AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Introduction to COMSOL based Modeling of Levitated Flywheel Rotor

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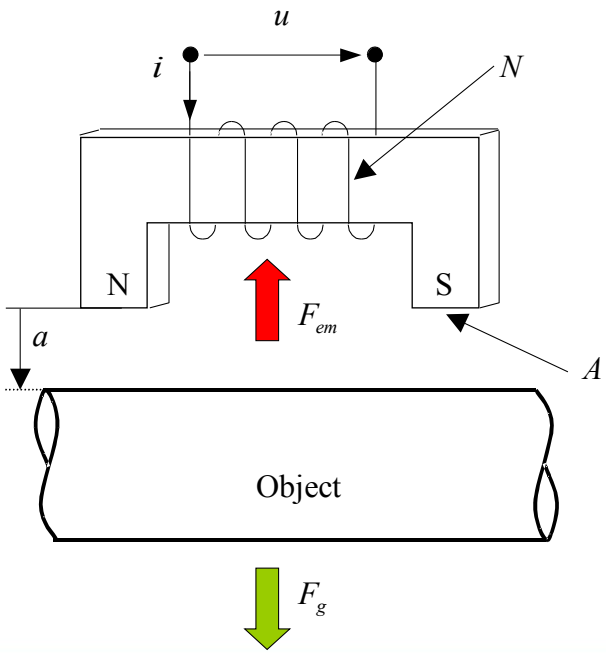
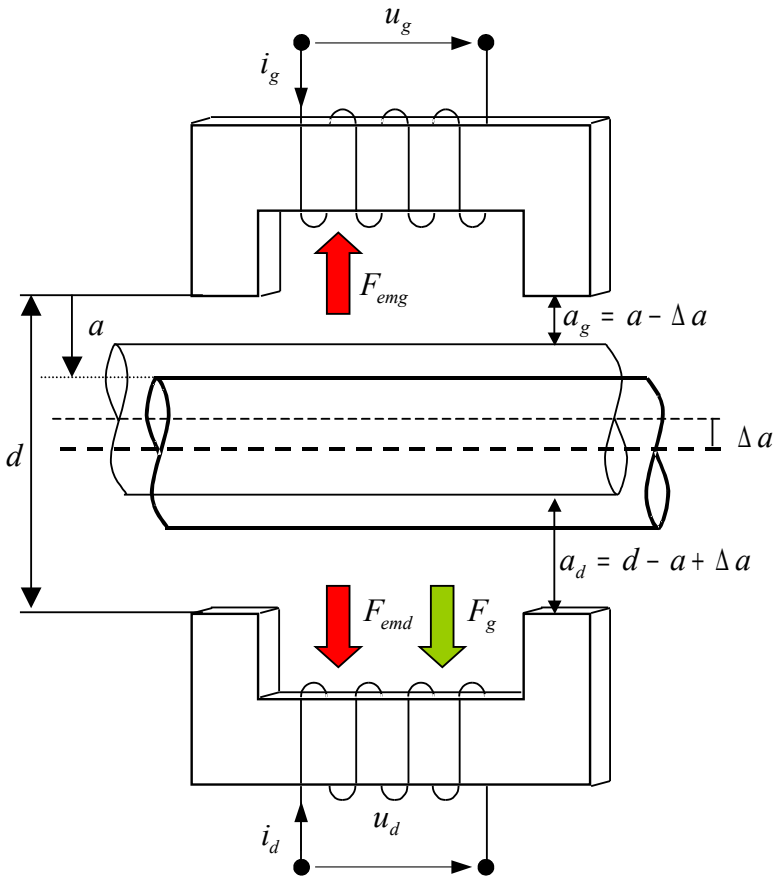
Agenda

- Active Magnetic Levitation
- Kinetic energy storage system
- Active Magnetic Suspension & Active Magnetic Bearing – laboratory equipment
- Flywheel optimization
- Components integration
- Eigenfrequency analysis
- Other aspects and future work
- Conclusions

Active Magnetic Levitation

- Non-contact operation
- No mechanical friction
- Dynamics control
- On-line monitoring and supervisory control



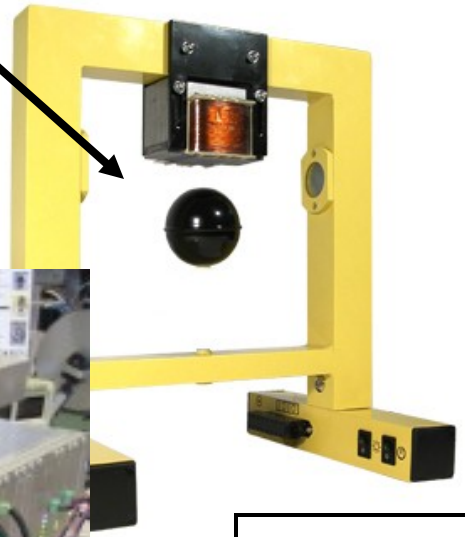


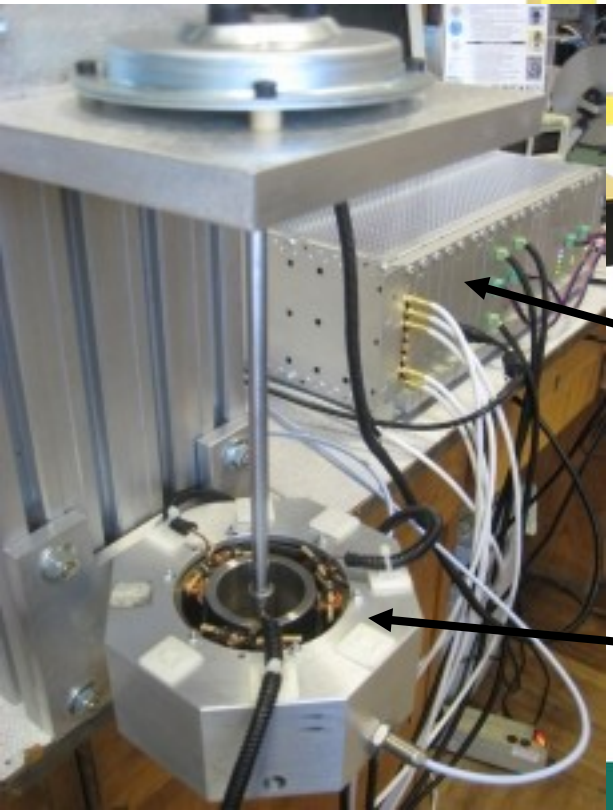
Kinetic energy storage system

- Flywheel energy storage (FES) works by accelerating a rotor (flywheel) to a very high speed and maintaining the energy in the system as rotational energy. When energy is extracted from the system, the flywheel's rotational speed is reduced as a consequence of the principle of conservation of energy;
- System components: rotor, bearings, motor/generator, control system, energy transmission system
- **Research towards optimal structure by analysis and study on materials, bearings, rotor dynamics, aerodynamical friction, safety, economical aspects**

AGH - Active Magnetic Suspension & Active Magnetic Bearing – laboratory equipment

Active Magnetic Suspension (**AMS**)





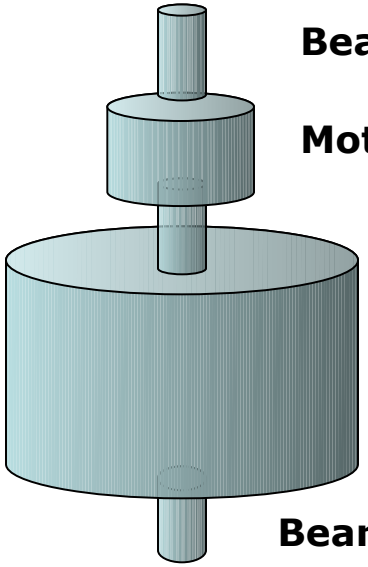
PAC - Hard real-time Controller

Active Magnetic Bearing (**AMB**)

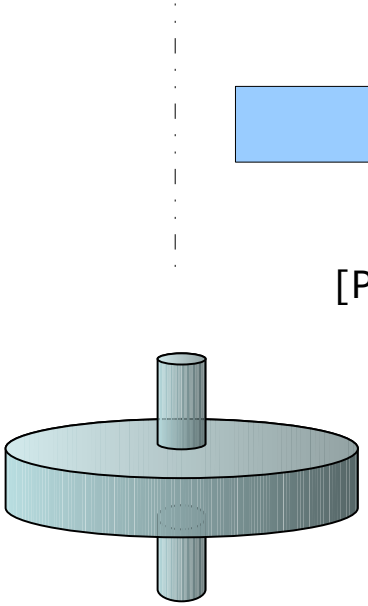
- Experience in Design, Prototyping, Modelling, Simulation, Identification and Control System
- AMS and AMB prototypes
- Custom controller
- Custom methods for integrated prototyping including control tasks

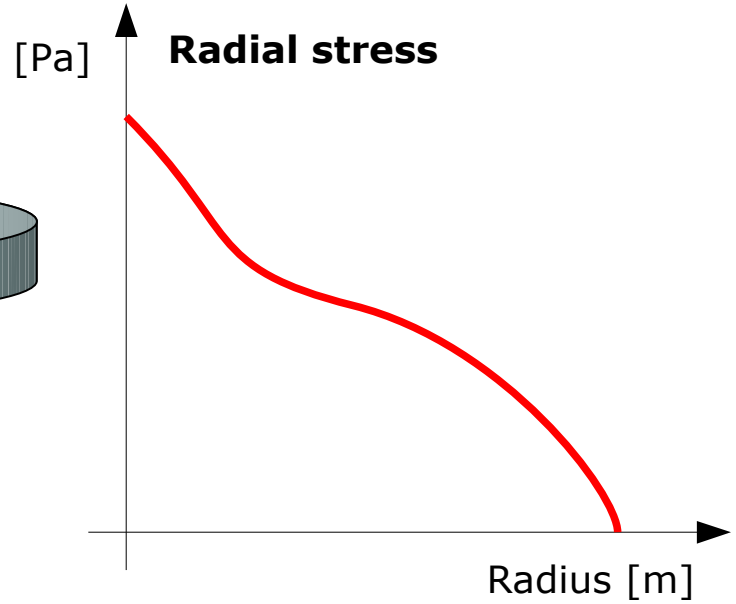
Towards optimal flywheel

Typical constructions



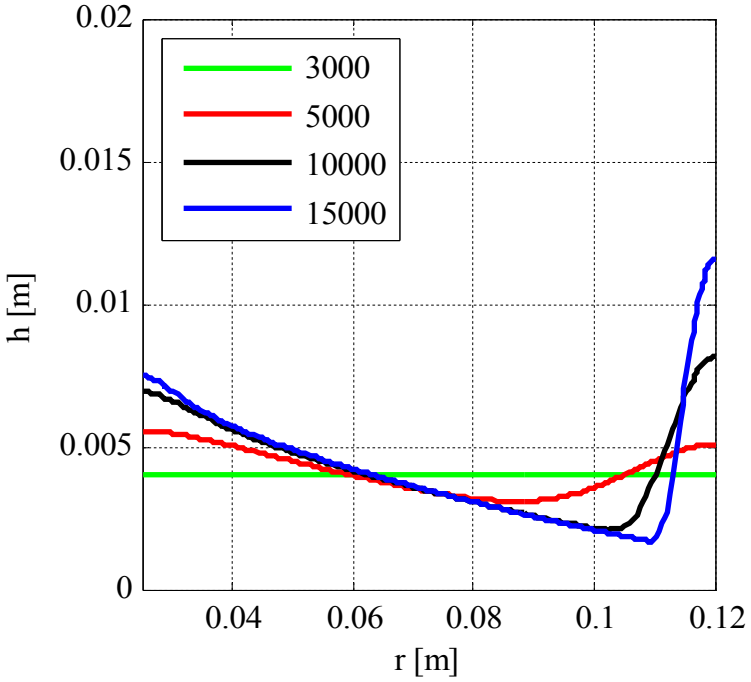
Towards flat disk and rigid body

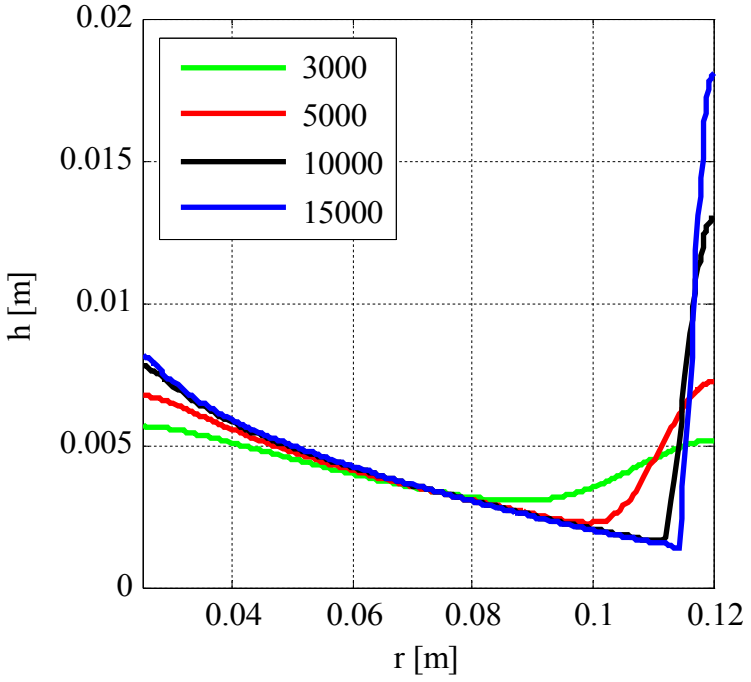




Optimization of Flywheel profile

- Aluminum
- Steel

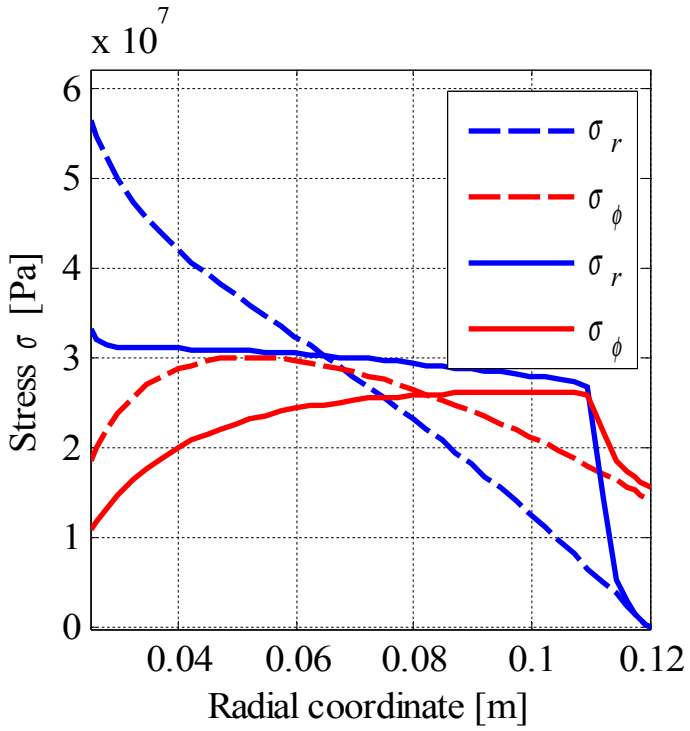




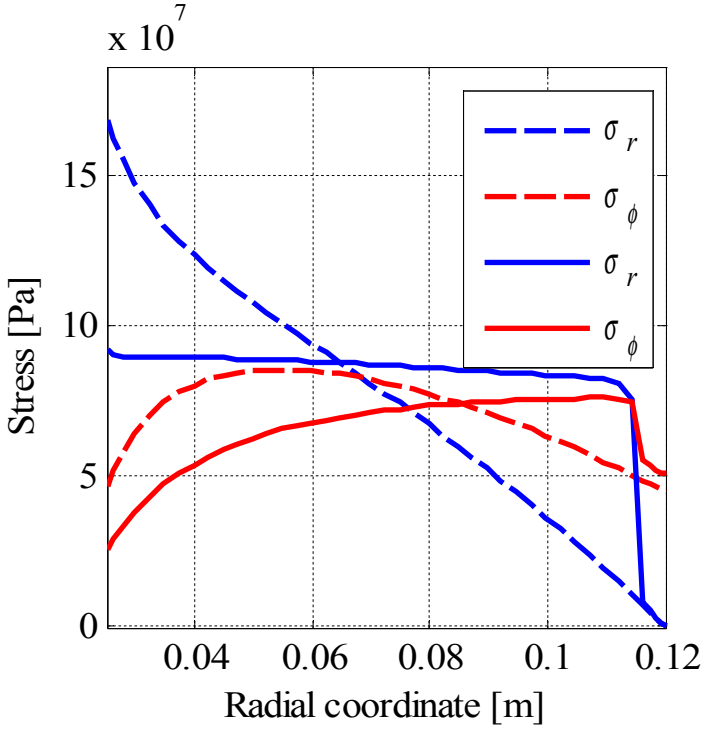
Flywheel profiles for a different rotational speeds given in rpms. a) aluminum; b) steel.

Optimization of Flywheel profile

- Aluminum

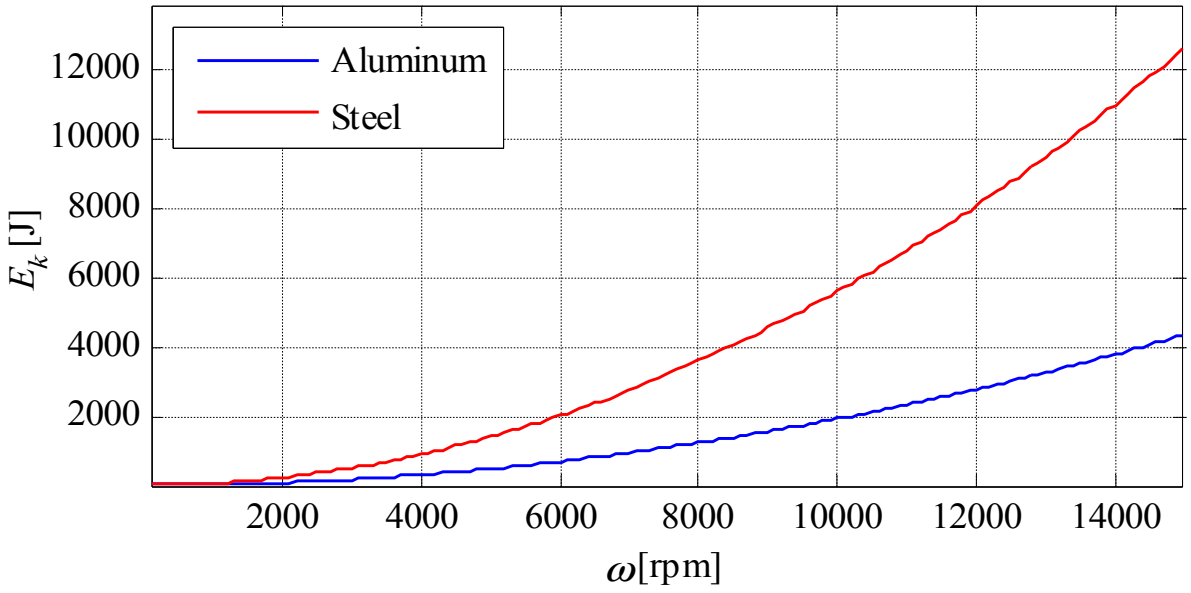


- Steel

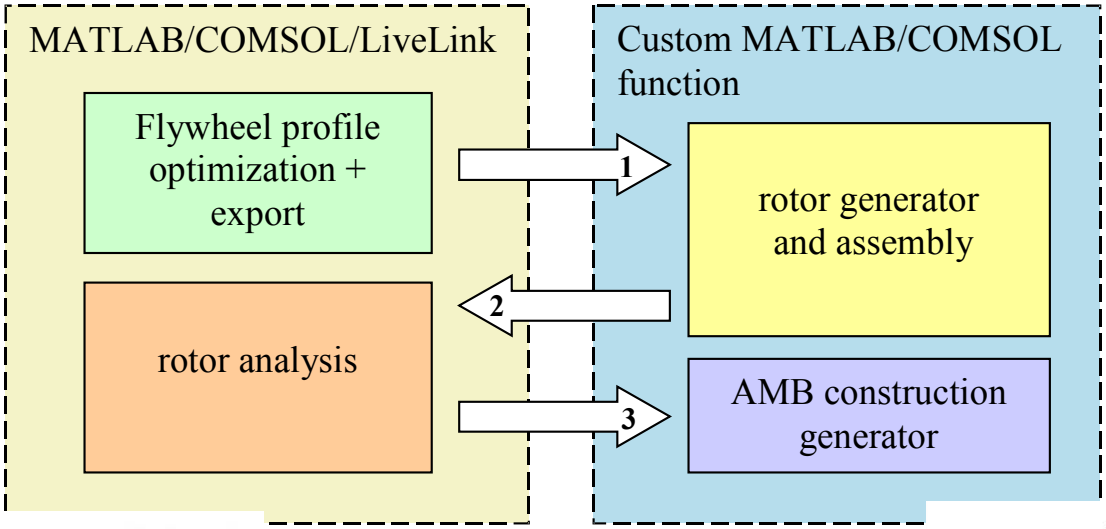


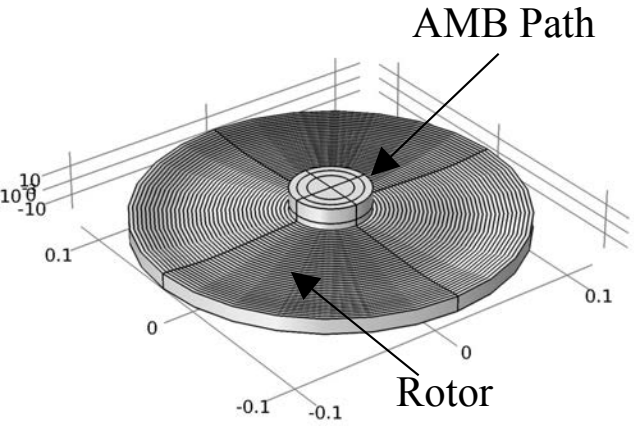
Radial (blue) and azimuthal (red) stress components for initial (dashed line) and optimized (solid line) flywheel profiles calculated at 1500 rpm. a) aluminum; b) steel

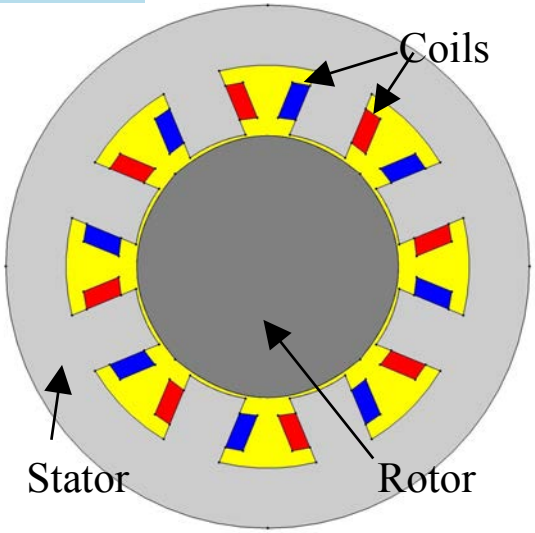
Kinetic energy stored vs rotational speed



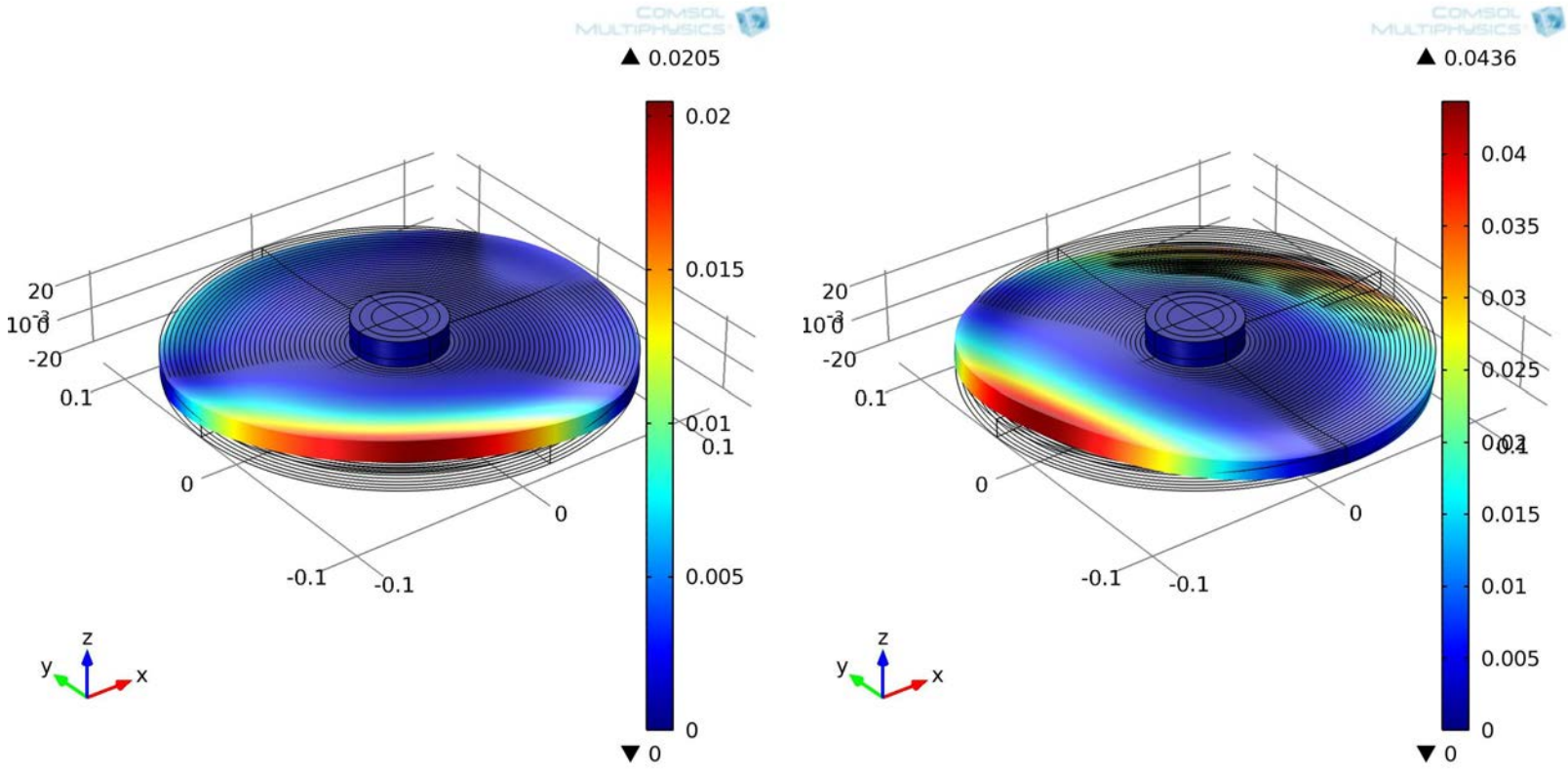
Towards complex prototyping







Rotor eigenfrequency analysis



Surface displacement in nanometers for rotational speeds: a) 3000 rpm; b) 15000 rpm.

Other aspects and future work

- Components to be included:
  - motor/generator
  - AMB control
  - Rotor dynamics
- Extension of current study stage:
  - Model of the complete system
  - Thermal, Magnetic and Aerodynamic aspects
- Multiobjective optimization

Conclusions

- COMSOL allows to perform a number of required analysis
- Custom methods for design, optimisation, integration and AMB generation
- On the base of construction properties the AMB and rotor dynamics can be considered
- It is possible to build the complete 3D virtual prototype?

Thank you for your attention