

Expert System for Synchronous Machines Based on Comsol Multiphysics

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Expert System for Synchronous Machines Based on Comsol Multiphysics

- Introduction on cogging torque
- Structure and capabilities of EaSync
- Demonstration
- Improving the calculation of cogging torque
- The measuring rig
- Educational aspects
- Conclusion

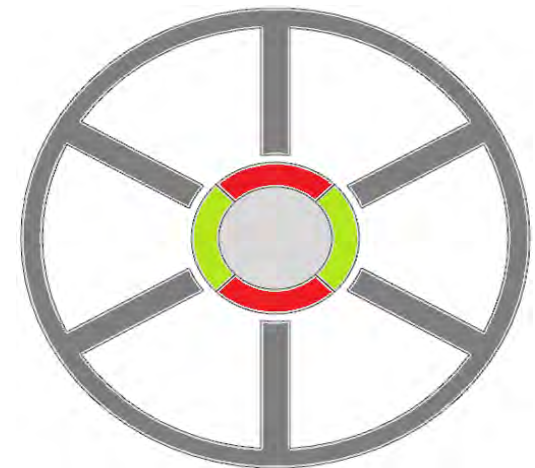


INTRODUCTION

What is cogging torque?

- Cogging torque is normally an unwanted effect in synchronous machines with permanent magnets.
- It derives from the interaction of permanent magnets with the pole pieces in the stator.

$$T_W = l \frac{dW_{mag}}{d\alpha}$$



- The change of magnetic energy W_{mag} stored in the machine leads to this effect.
- The rotor has preferred positions. It is similar to a bended spring due to the rotation of a camshaft.

How to reduce cogging?

- Cogging torque can be reduced by:
 - choosing advantageous combination of poles and slots
 - improving the geometry of the Stator
 - improving the shape of the magnets
 - changing the magnetization of the magnets
 -
- To reduce the cogging torque effectively more than one parameter must be changed at the same time
- This is a typical optimization task for FEA tools like Comsol Multiphysics and MATLAB Optimization Toolbox
- Unfortunately this tools are not coupled



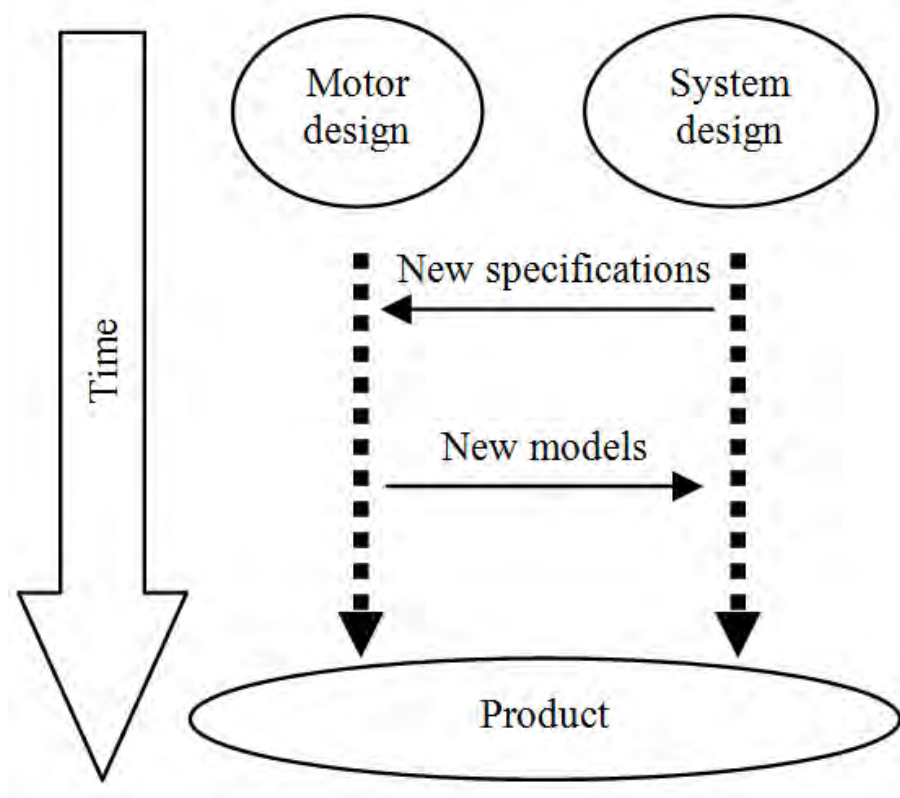
STRUCTURE AND CAPABILITIES OF EASYNC

EaSync is...

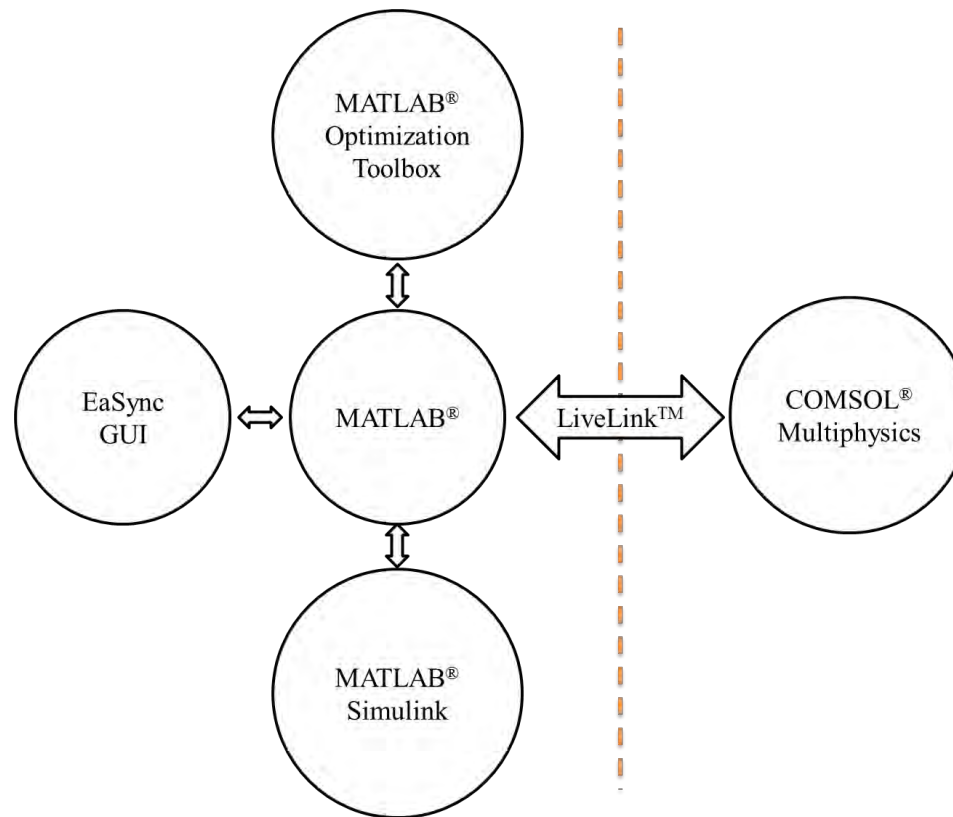
- a software tool being programmed at the Ostfalia University
- a composition of „easy“ and „synchronous“
- a growing expert system for designing synchronous machines from the scratch or improving existing designs
- based on student research projects
- based on COMSOL MULTIPHYSICS® Multiphysics and MATLAB®



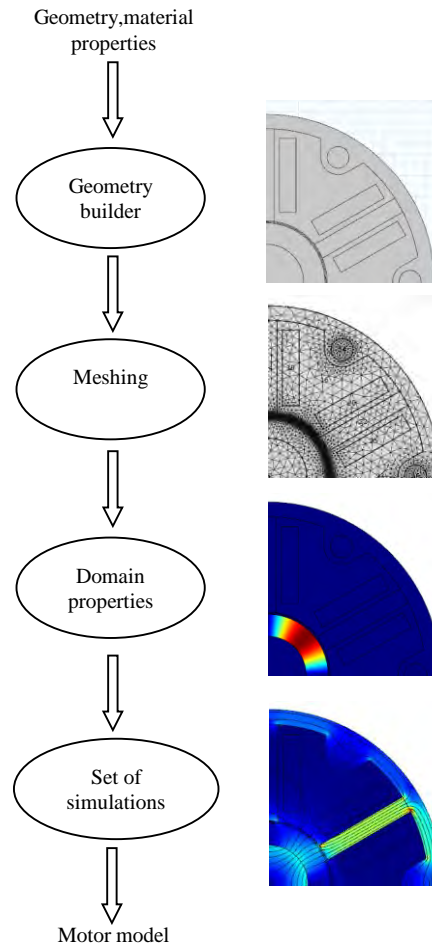
Designing process of a mechatronic system with synchronous machine



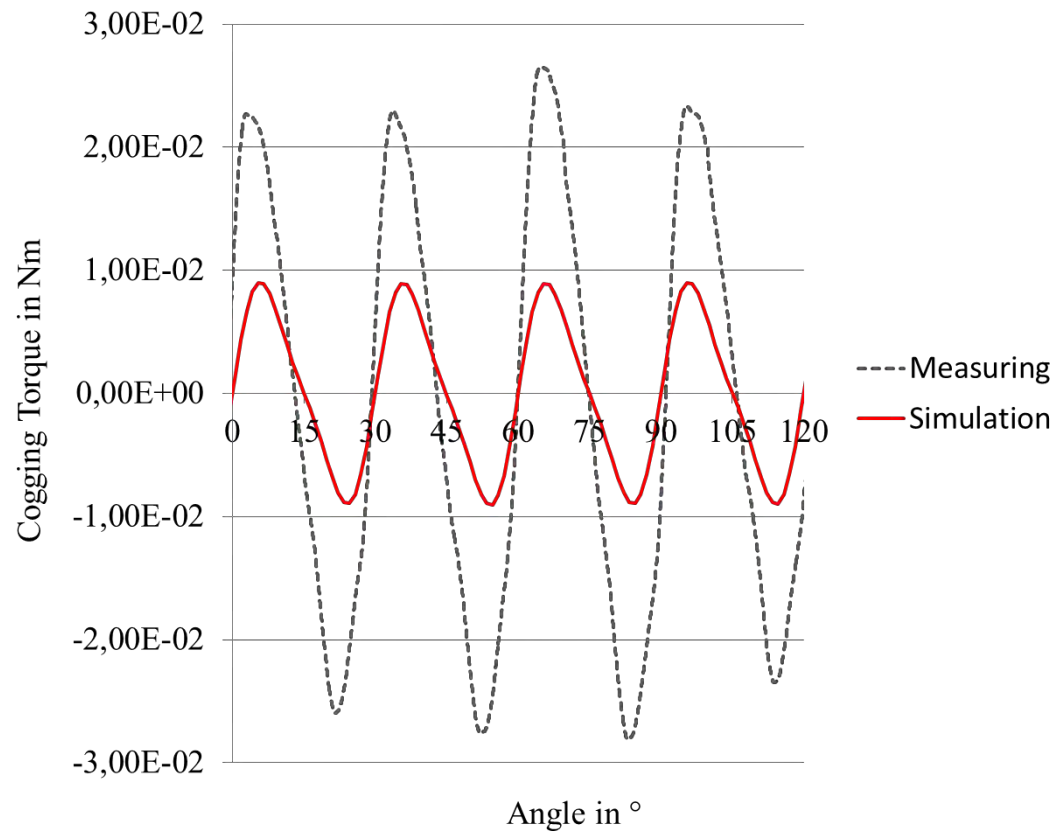
Structure of EaSync



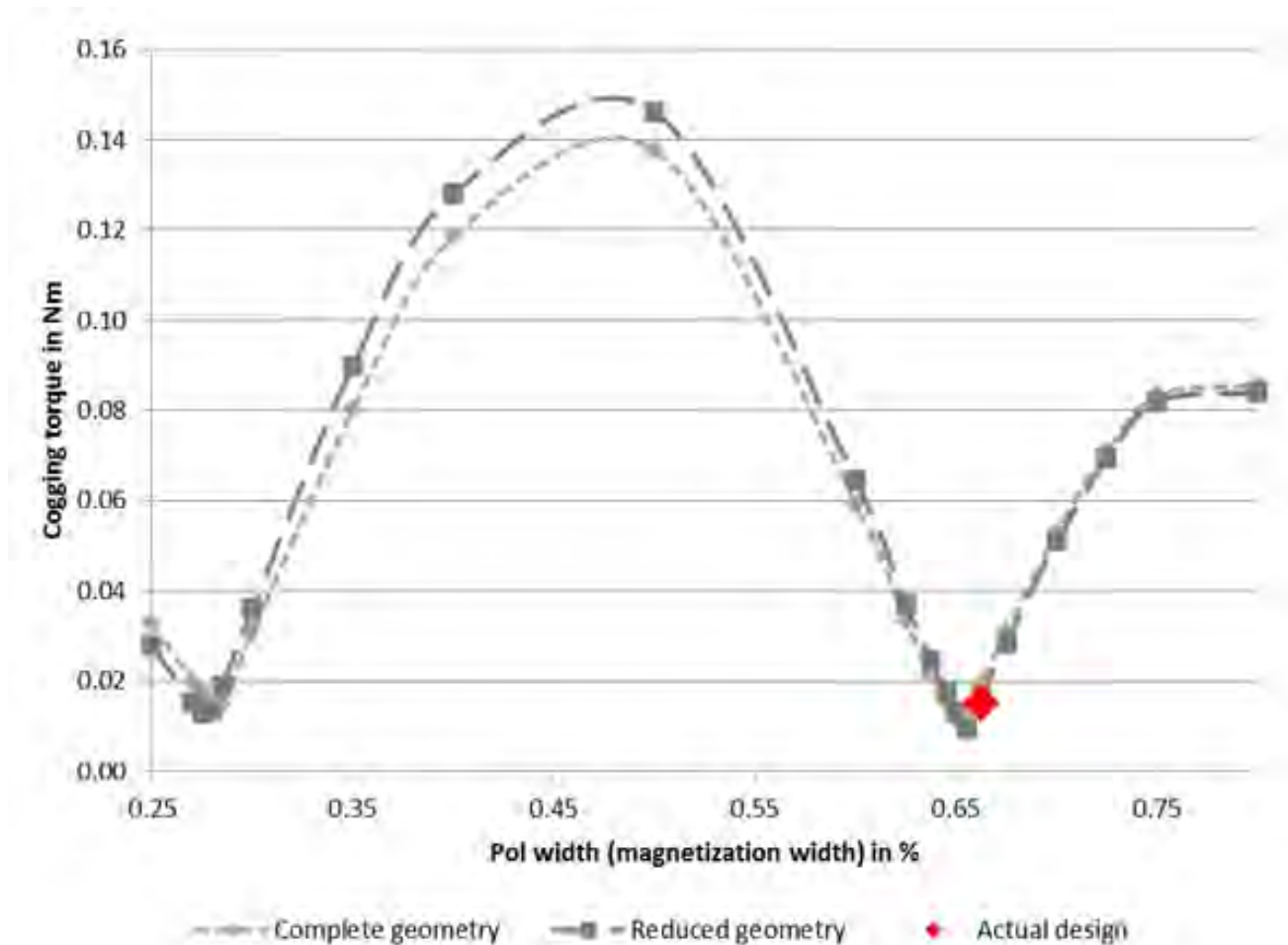
Structure of EaSync



Simulation vs. Measuring



Optimization process using EaSync

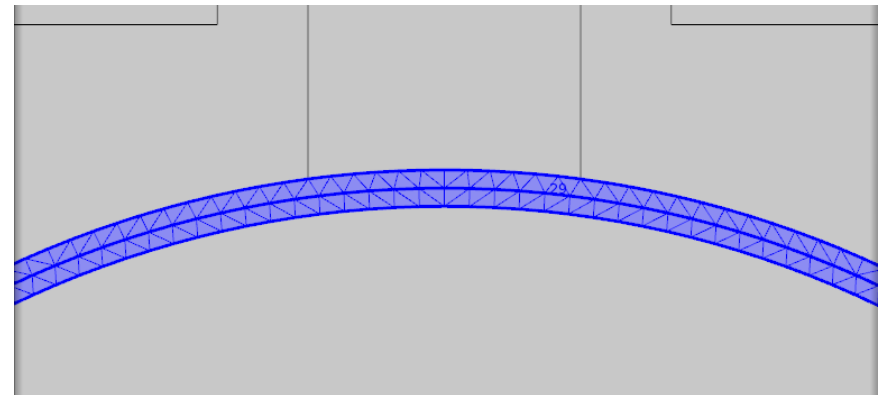


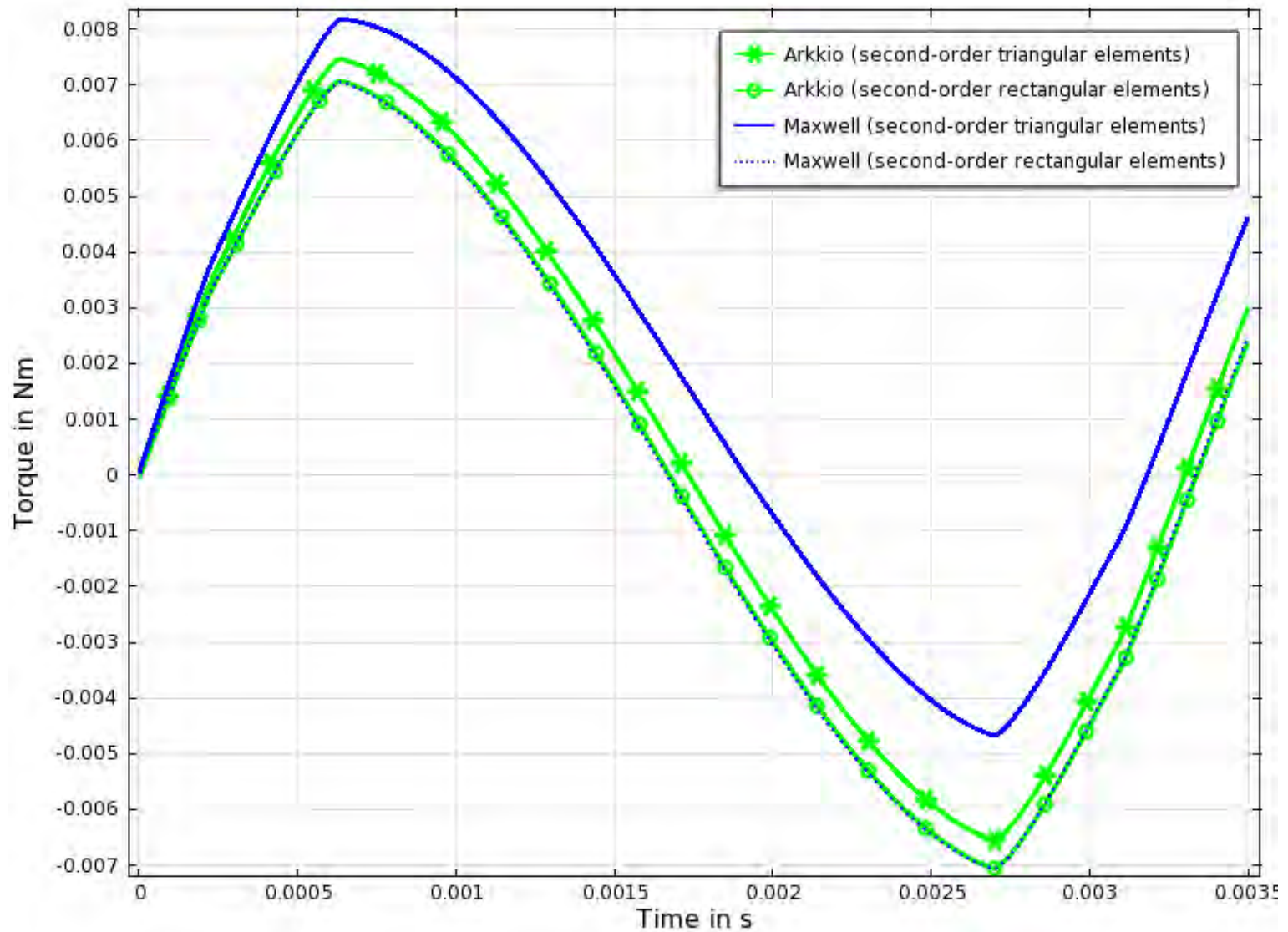


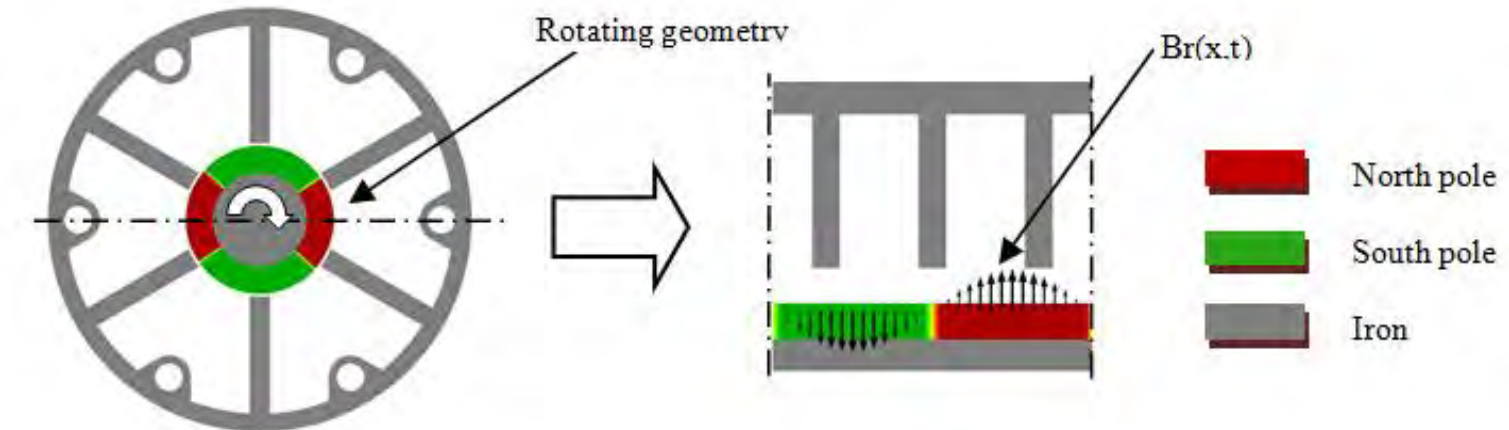
IMPROVING THE CALCULATION OF COGGING TORQUE

Improving the calculation of cogging torque

- The quality of the calculation mainly depends on:
 - The element type and element quality in the air gap:
 - Triangular elements
 - Rectangular elements
 - The element order:
 - first-order element
 - second-order element
 - The calculation method:
 - Maxwell stress tensor (classic)
 - Method proposed by Arkkio
 - Magnetic co-energy

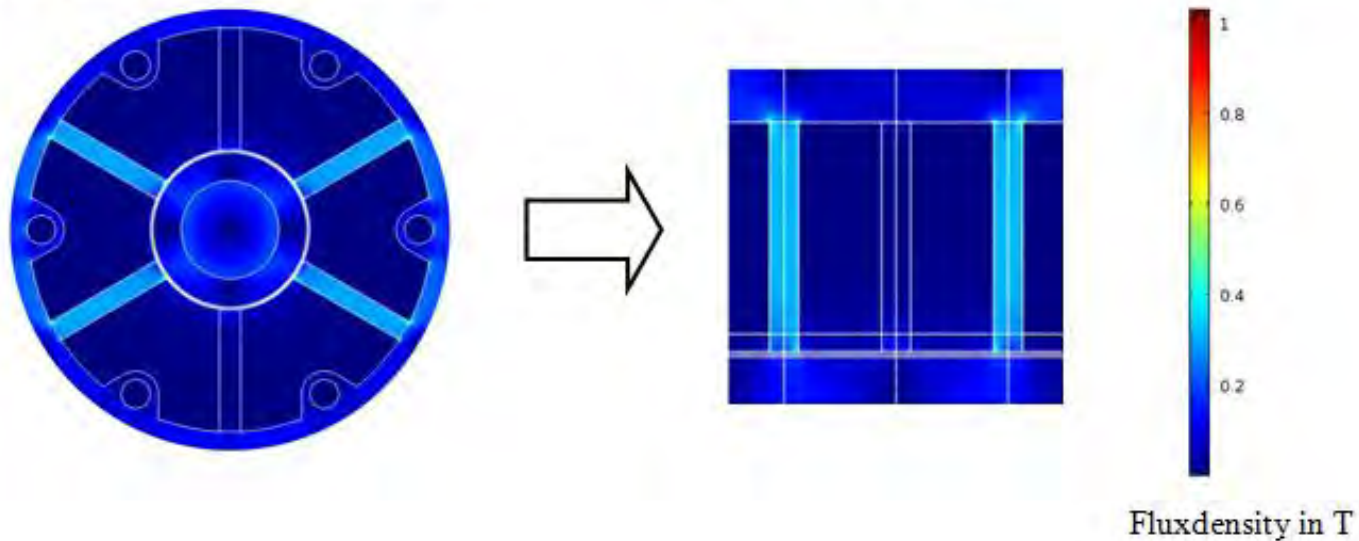






Complete geometry with moving mesh

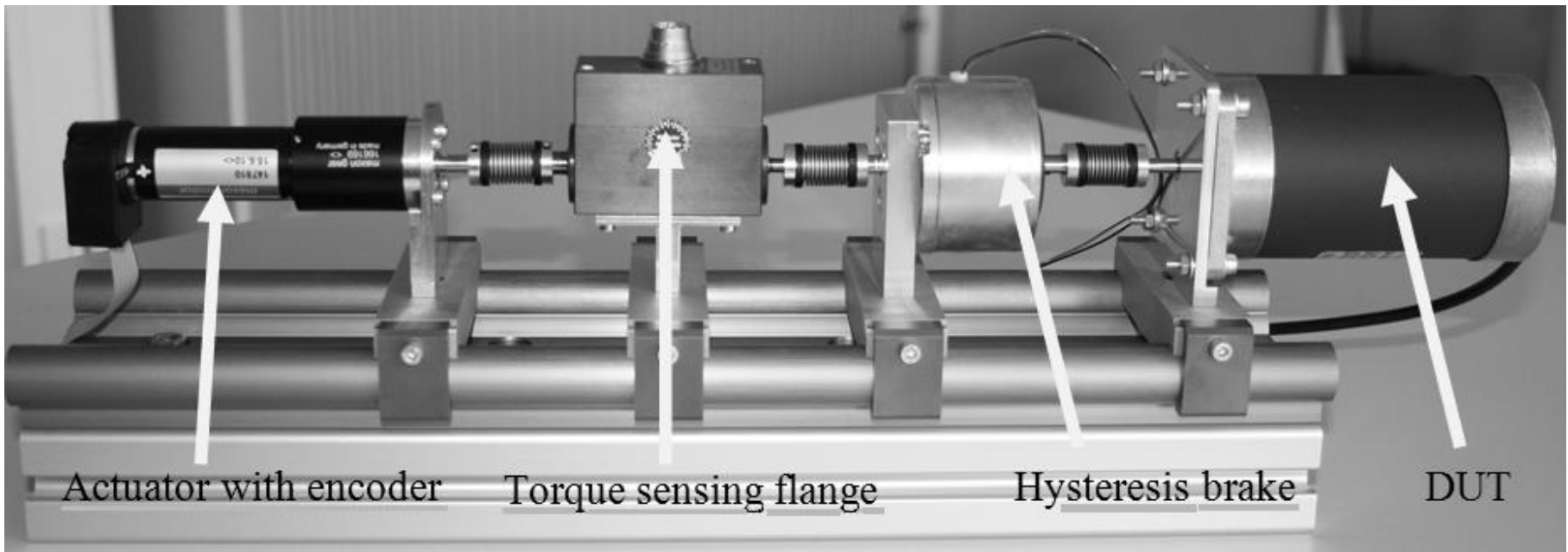
Reduced geometry



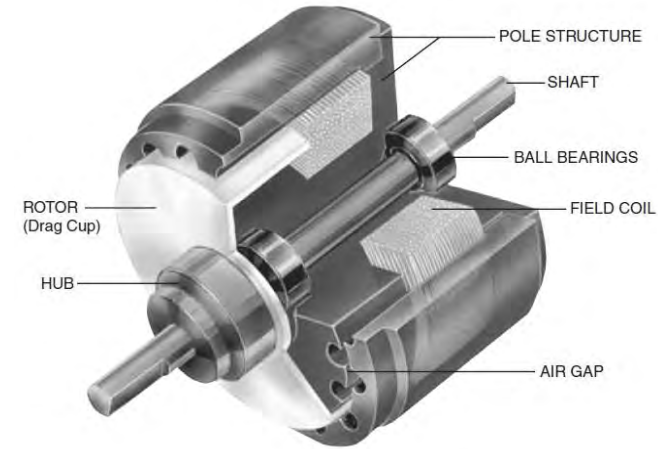


THE MEASURING RIG

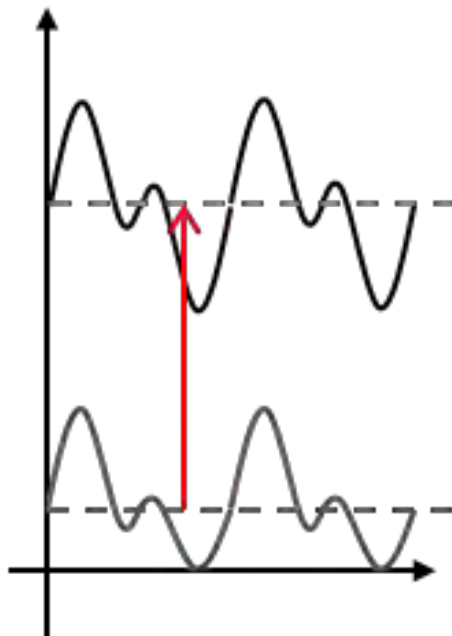
The measuring rig



The hysteresis brake

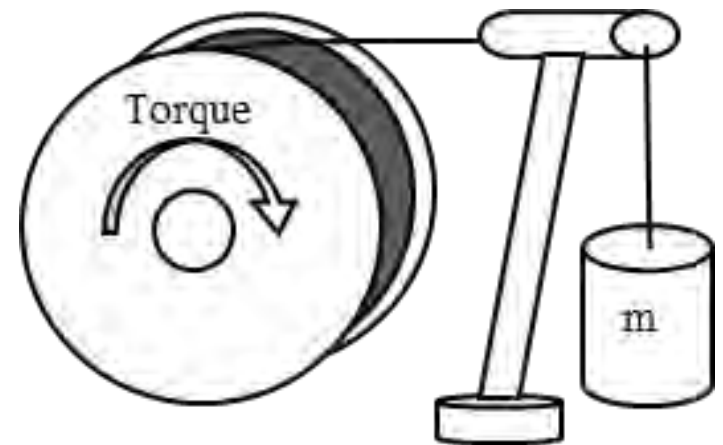


Torque



- ← Offset hysteresis brake
- Torque with hysteresis brake
- - Torque without hysteresis brake

Angle





EDUCATIONAL ASPECTS

Educational aspects

- 100% based on student research
- Wide spectrum
 - Bachelor / Master students in project works
 - Bachelor / Master students in single student research projects
 - Master thesis
 - (dissertation project)



CONCLUSION

Conclusion

- What we have:
 - Interaction between MATLAB and COMSOL using a GUI
 - Basic tool to design a synchronous machine and proof existing concepts
 - Automated geometry building and reduction
 - Automated meshing
 - Automated configuration of domain characteristics (windings, magnets)

Conclusion

- What we still need:
 - More machine types
 - More winding types
 - More interaction between GUI and user:
 - What should be changed to achieve a better design? (e.g. high cogging → change pole width)
 - Guided design process



Thank you for your attention

END