TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Electrical Engineering and Information Technology

Institute of Electromechanical and Electronic Design

Analysis and Model-Based Optimization of an Electromagnetic Valve Actuator

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1 Introduction

2 Analysis, modelling and simulation

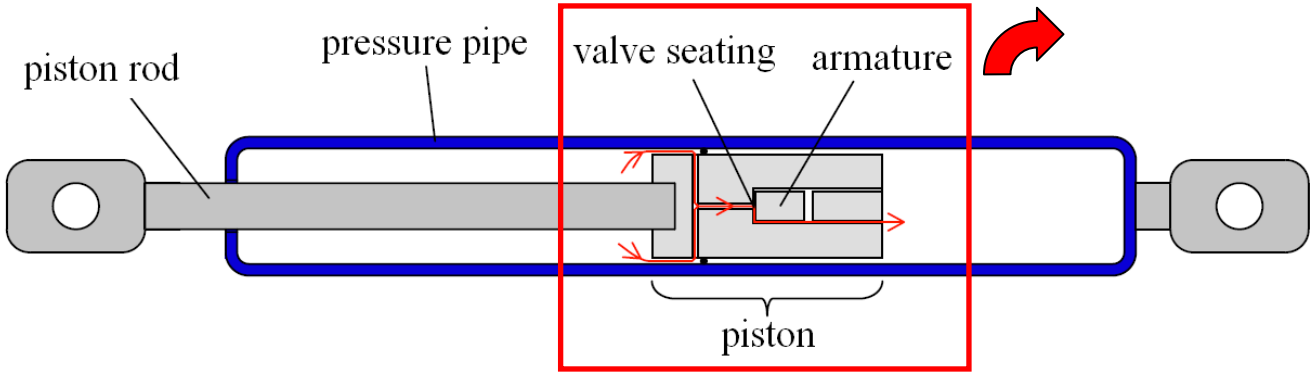
3 Validation of models and simulations

4 Optimization

5 Summing up / way forward

1 Introduction

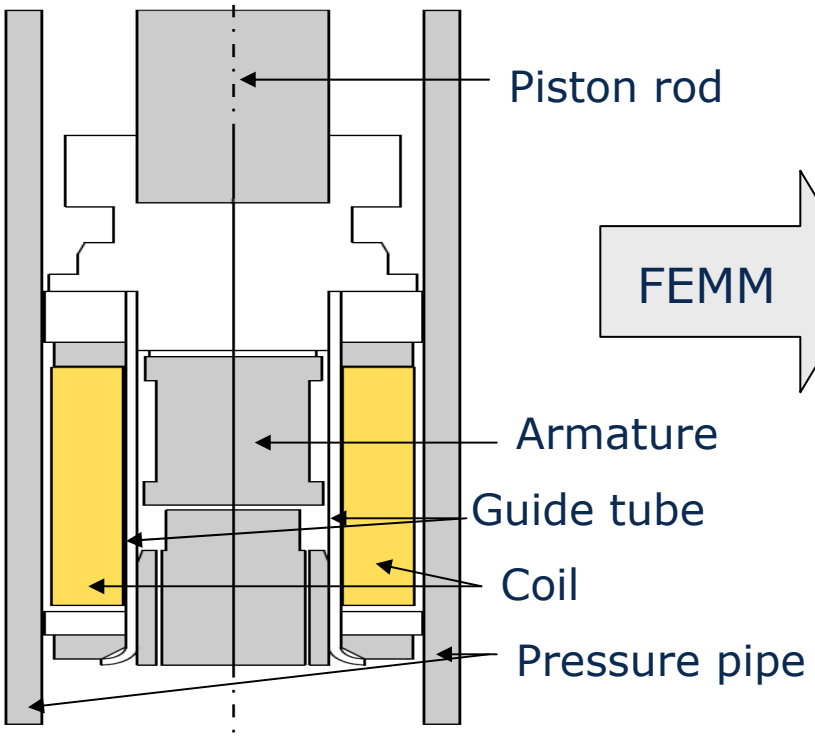
- Stabilus GmbH manufactures gas springs for automobile applications
- An electromagnetic valve actuator placed within the piston enables controlling
- Gas spring can be fixed at any user-defined position



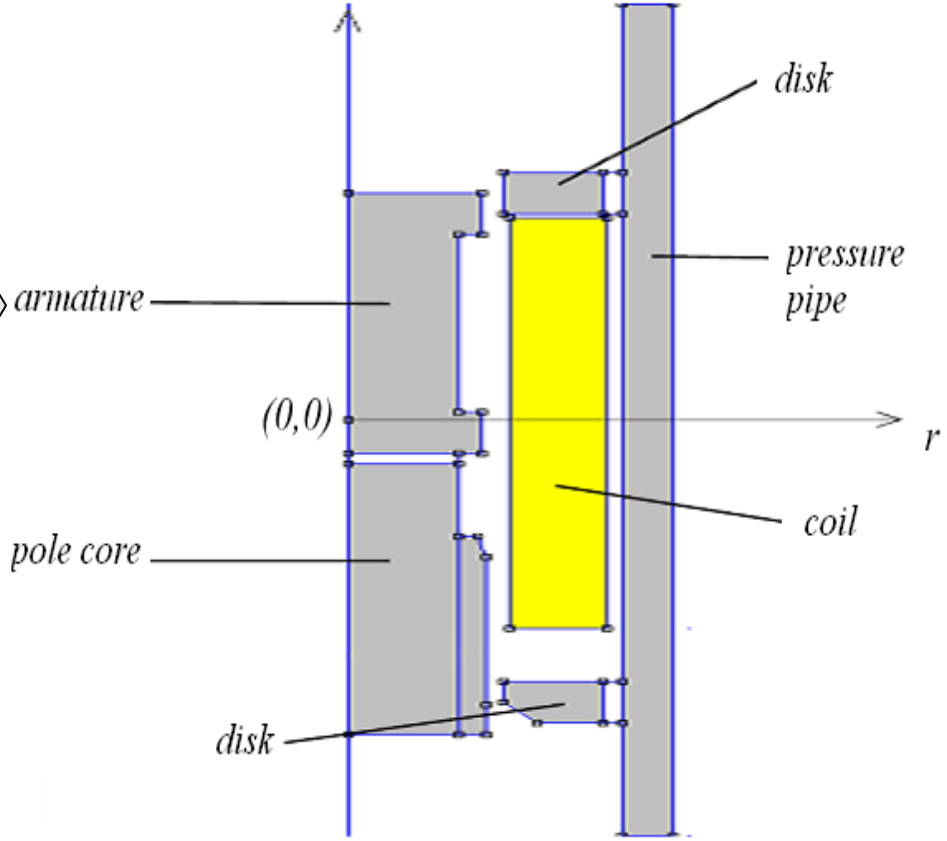
- Developers get a better system understanding by using models
- Early identification of weak points and optimization potential
- Save experimental time and equipment by the usage of simulations

2 Analysis, Modelling and Simulation

Magnetic FE-Model (1)

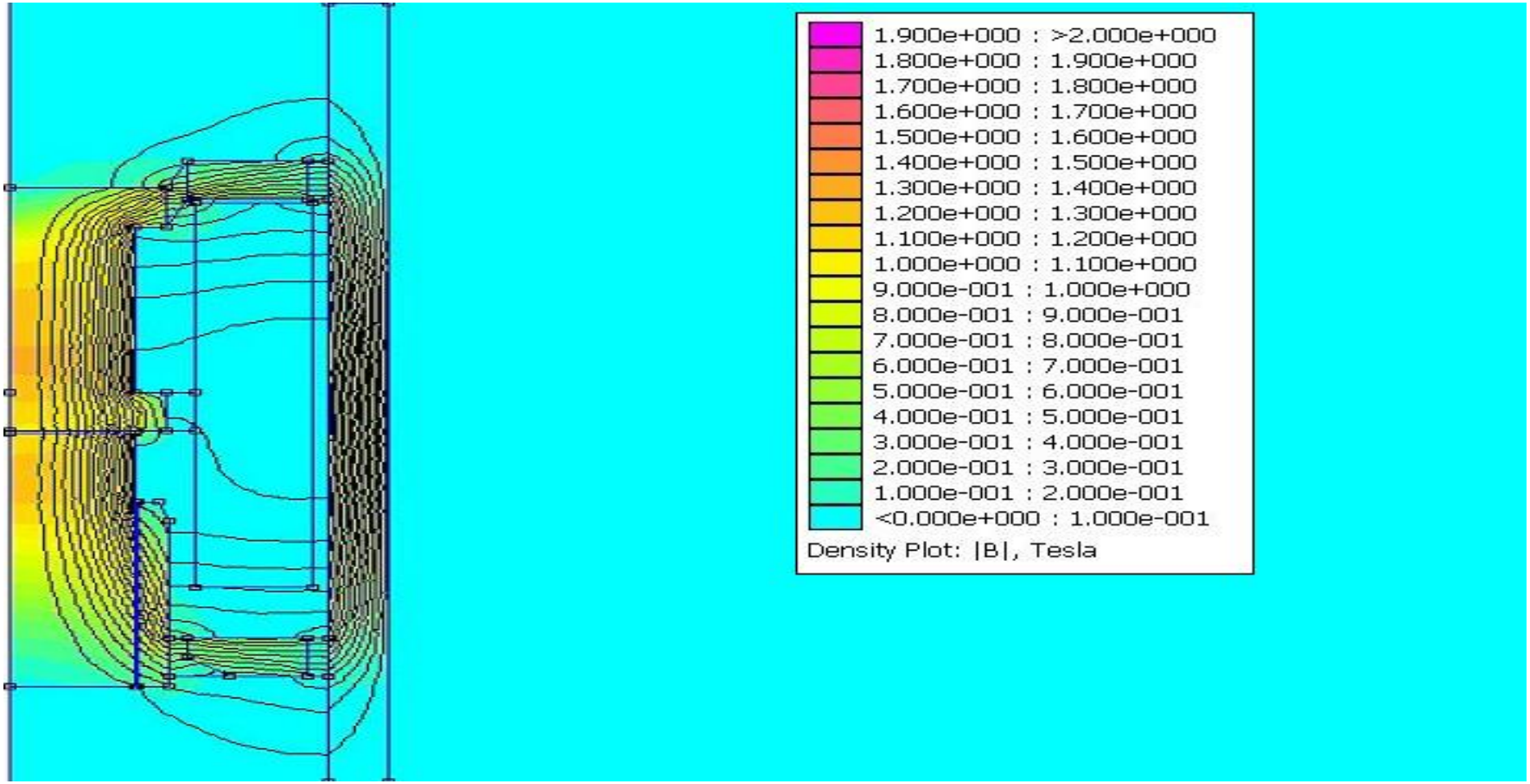


FEMM



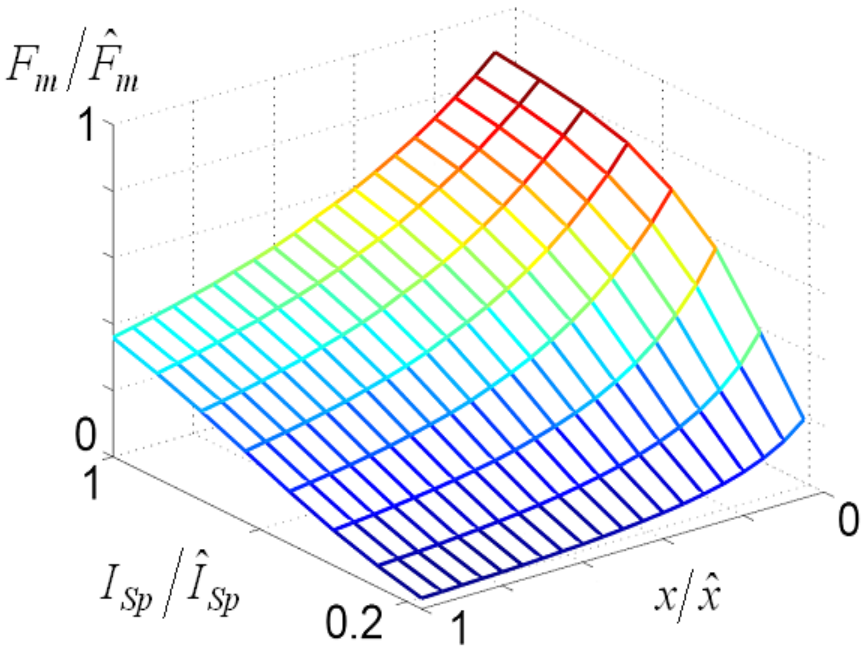
2 Analysis, Modelling and Simulation

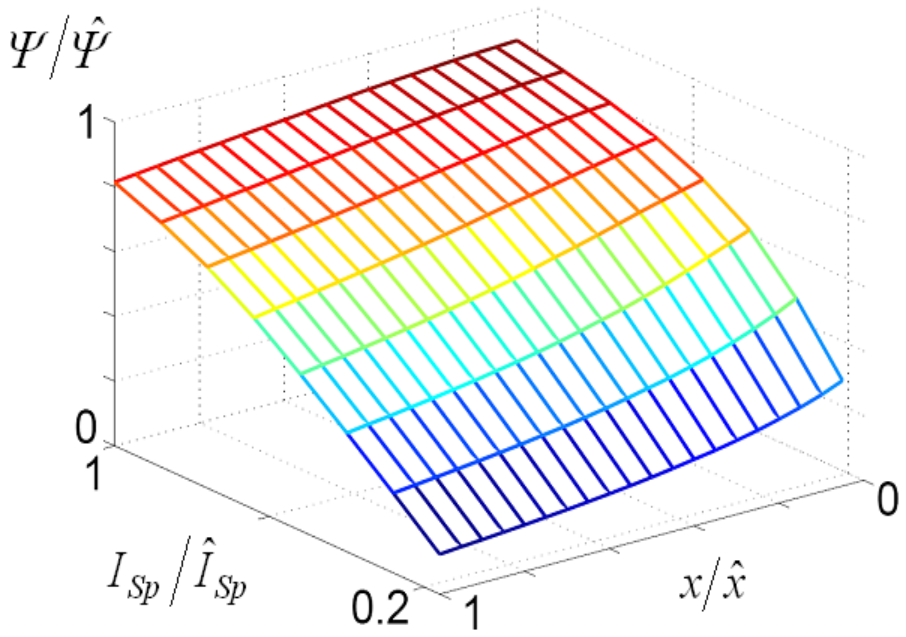
Magnetic FE-Model (2)



2 Analysis, Modelling and Simulation

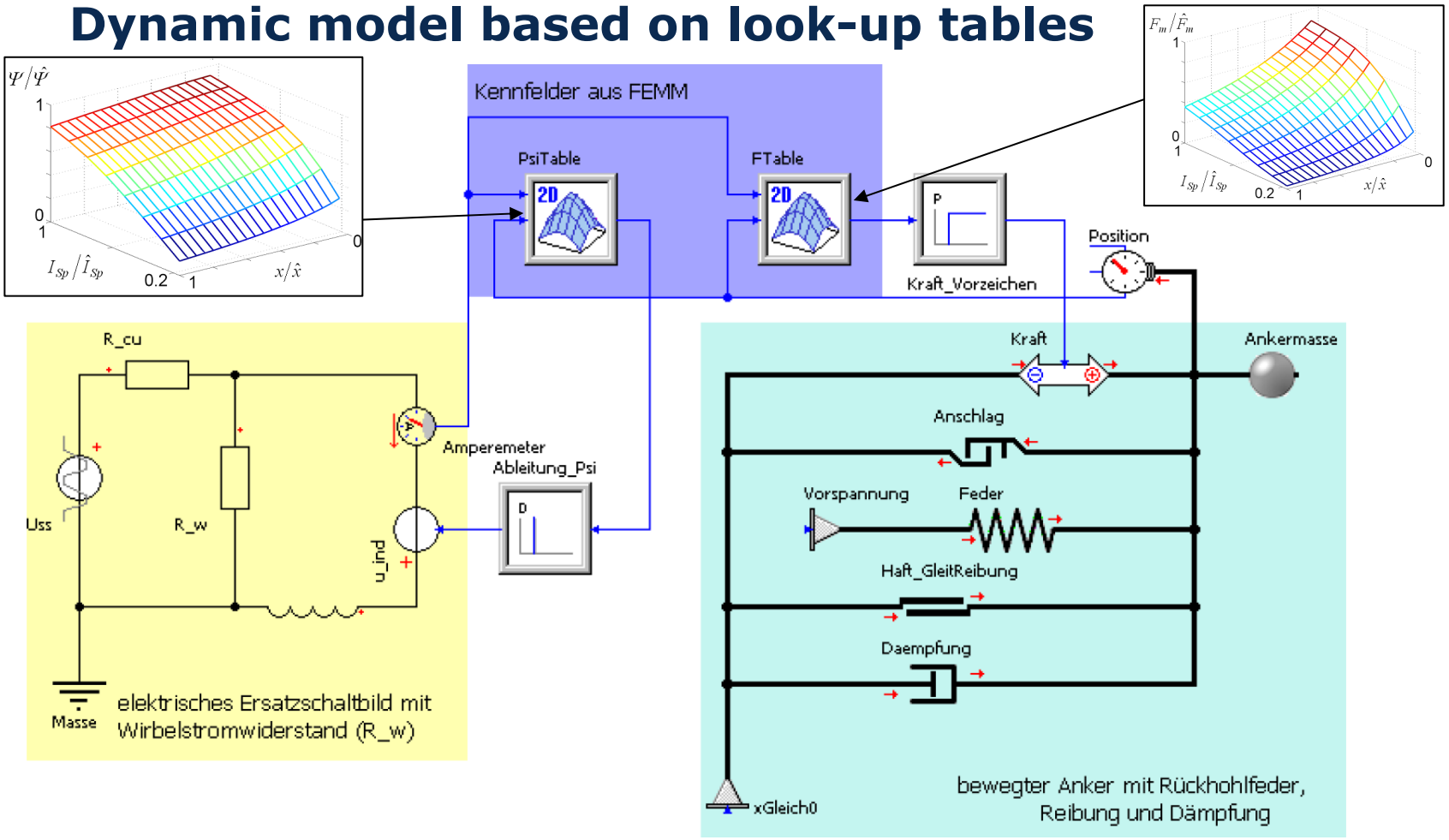
Magnetic FE-Model – characteristics





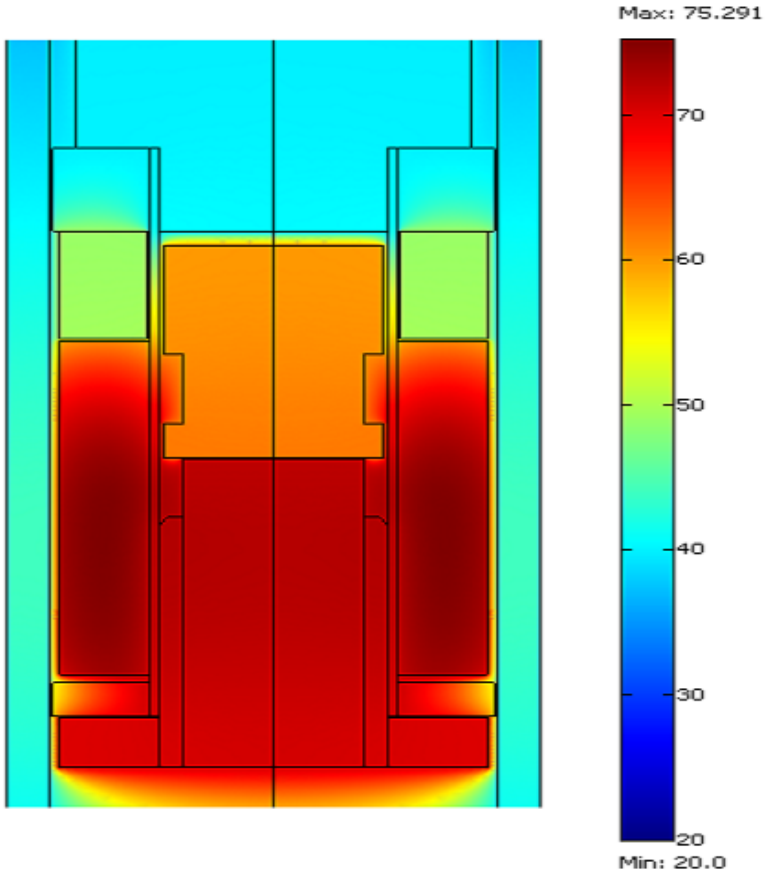
2 Analysis, Modelling and Simulation

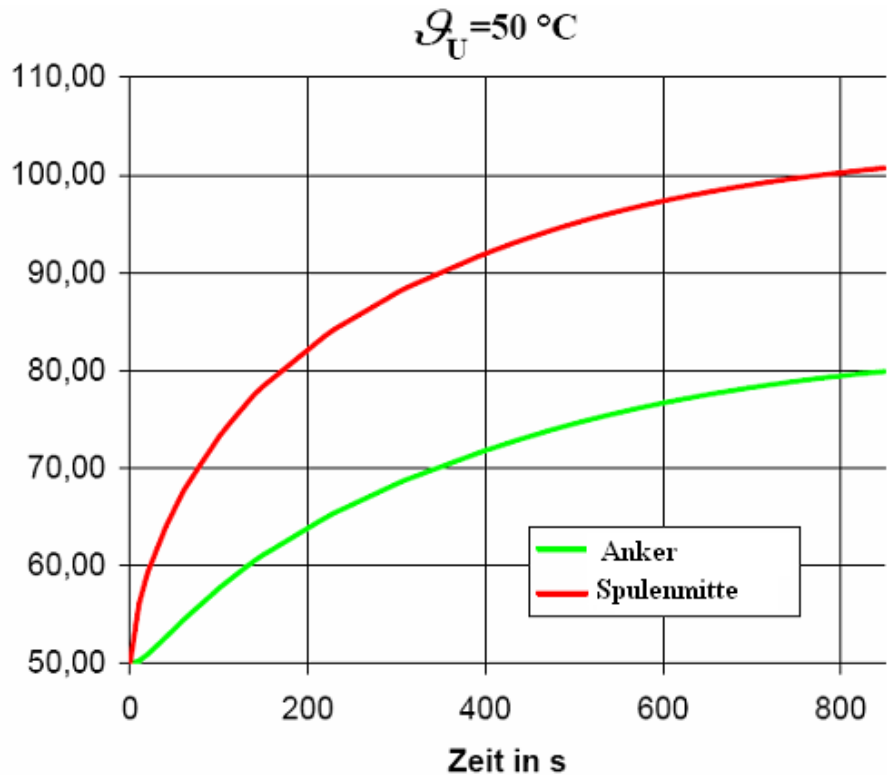
Dynamic model based on look-up tables



2 Analysis, Modelling and Simulation

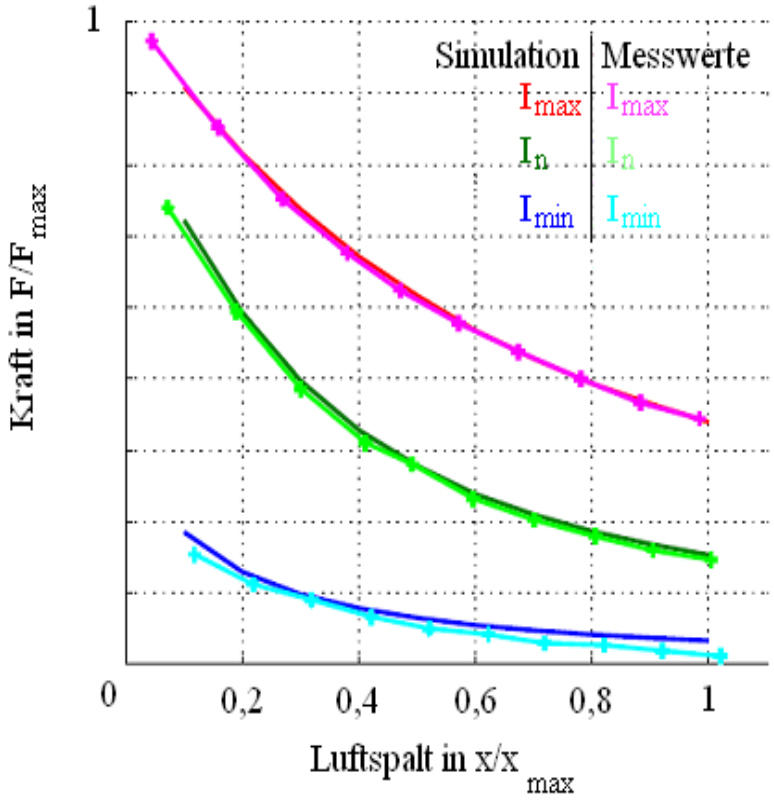
Thermal FE-Model

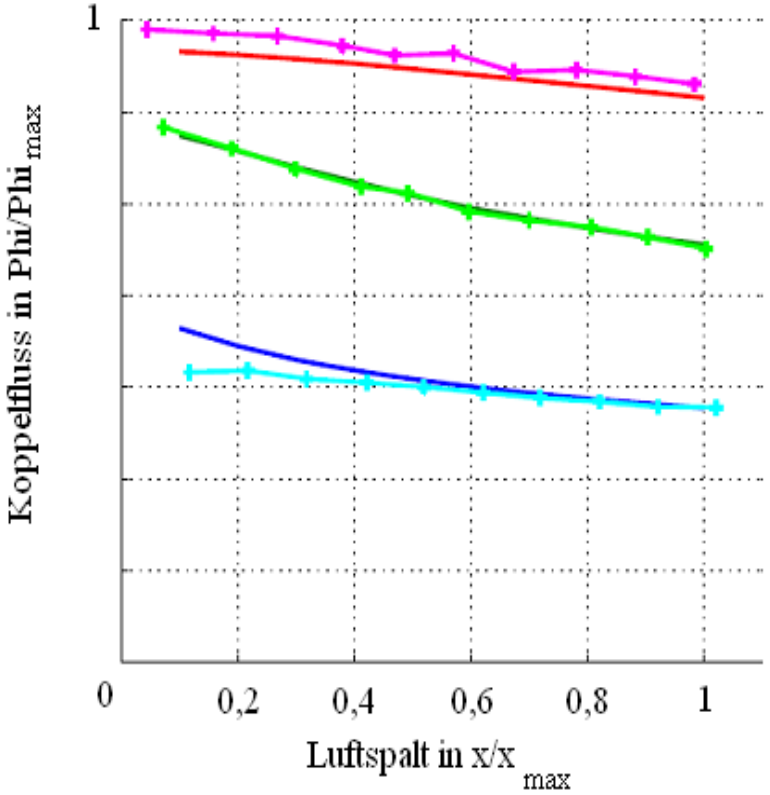




3 Validation of models and simulations

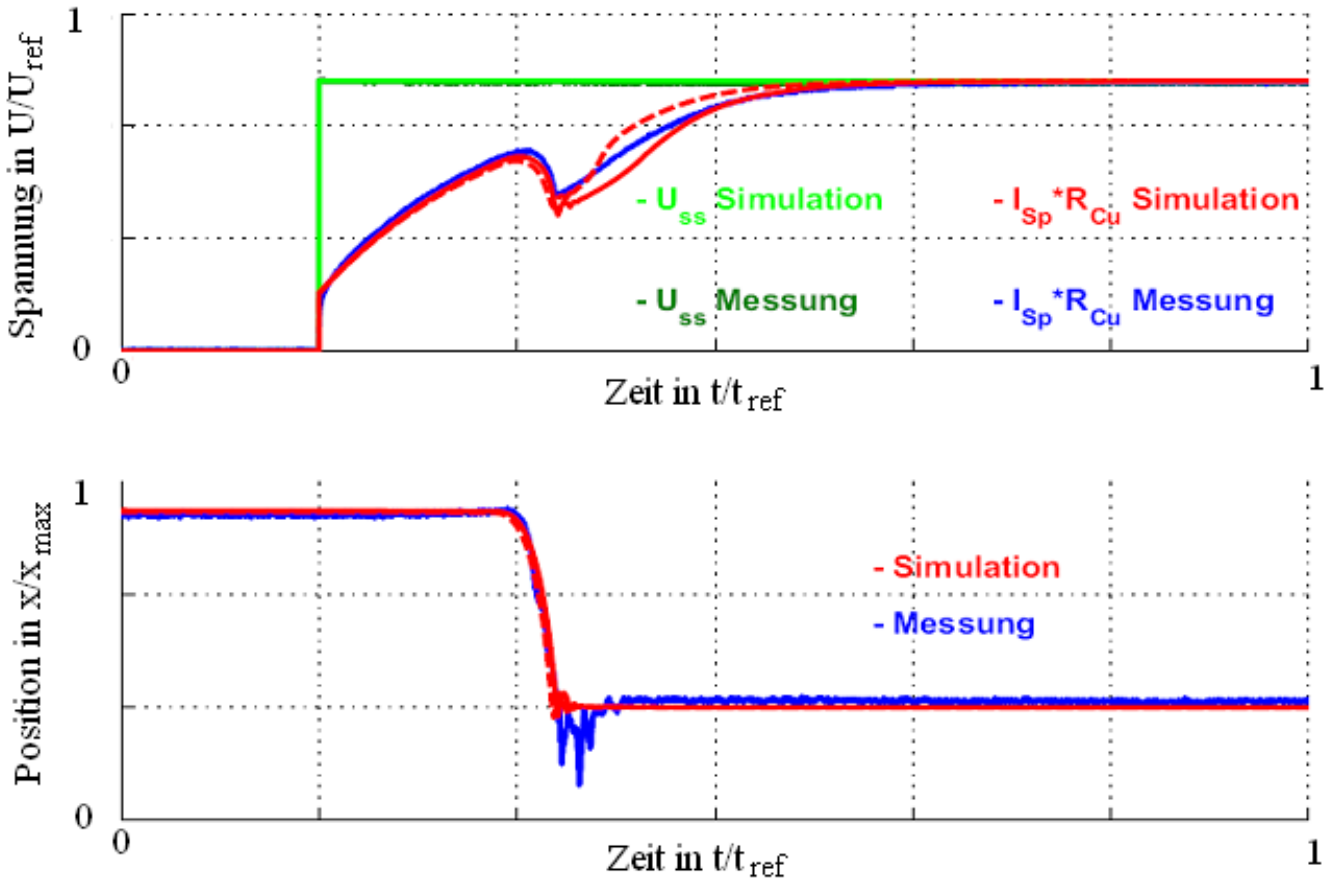
Steady state model





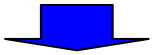
3 Validation of models and simulations

Dynamic model

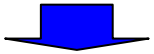


4 Optimization

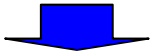
Actuator exerts insufficient force for a wide range of possible boundary conditions



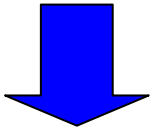
Gas spring is not working properly in this case!



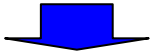
Optimization of magnetic force



Reliable opening in any condition



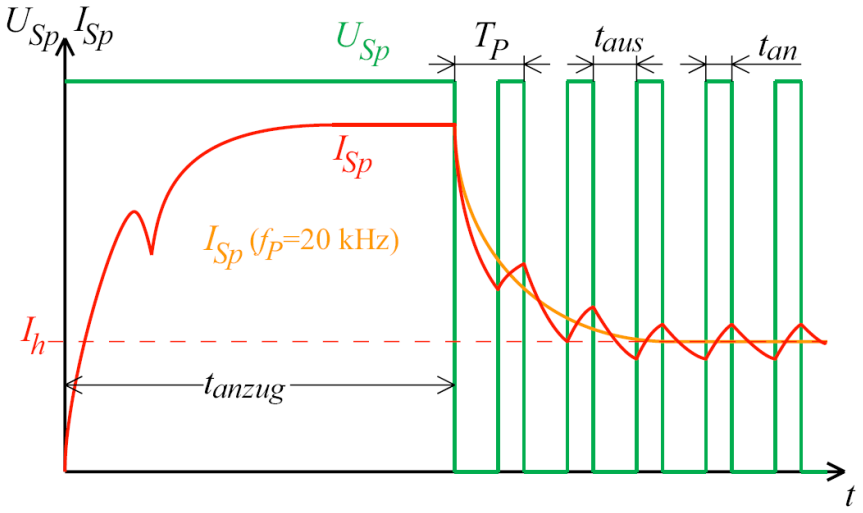
Design modifications using the models were done



First improvements attained

4 Optimization

What does over-excitation mean?



- Larger magnetomotive forces possible when switching-on
- Considerably less magnetomotive forces necessary to hold the armature

Methodology

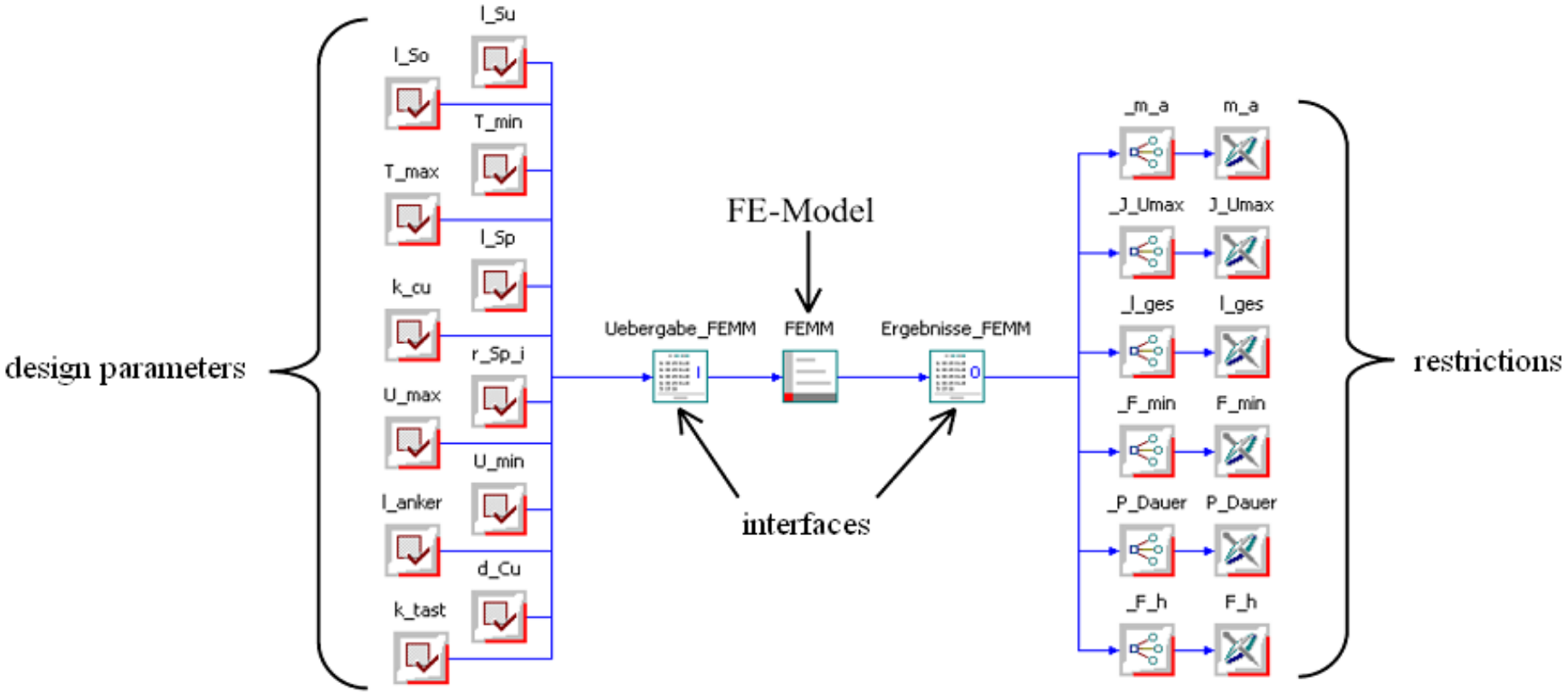
Identification of thermal constraints using FE-Models

Computer-aided Optimization in OptiY

Simulation and characterisation of the optimized actuator

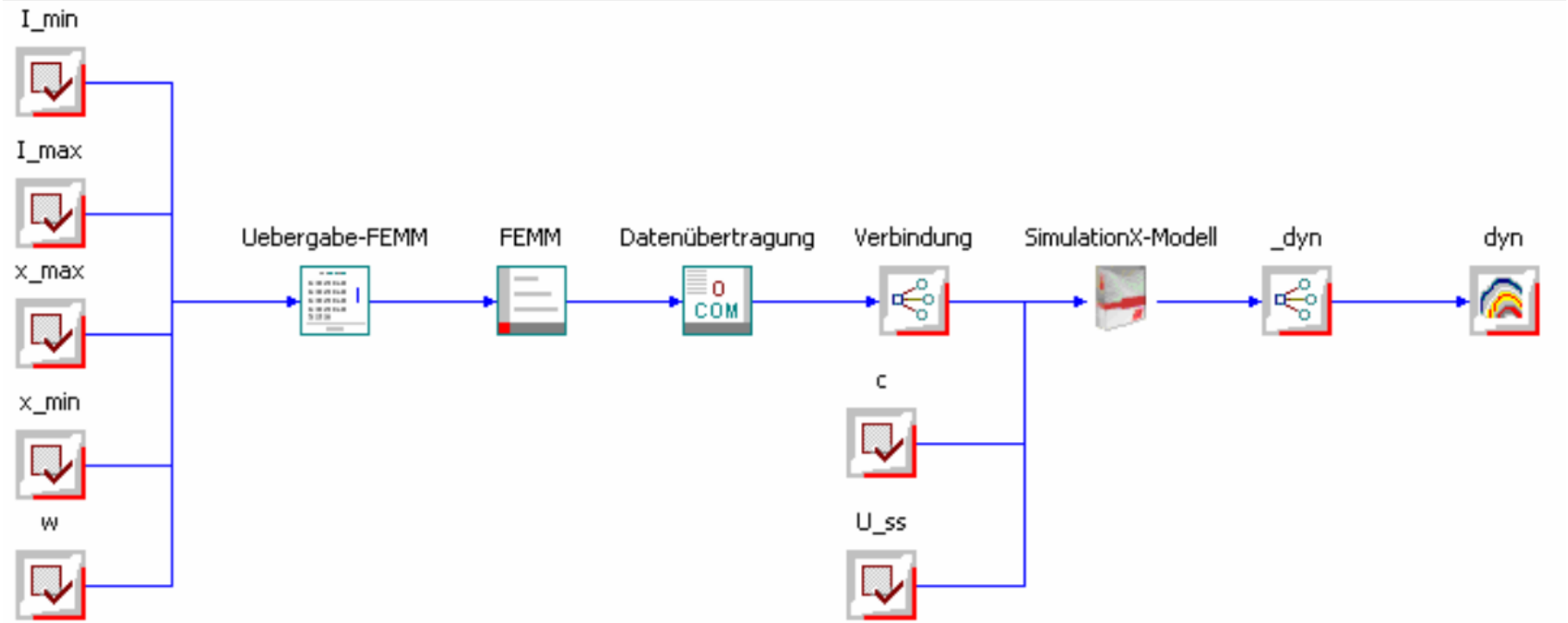
4 Optimization

Steady state optimization of the actuator in OptiY



4 Optimization

Dynamic optimization of the actuator in OptiY



5 Summing up / Way forward

Design method to handle complex mechatronic systems was shown

All preconditions fulfilled for the application of simulation-models and optimization-tools at Stabilus GmbH:

- FE-Models and dynamic models generated und validated
- Optimization of the valve actuator in several steps
- Using over-excitation-control an actuator was designed, that satisfies all constraints

Methodology applicable for other mechatronic systems