Numeric model of the large-diameter slewing ring in combination with shell structures

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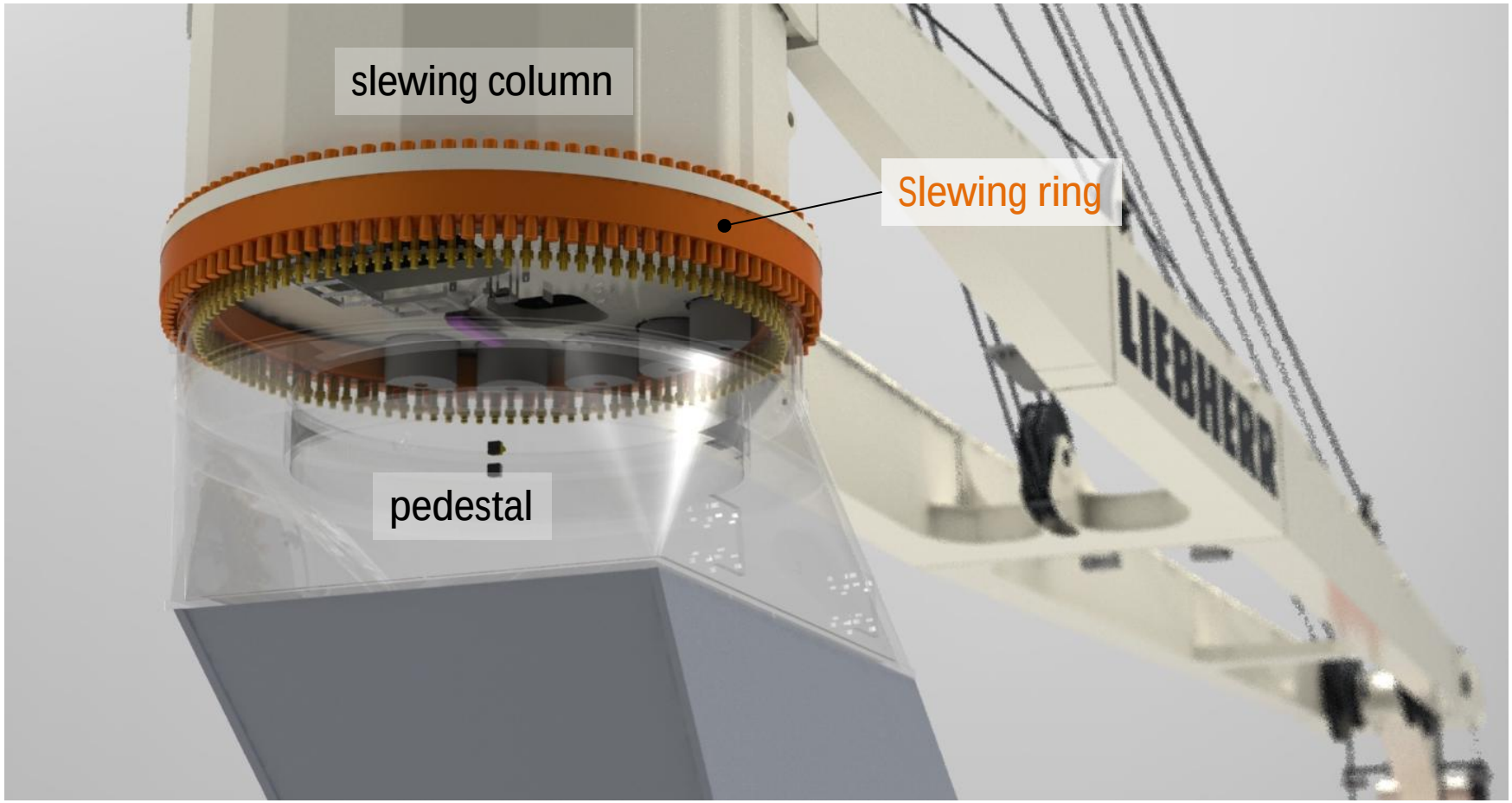
Problem / Motivation

Volumetric part in shell-dominated assembly with system relevant behaviour



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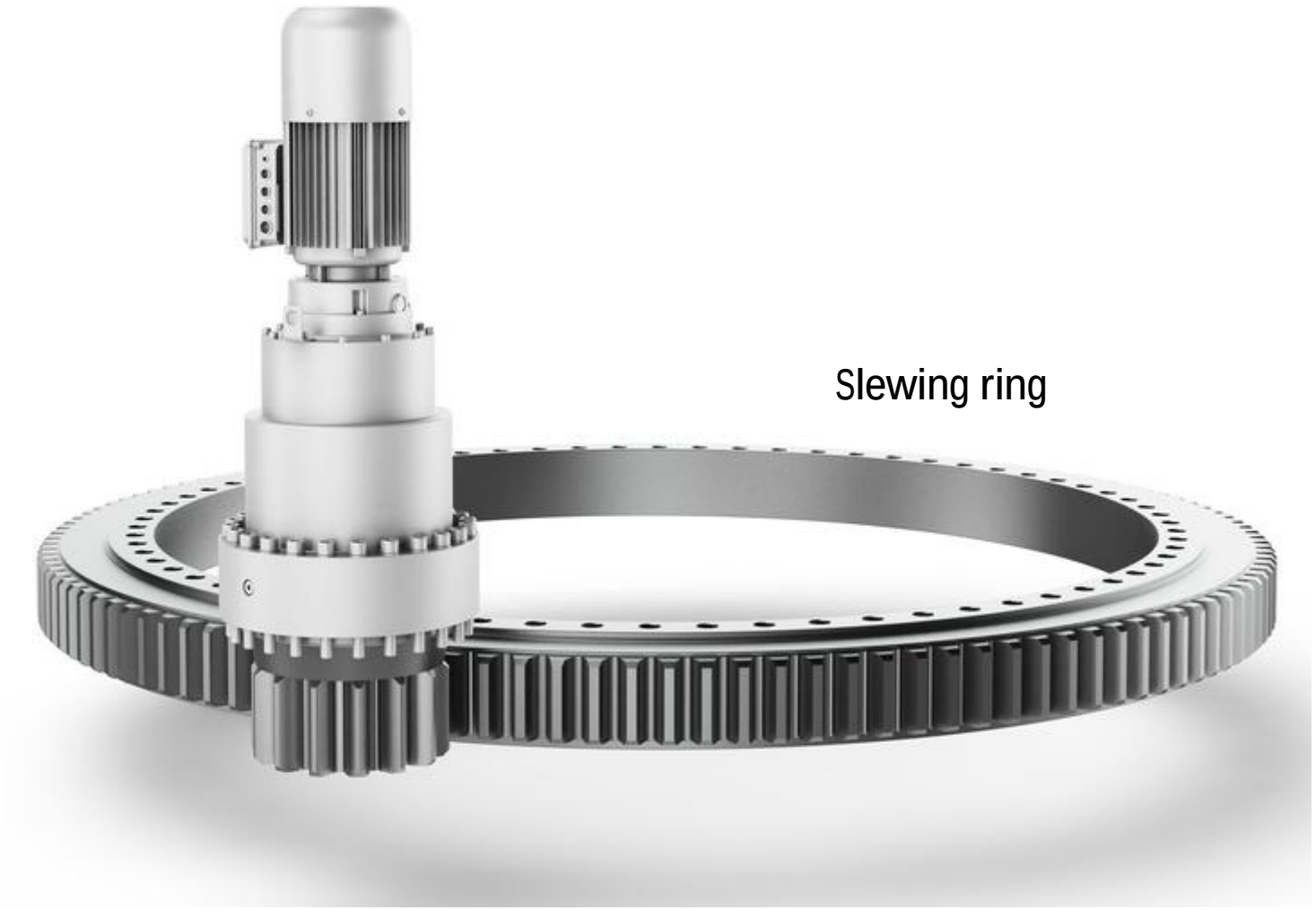
Part of interest



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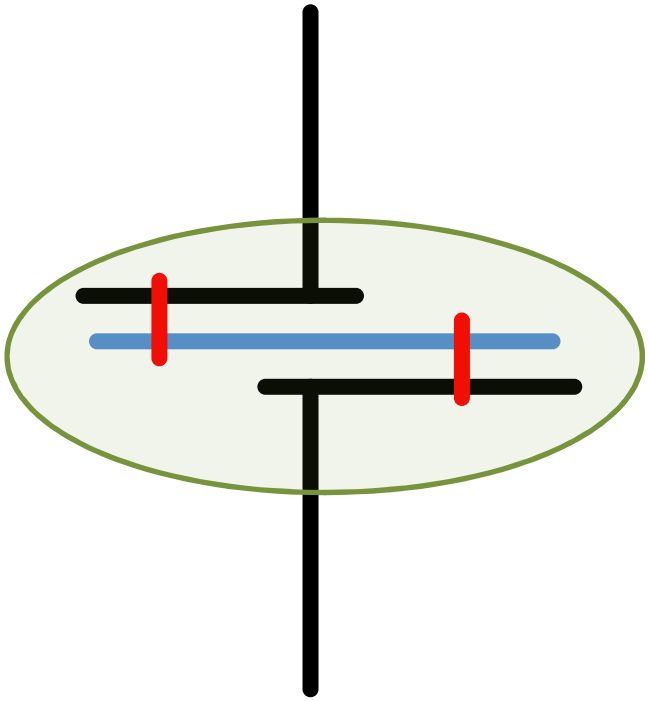
schematic assembly

crane slewing column



slewing ring

connection with pre-stressed bolts, several contacts and axial rotation bearing

= highly non-linear mechanical connection

pedestal – connection to base structure

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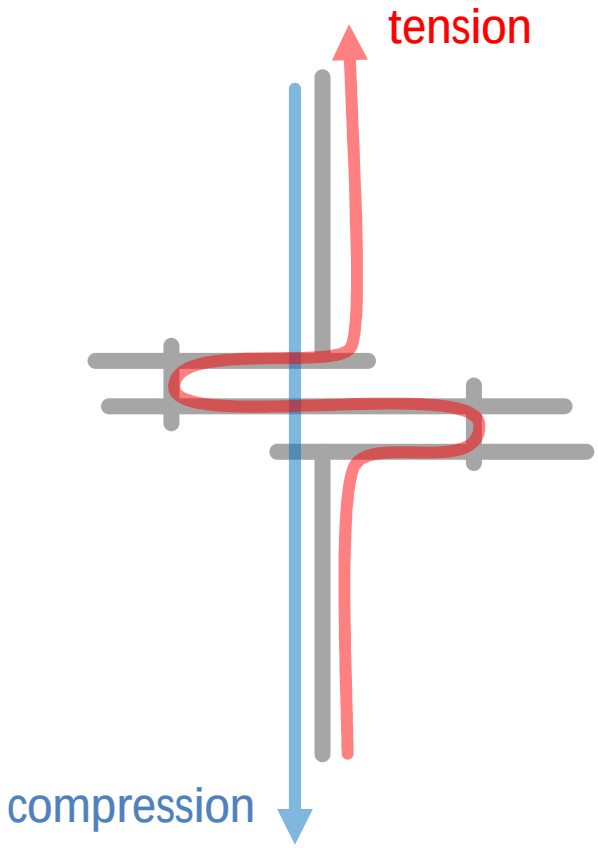
schematic assembly

flow of forces



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requirements and approaches

requirements	global volumetric model	global shell model with MPC + volumetric sub-model	global shell model with MPC + analytic detail proofs
automatable (APDL)			
integrated in existing developement process			
relative rotation between connected parts			
compatibility to global shell models			
including pre-stress of bolt connections			
including non-linear effects due to contact			
realistic flow of forces			
acceptable solution time			

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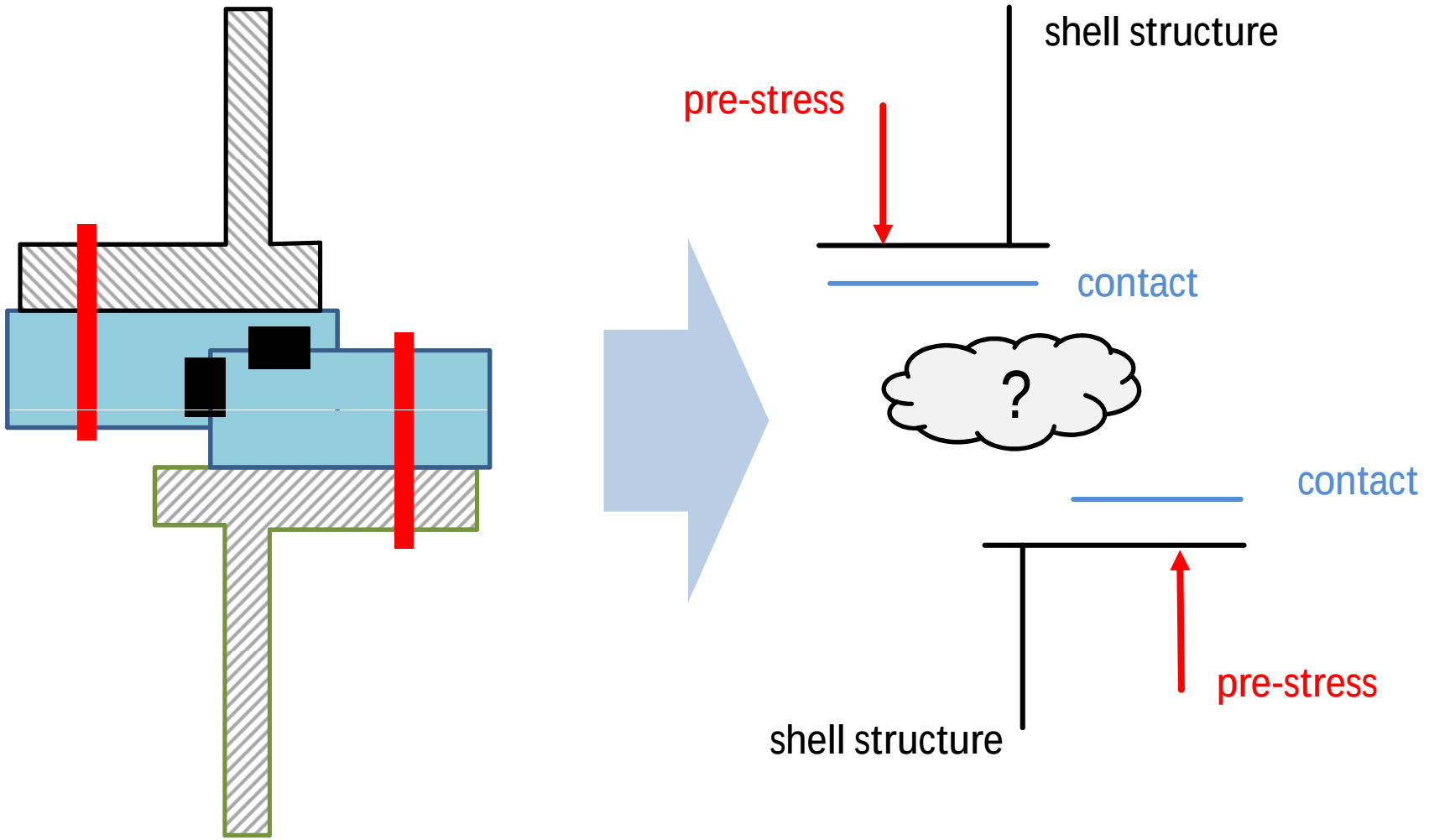
concept



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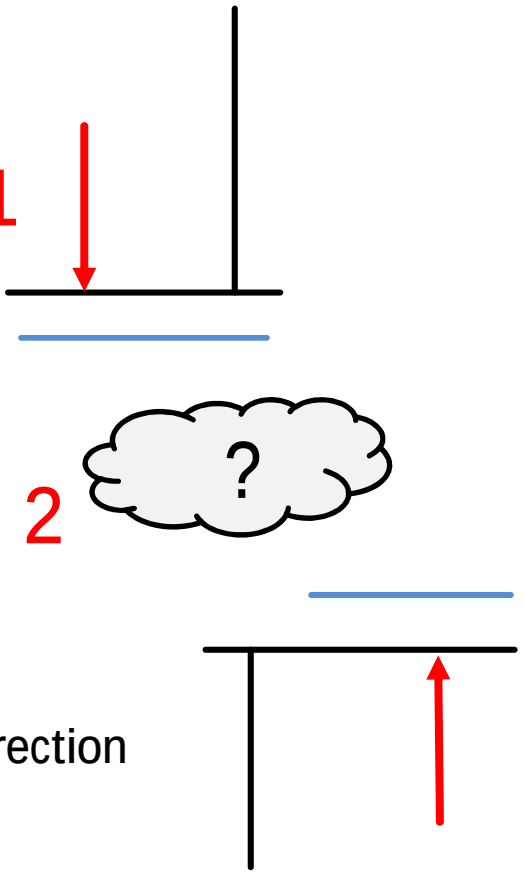
physical reduction

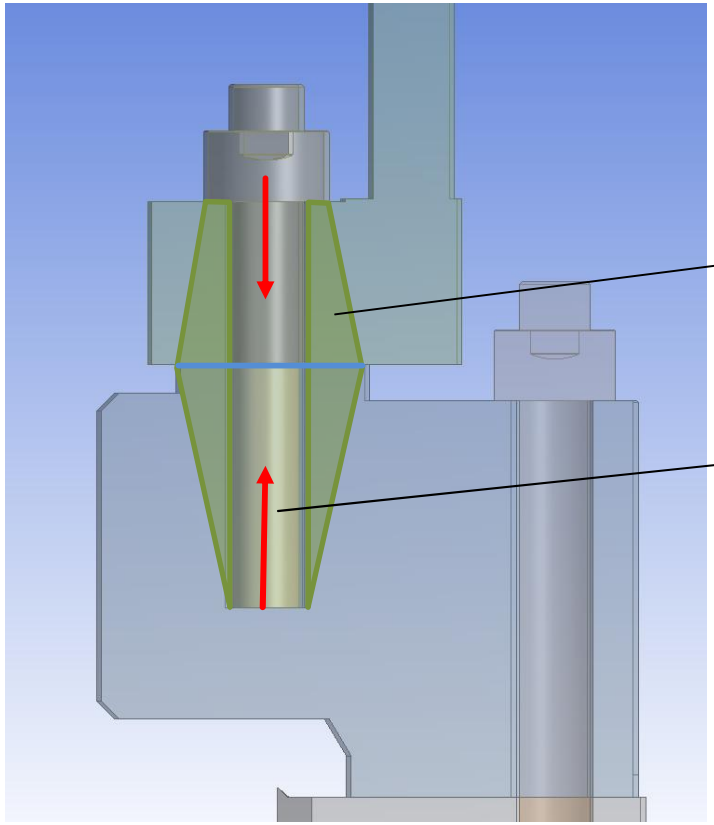


reduction results in two main problems:

1. pre-stress connection of a shell in thickness direction
2. mechanical system between contact surfaces

solving the problems

1. Pre-Stress effect on shell flanges



shell elements

beam element
representing
effective stiffness of
flange in thickness
direction

beam element
+ pre-stress element
representing pre-stressed bolt

shell contact elements

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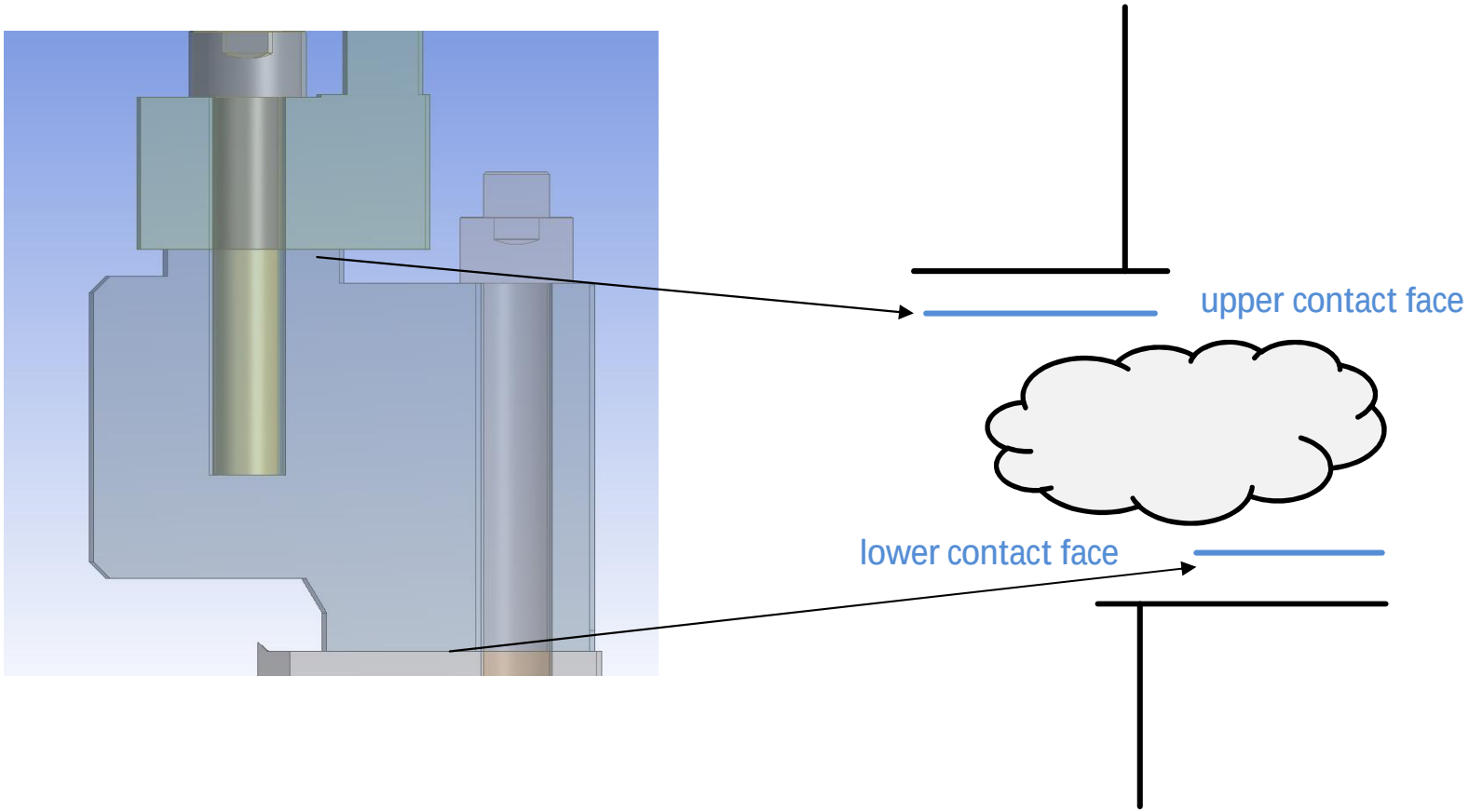
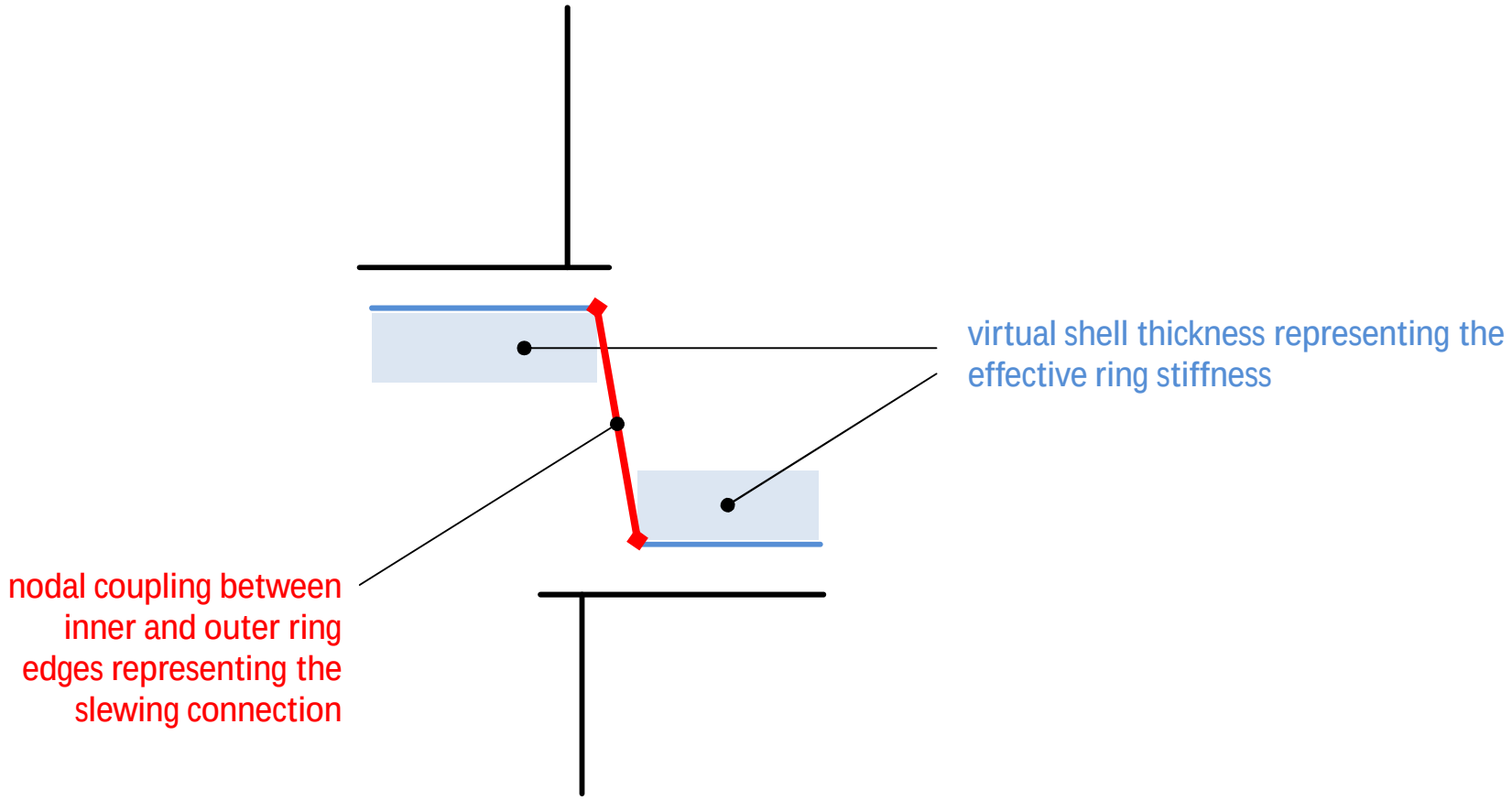
solving the problems

2. mechanical behaviour between contact faces



solving the problems

2. mechanical behaviour between contact faces



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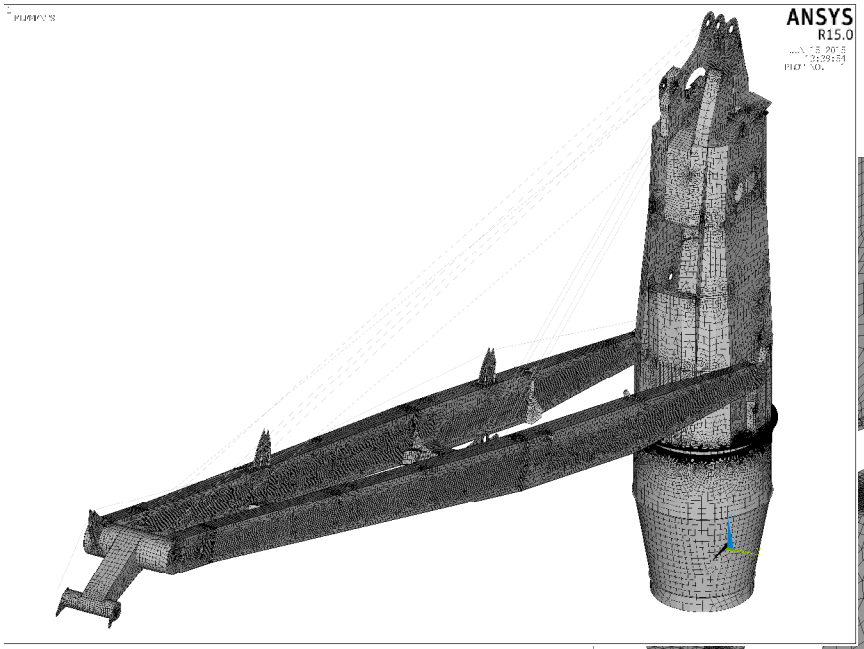
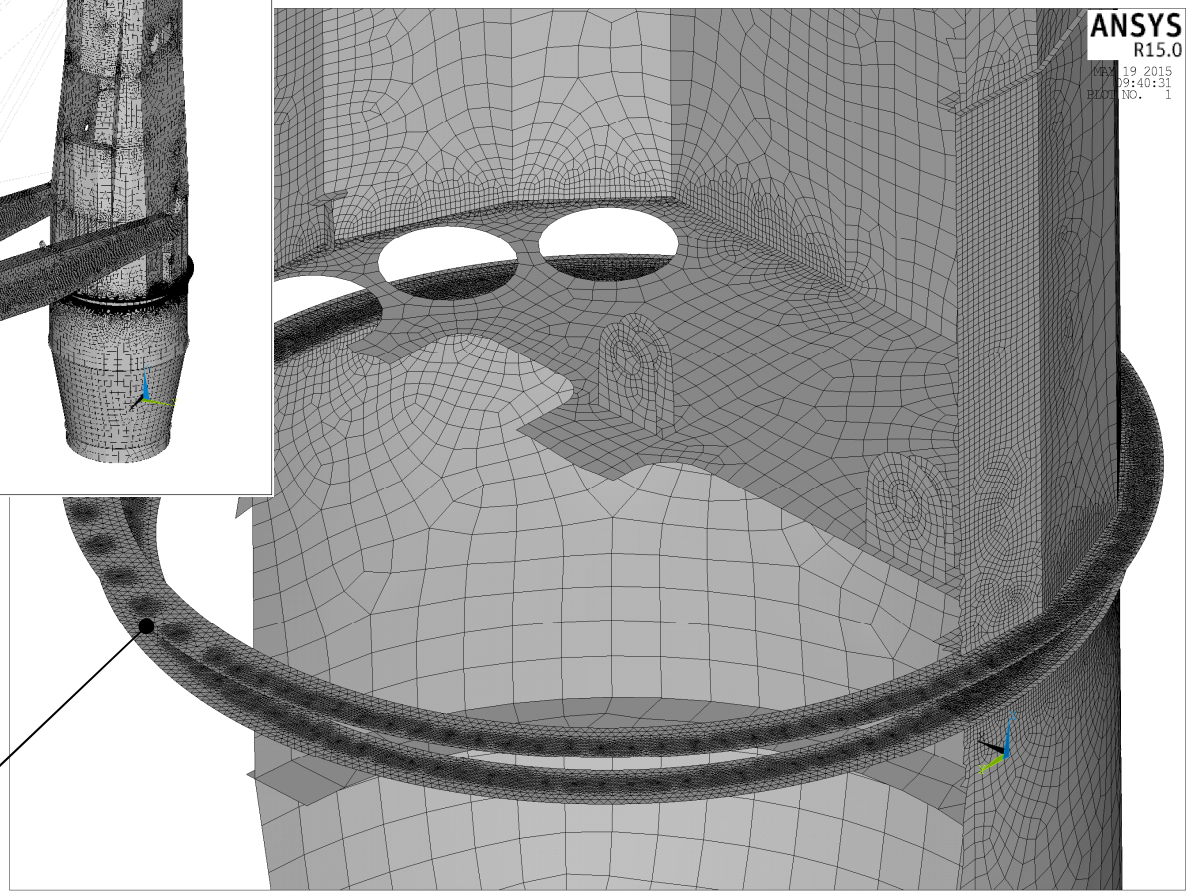
practical implementation



global FE model of complete crane steel structure



shell elements representing the upper and lower contact areas of the slewing ring

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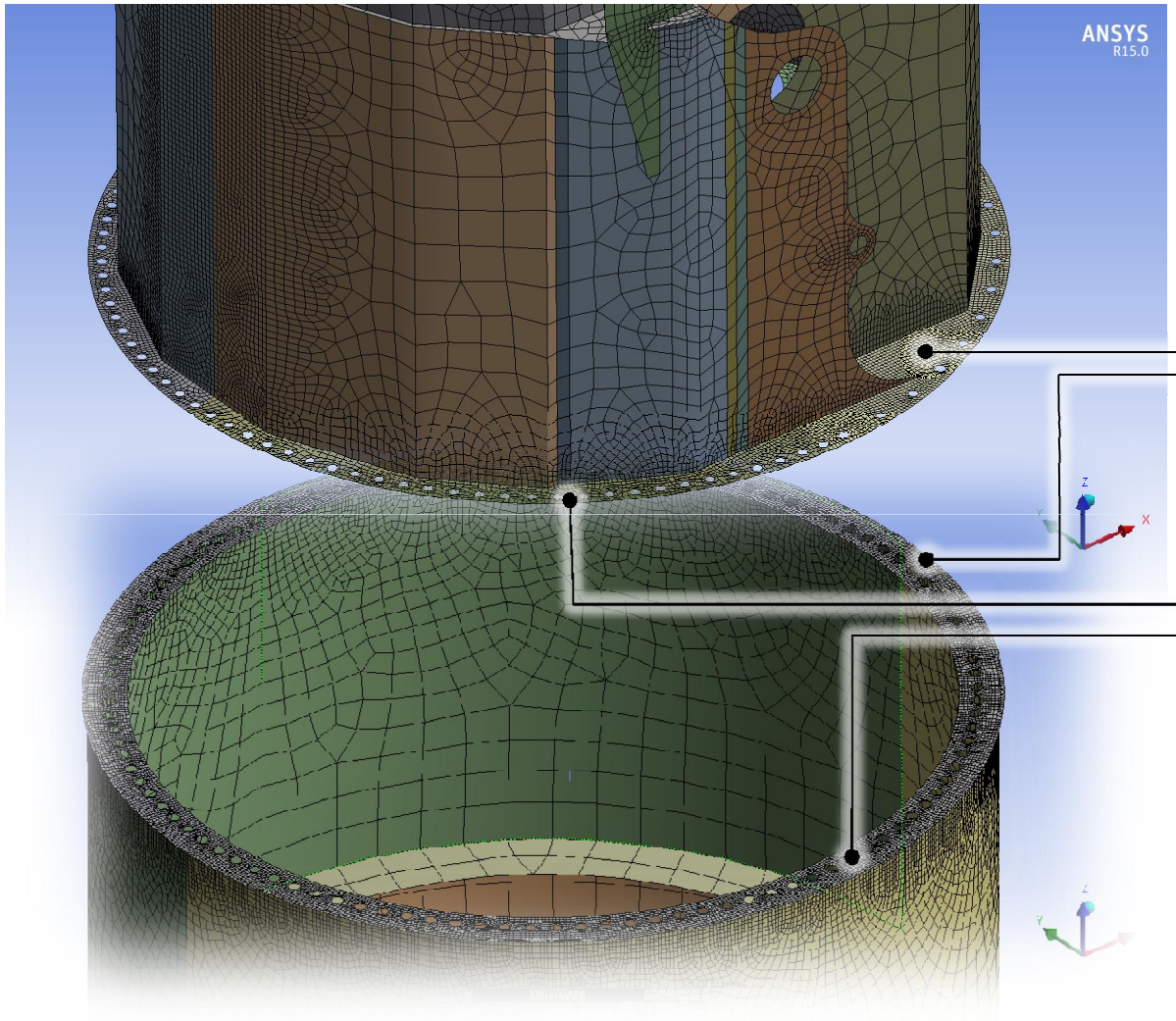
Automation process in ANSYS



geometry pre-processing:

defining named-selection for flange sheet

automated generation of named selections for each pin hole via object generator

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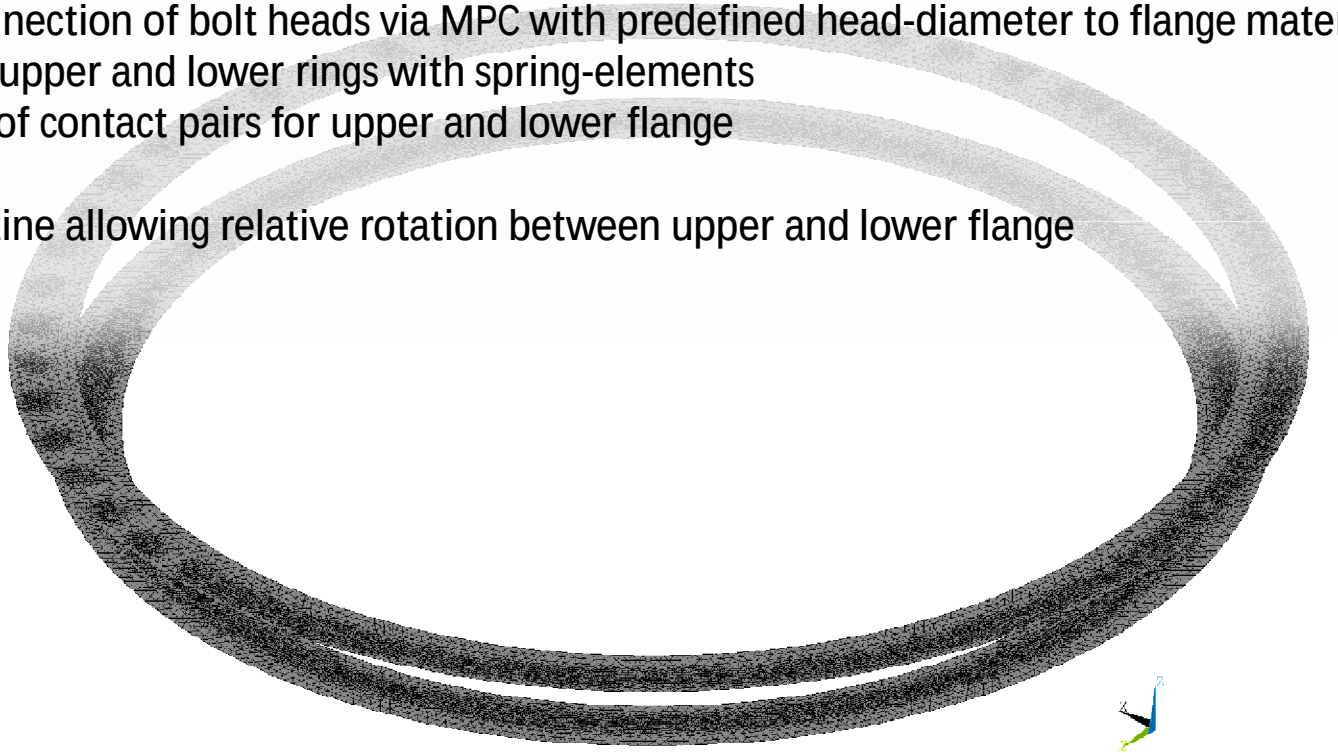
Automation process in ANSYS

full automated APDL routine containing:

- mesh generation with local refinements at pin holes
- relative positioning of all parts depending on predefined bearing ring thickness
- generation of pre-stress-elements with proper cross sections and strain-length
- realistic connection of bolt heads via MPC with predefined head-diameter to flange material
- coupling of upper and lower rings with spring-elements
- generation of contact pairs for upper and lower flange

- update routine allowing relative rotation between upper and lower flange



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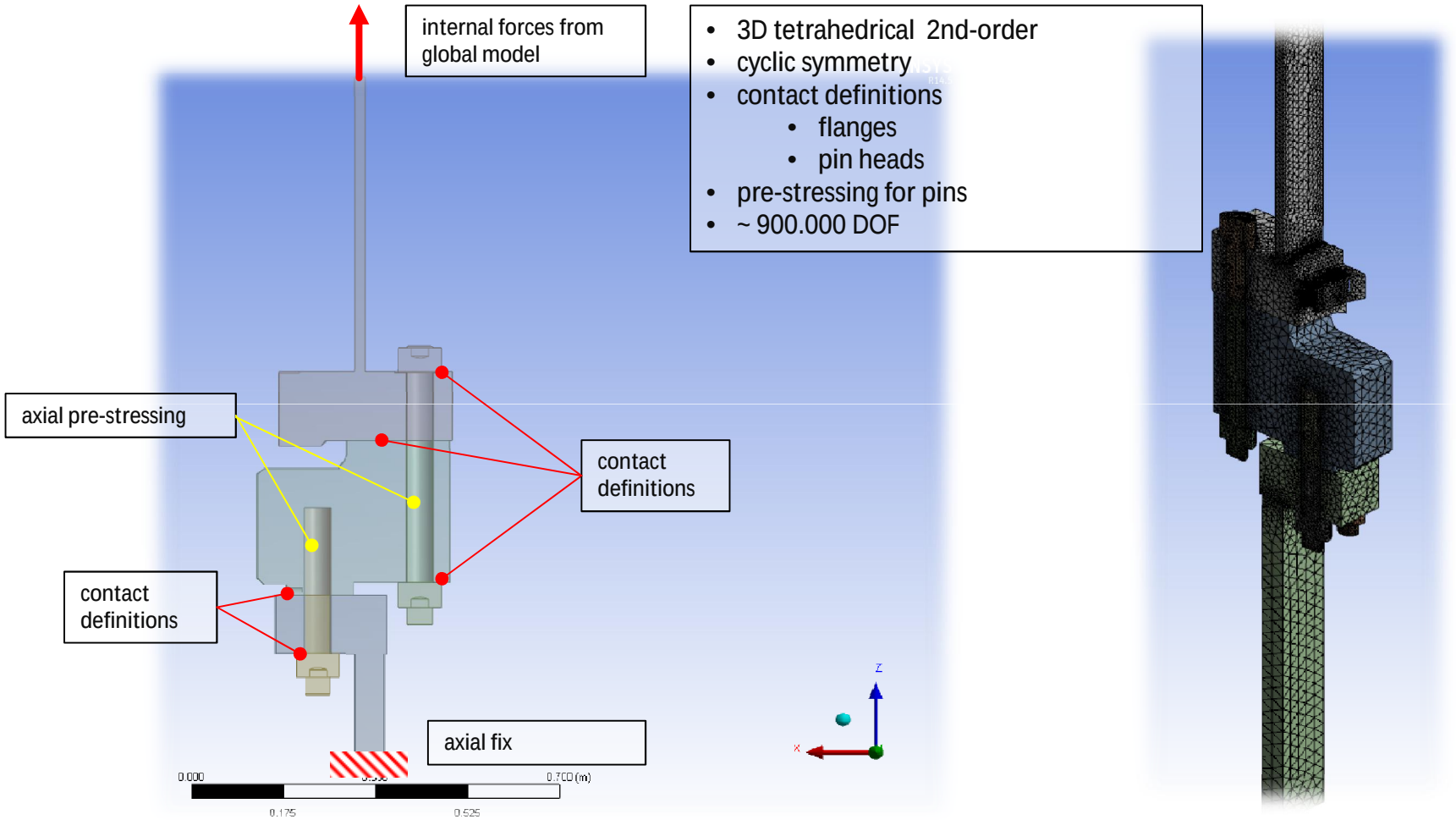
numerical validation model



- 3D tetrahedrical 2nd-order
- cyclic symmetry
- contact definitions
  - flanges
  - pin heads
- pre-stressing for pins
- ~ 900.000 DOF

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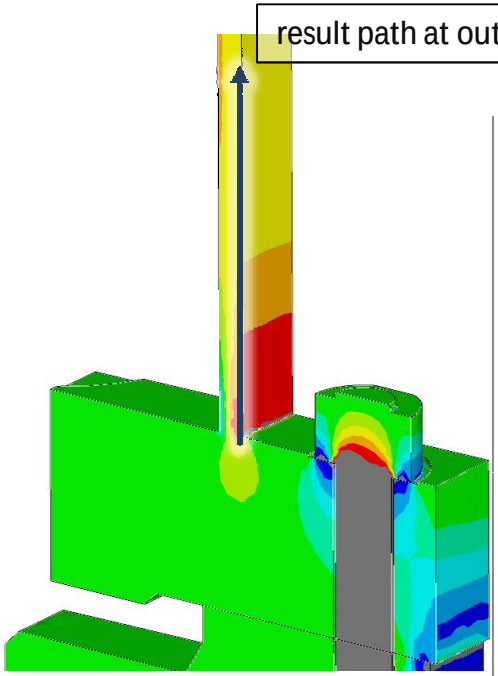
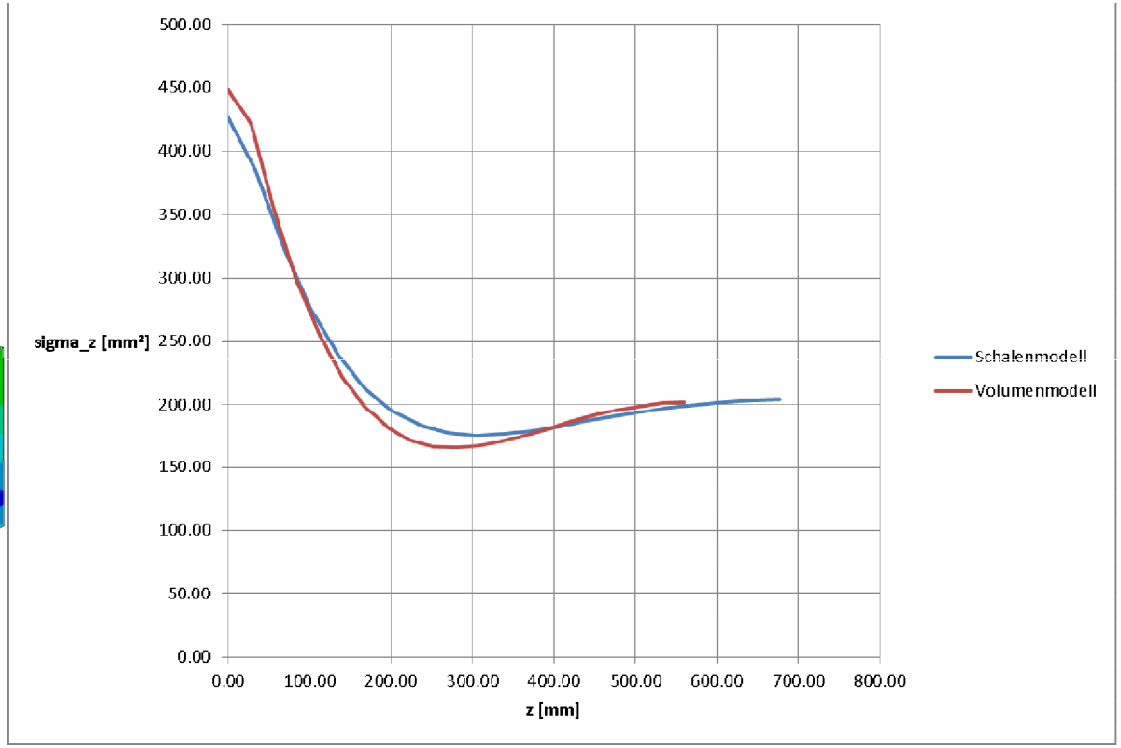
numerical validation





numerical comparison of axial stress distribution in cylinder sheet

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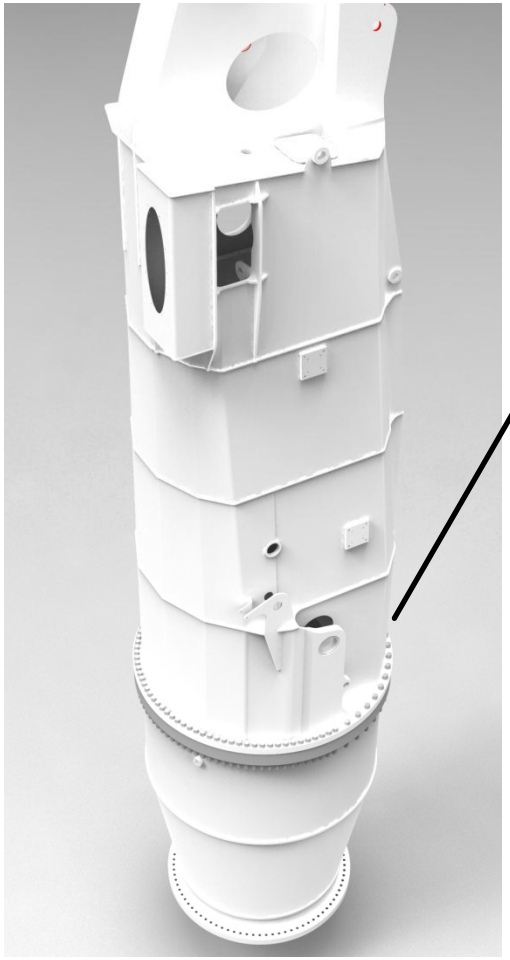
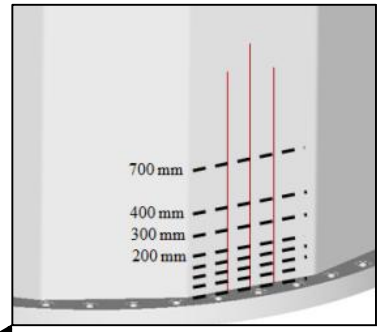
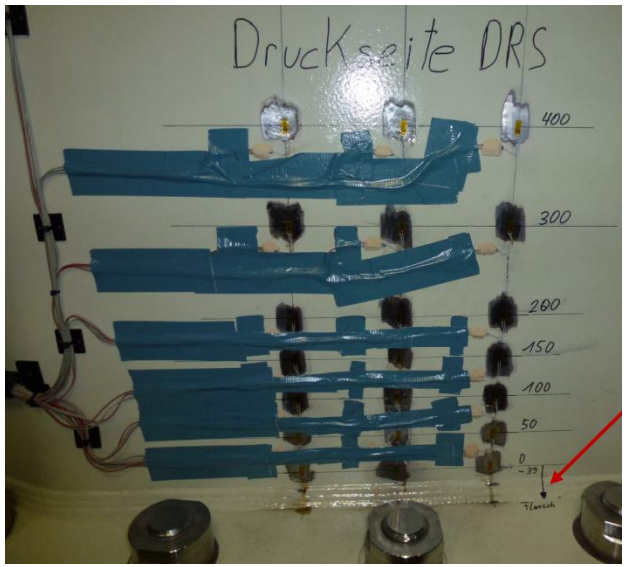
validation by measurement (in progress)





Compression side

outside



inside

Application of strain gauges on slewing column (and adapter) compression side

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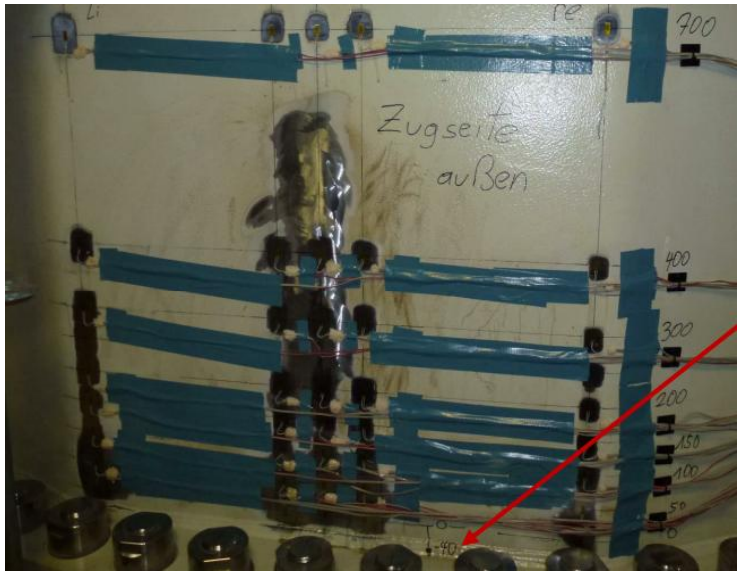
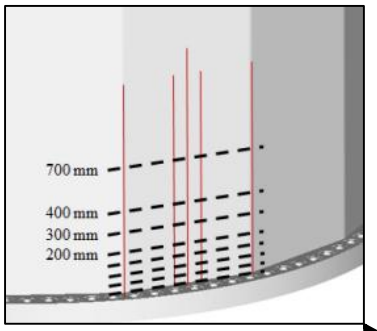
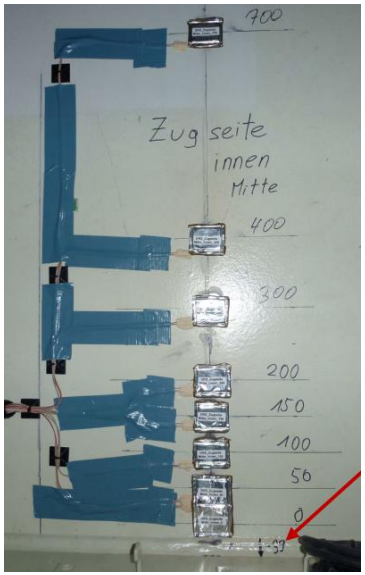
validation by measurement (in progress)

Tension side

outside







inside

Application of strain gauges on slewing column (and adapter) tension side

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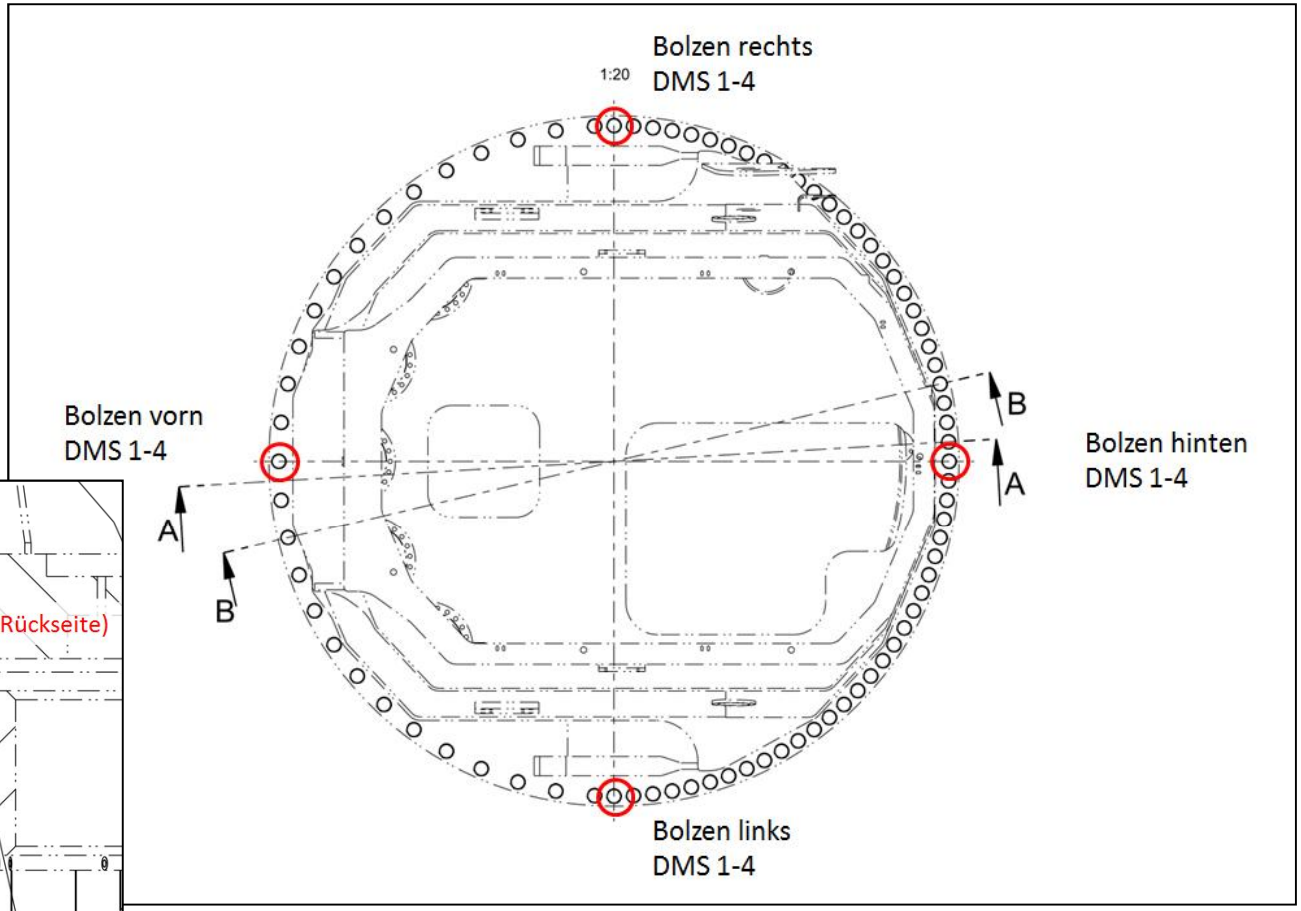
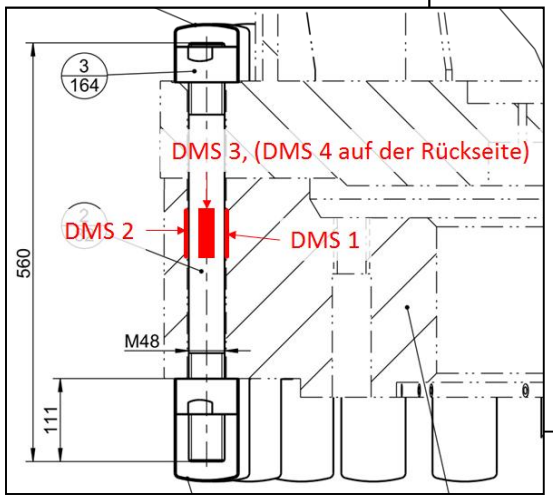
validation by measurement (in progress)





Application of strain gauges on pins

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validation by measurement (in progress)

final goals for measurement:

- calibration of uncertain parameters of the flange model
- validation of global behaviour
- knowledge of model limits
- base for model improvements / corrections

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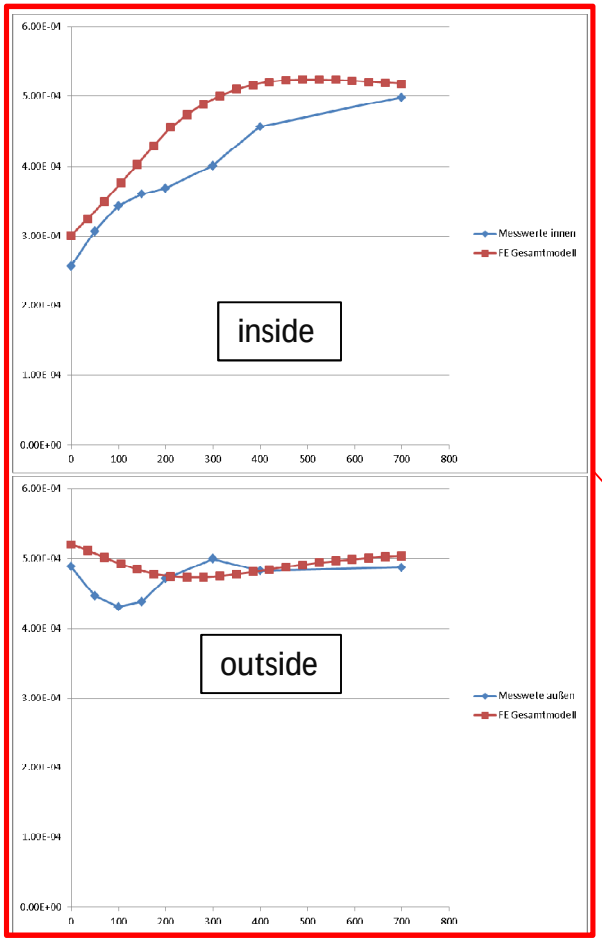
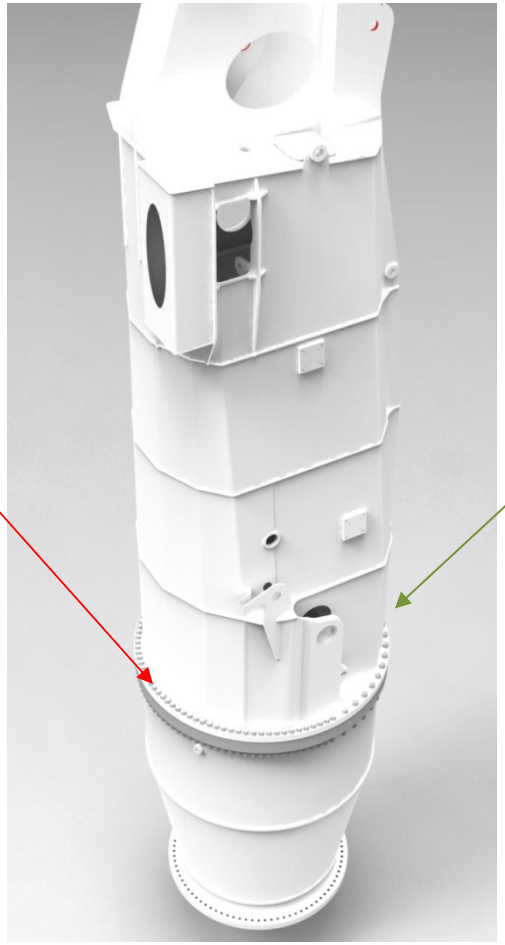
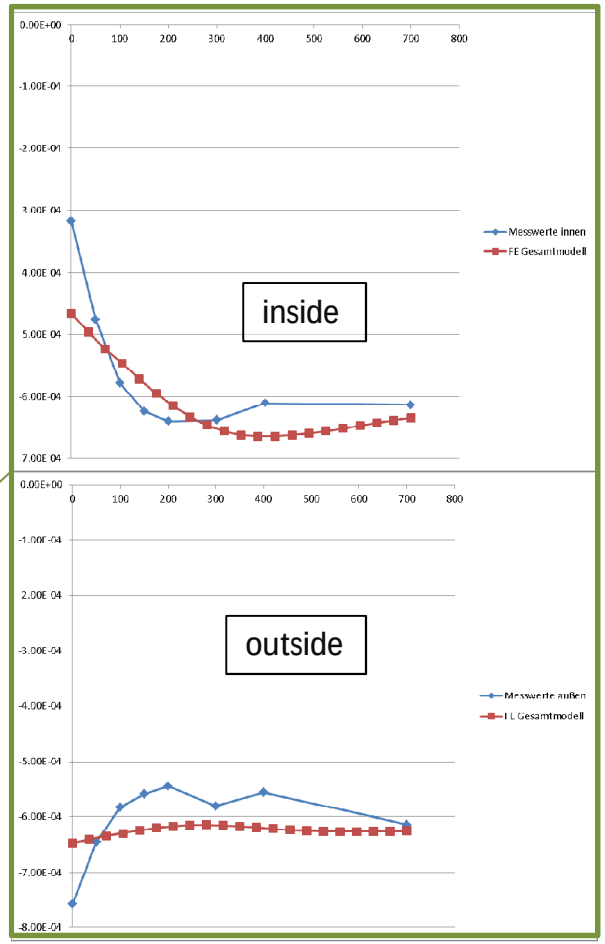
validation by measurement (in progress)

calculation results vs. measurement







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to be continued...

Thank you for your attention (and patience) !

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