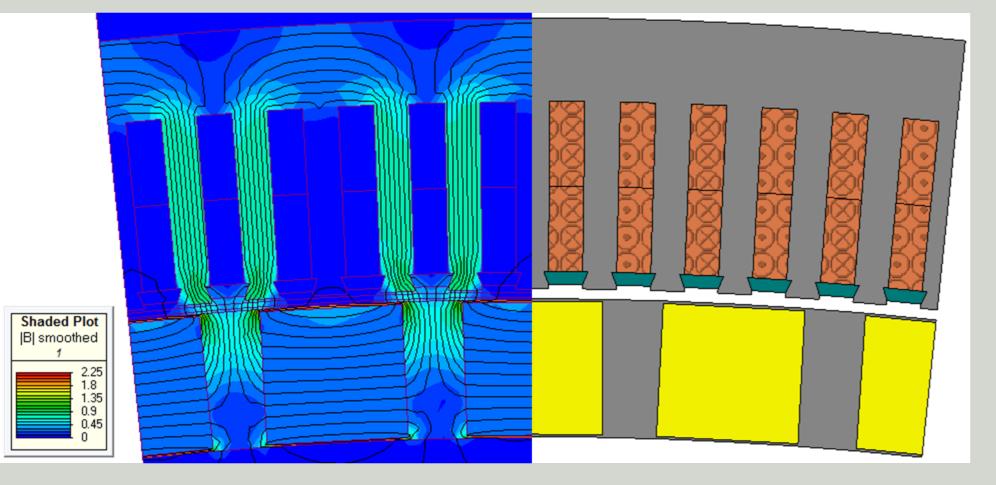


Figure 7 : Ferrite magnets arranged in a spoke manner can produce an air gap flux density higher than their remanent flux density, which is likely to be 0.3-0.4 Tesla.

▷ Others?

- Endorsement of best option or options
- Construction and testing of scaled prototype

Acknowledgement

- Thanks to DONG Energy for their contributions in funding and advising of this project.
- Testing of the prototype machine will take place at PowerLabDK.

http://www.cee.dtu.dk/

