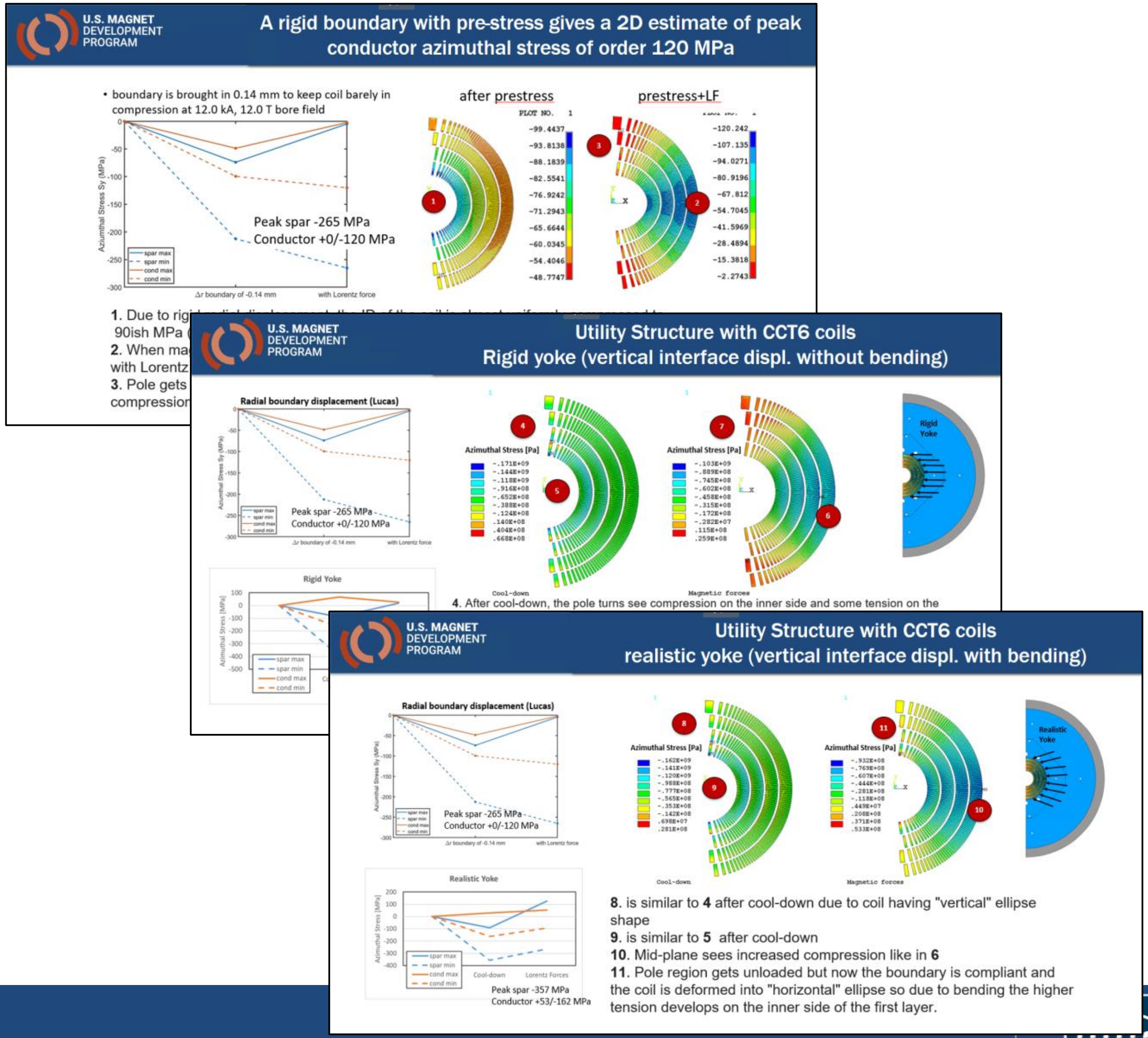
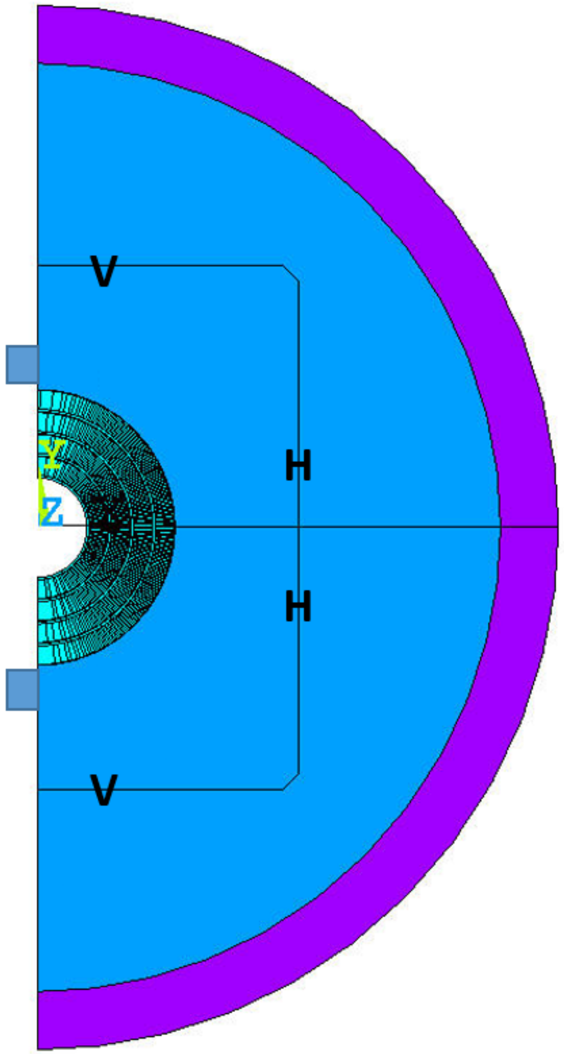
Status of the support structure analysis

- Fixed boundary displacement and ultra-rigid (unrealistic) structure materials
  - Similar stress level as in Lucas analysis
- Realistic materials and open yoke/pad vertical interface
  - Risk of over-compression of pole region during cool-down (coil ovalization)
  - Tensile stress in the pole region to be investigated in 3D
- Sensitivity study performed
  - Key location and shim thickness
  - Pad material, shape and size
- Closed pad interface study
  - Mitigation of coil over-compression during cool-down

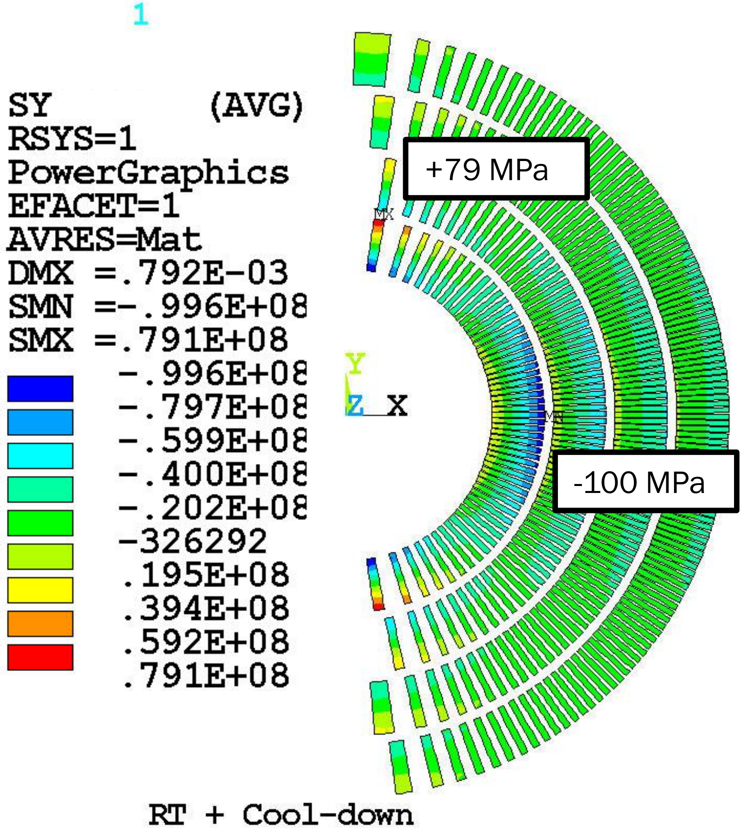


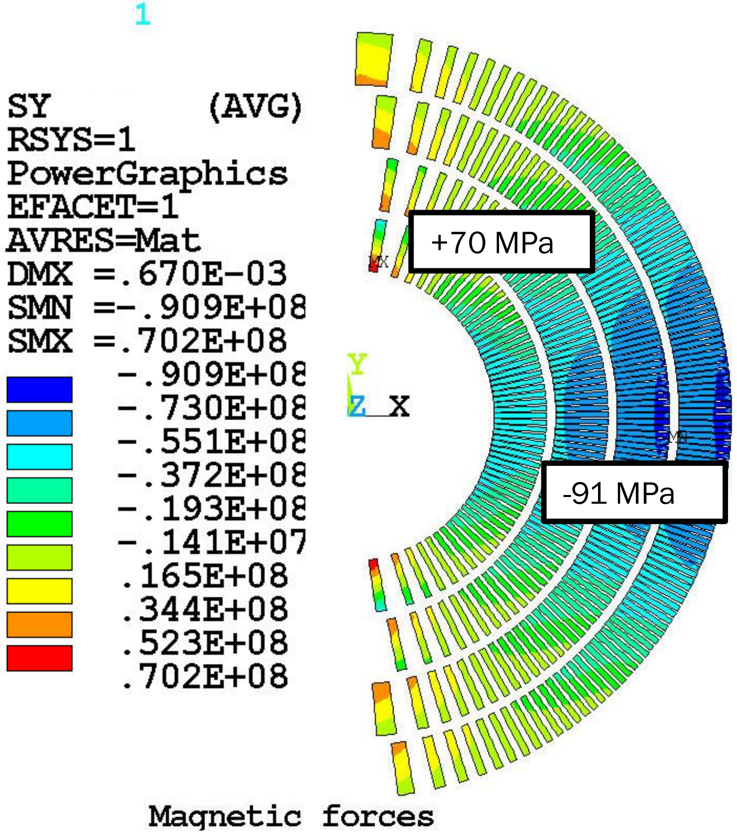
Closed vertical interface of the pad



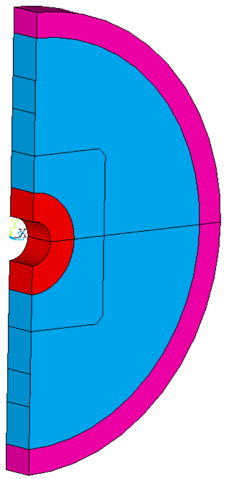
- Concept with simplified geometry and simplified interface control
- Pad stopper added to model interface
  - Stopper displacement for simplified shrinkage modeling
- Goal
  - Closed interface prevents ovalization and over-compression of the coil during cool-down
  - High CTE material used for the interface pin to allow shell shrinkage to increase coil-pre-stress during cool-down

Initial results with simplified model





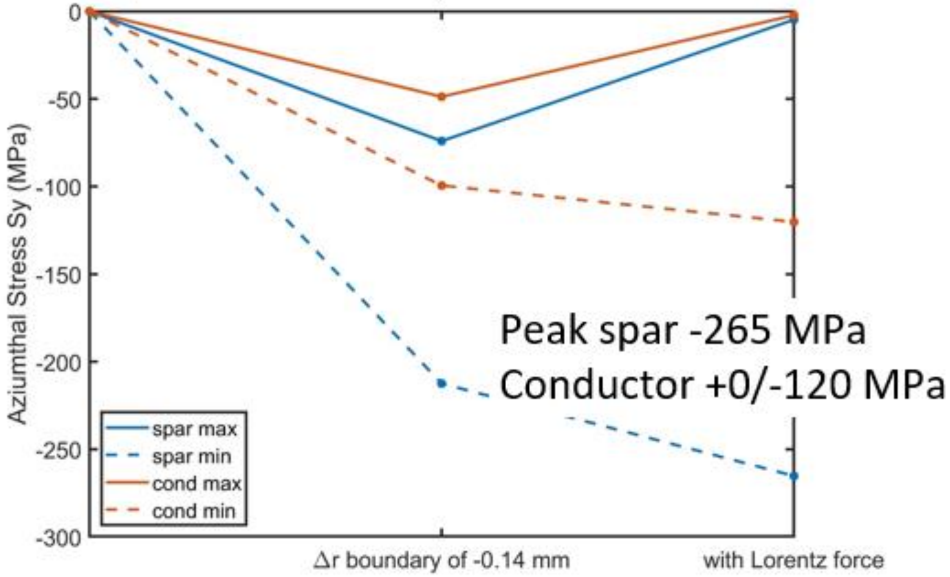
- Closed pad interface allowed to decrease cool-down stress (~160 -> ~100 MPa)
- Detailed 2D model with the closed interface is being prepared
- 3D model is being prepared to investigate pole-region normal and sheer in the channel

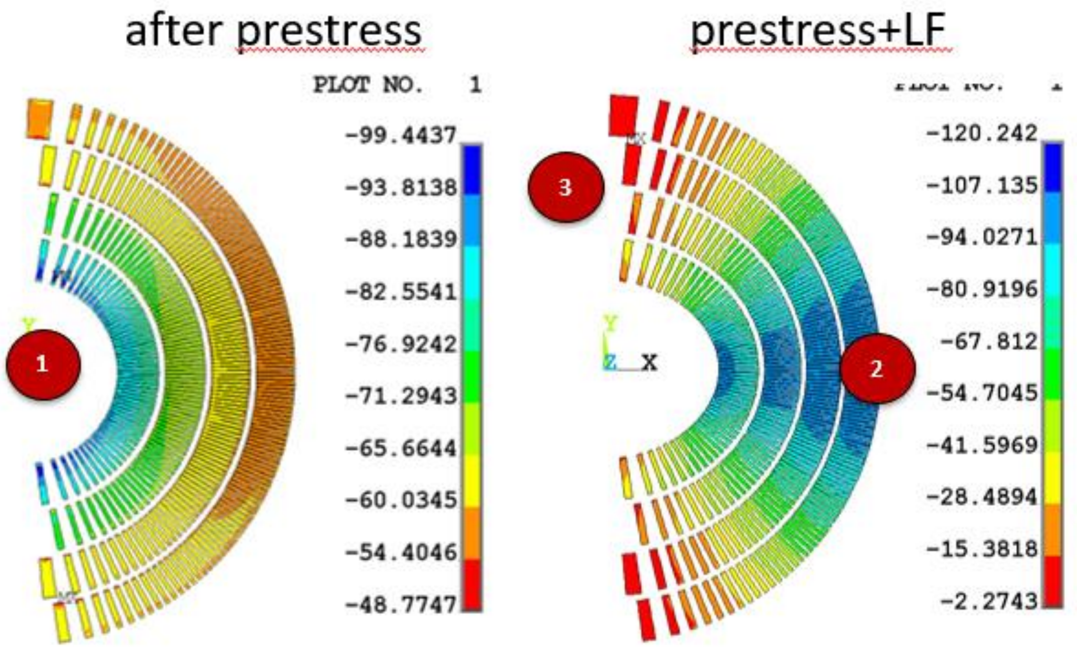


Backup

A rigid boundary with pre-stress gives a 2D estimate of peak conductor azimuthal stress of order 120 MPa

- boundary is brought in 0.14 mm to keep coil barely in compression at 12.0 kA, 12.0 T bore field



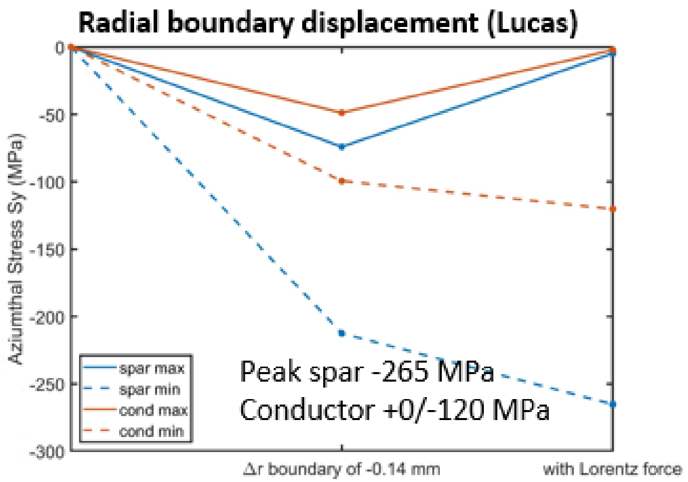


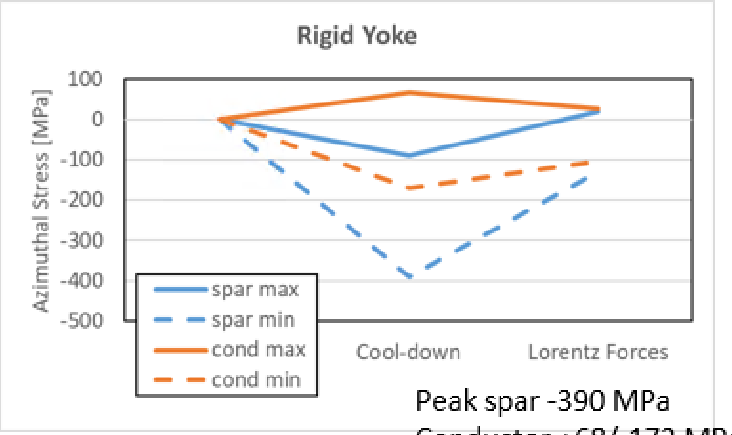
1. Due to rigid radial displacement, the ID of the coil is almost uniformly compressed to 90ish MPa (mid-plane and pole alike)

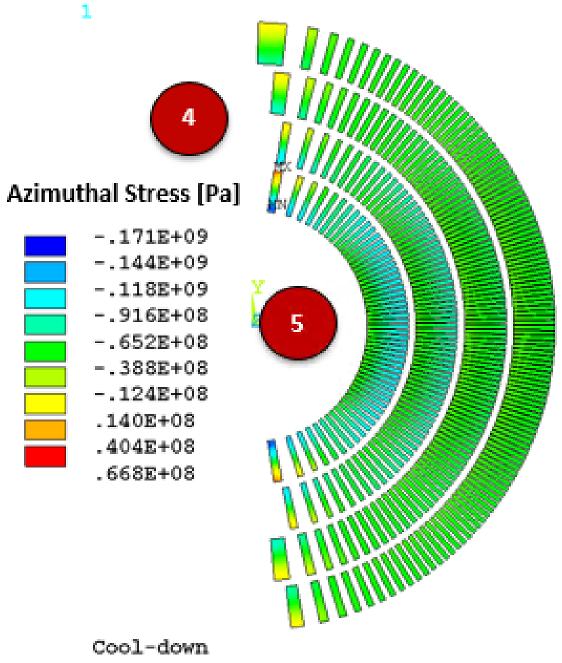
2. When magnetic forces are applied the compression due to displacement gets accumulated with Lorentz forces on the mid-plane and goes to about 120 MPa (about 30 MPa increase?)

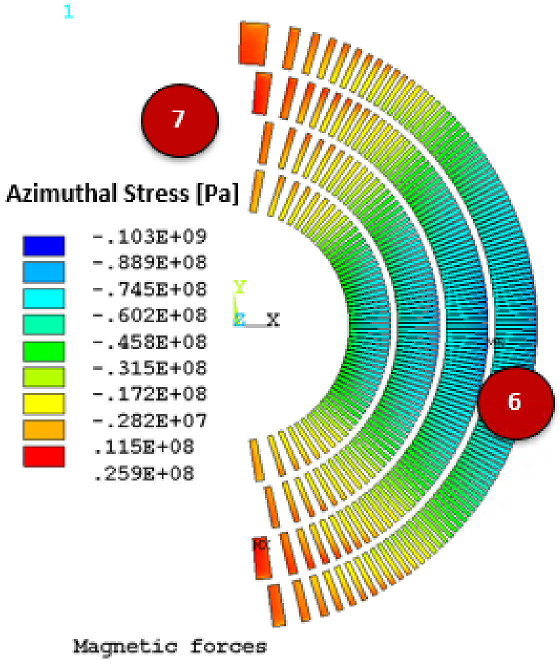
3. Pole gets unloaded due to magnetic forces compensating the initial azimuthal compression due to radial displacement. There is no bending because the boundary is fixed

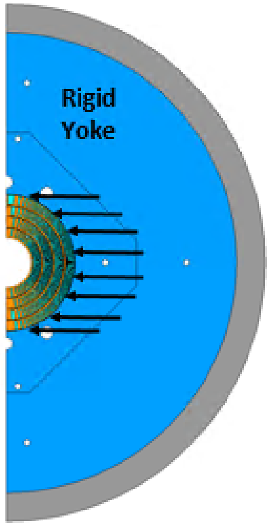
Utility Structure with CCT6 coils
Rigid yoke (vertical interface displ. without bending)











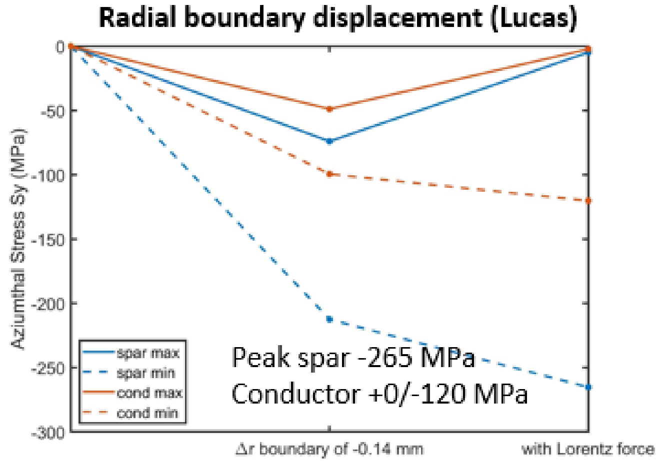
4. After cool-down, the pole turns see compression on the inner side and some tension on the outer side due to bending

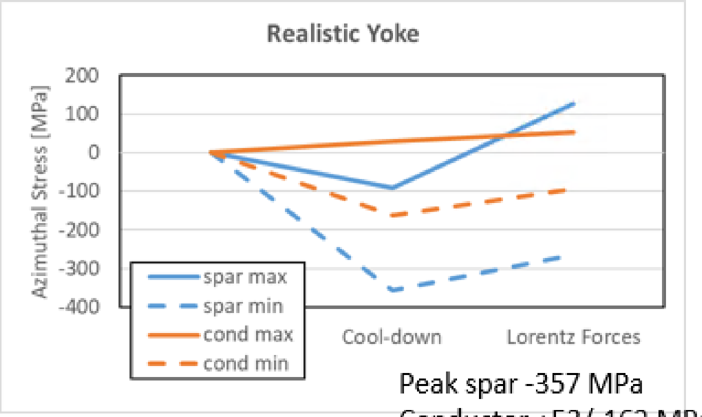
5. Mid plane sees compression but lower than in Lucas case because part of the compression is compensated by bending

6. When magnetic forces are applied the mid-plane sees higher compression, as expected (about 30 MPa increase?)

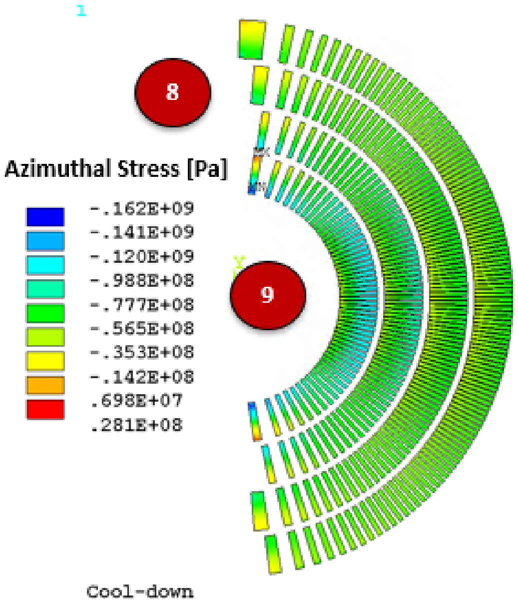
7. Pole region gets unloaded but the coils still has the "vertical" ellipse deformation from the cool-down but with tension higher in the outer turns and lower in the inner turns (rigid boundary does not allow it to have "horizontal" ellipse shape typical for the case with magnetic forces)

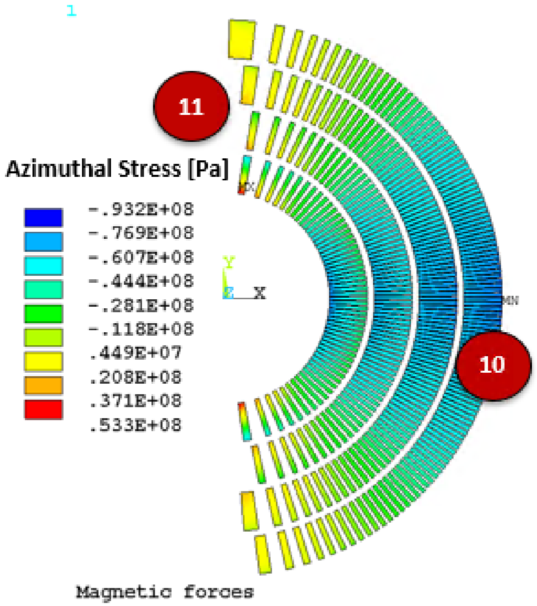
Utility Structure with CCT6 coils realistic yoke (vertical interface displ. with bending)

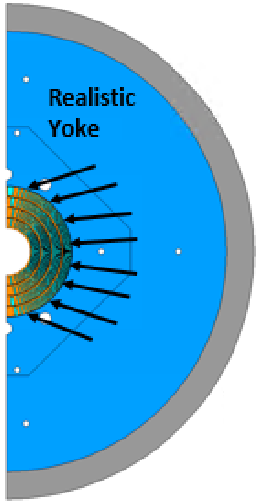




Peak spar -357 MPa
Conductor +53/-162 MPa







8. is similar to **4** after cool-down due to coil having "vertical" ellipse shape

9. is similar to **5** after cool-down

10. Mid-plane sees increased compression like in **6**

11. Pole region gets unloaded but now the boundary is compliant and the coil is deformed into "horizontal" ellipse so due to bending the higher tension develops on the inner side of the first layer.