EDIPO: Alternative design with detachable poles

X. Sarasola

SWISS PLASMA CENTER

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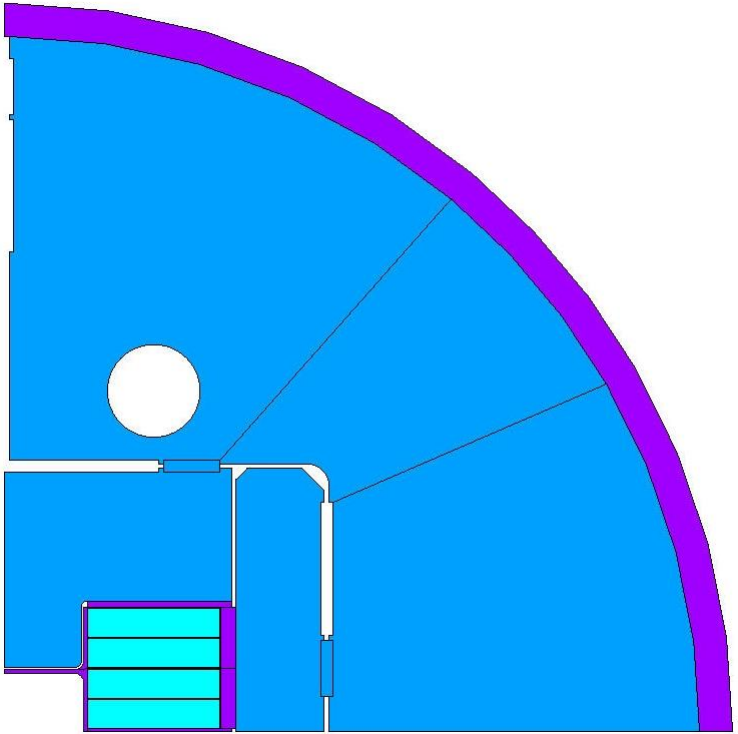
X. Sarasola

Alternative design without titanium pole



- **Changes in the 2D design:**
  - **Yoke outer radius** increases from 560 to **630 mm**
  - Thickness of the **steel shell** is reduced from 70 to **30 mm**
  - Adjustments in the contacts and boundary conditions in order to:
    - Make the **test well stress-free** during operation
    - **Reduce** the **stress in the coils**
  - Modifications to reduce the principal stress in the vertical pad/iron insert

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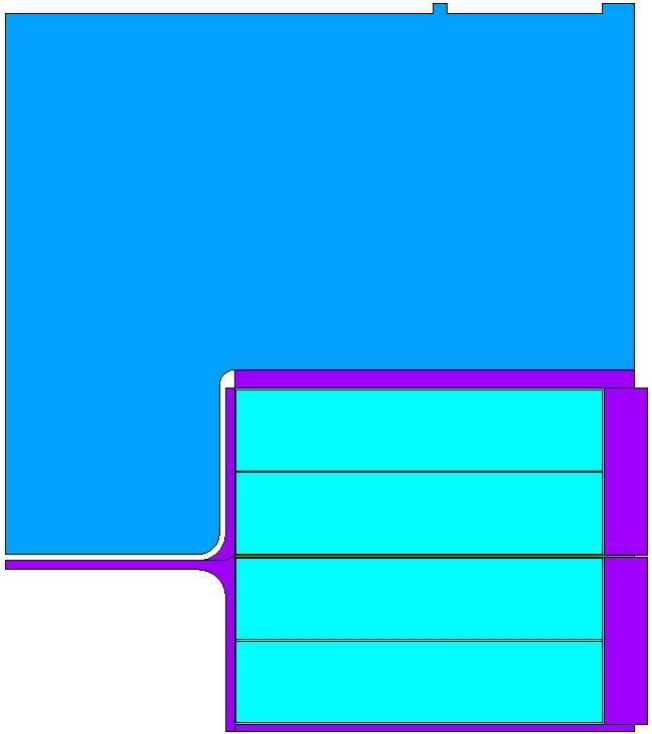

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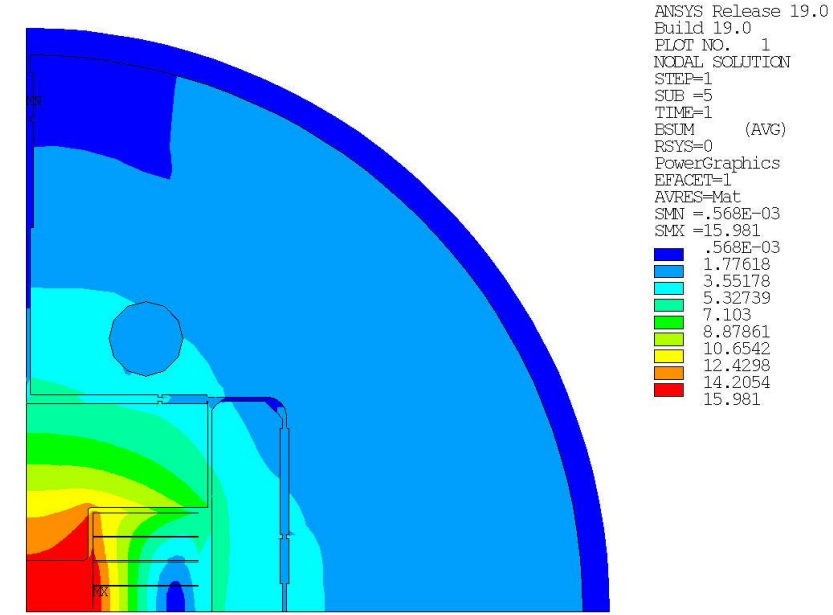
Magnetic model

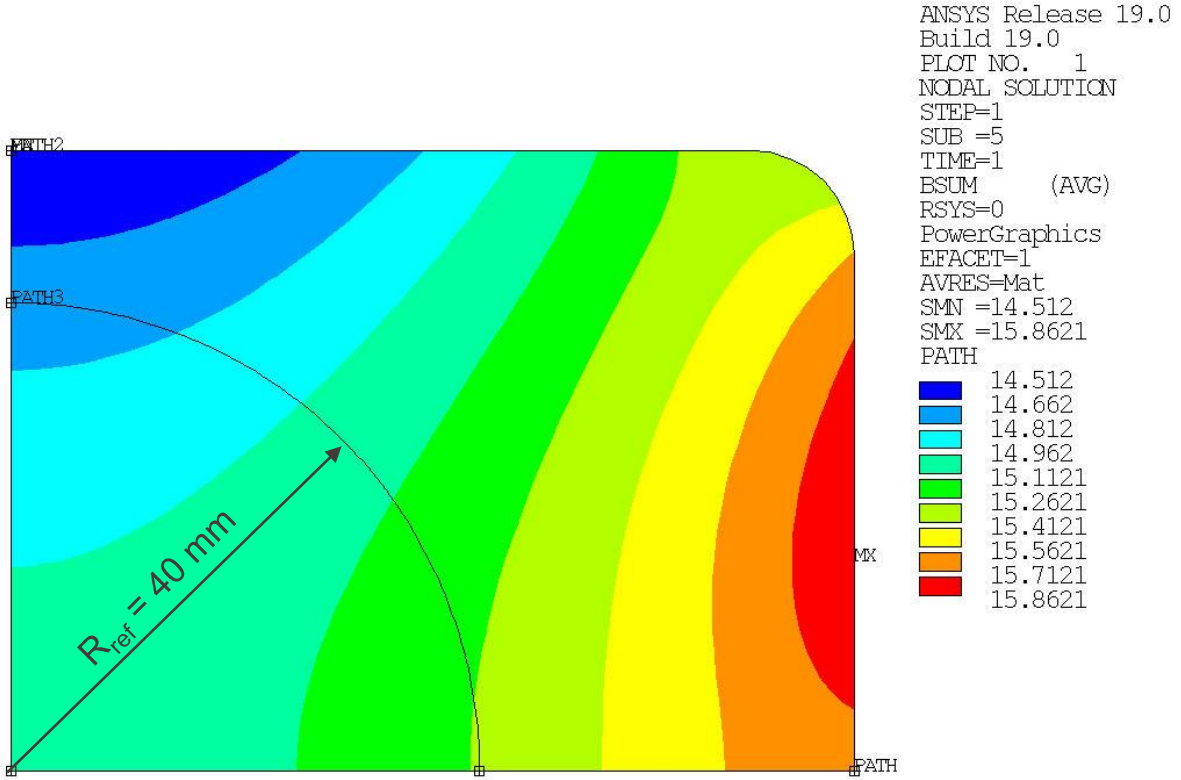
- The increase in the yoke outer radius leads to a modest gain in the field or a small reduction in the required number of turns to generate 15 T: **now 51 turns/pancake**

Test well thickness (mm)	3.0
# turns/pancake	51
Ins conductor area (mm^2)	13002
$I_{op} = 0.85 \times I_{ss}$ (kA)	11.66
B_{coil} (T)	15.98
$B_{center\ aperture}$ (T)	15.01



EDIPO, magnetic model

Magnetic model – field quality



EDIPO, magnetic model

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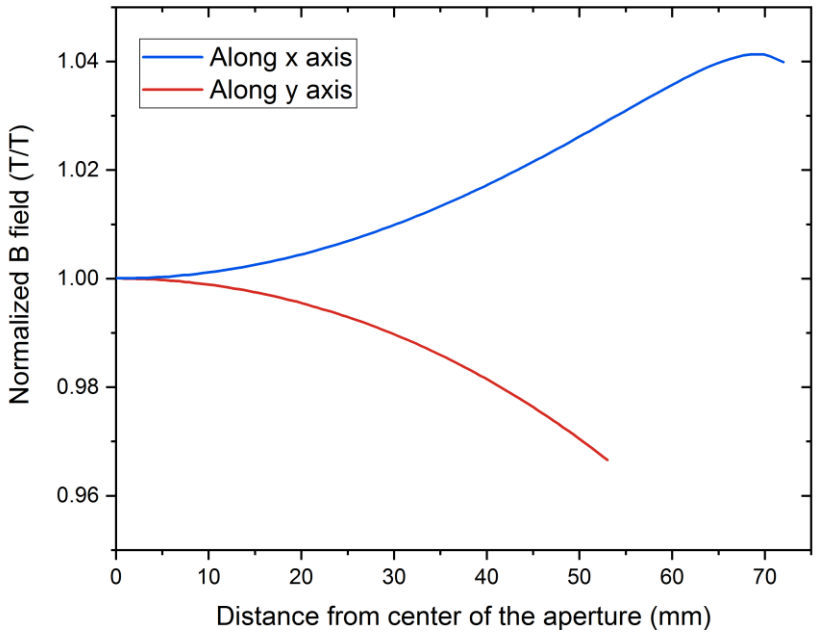
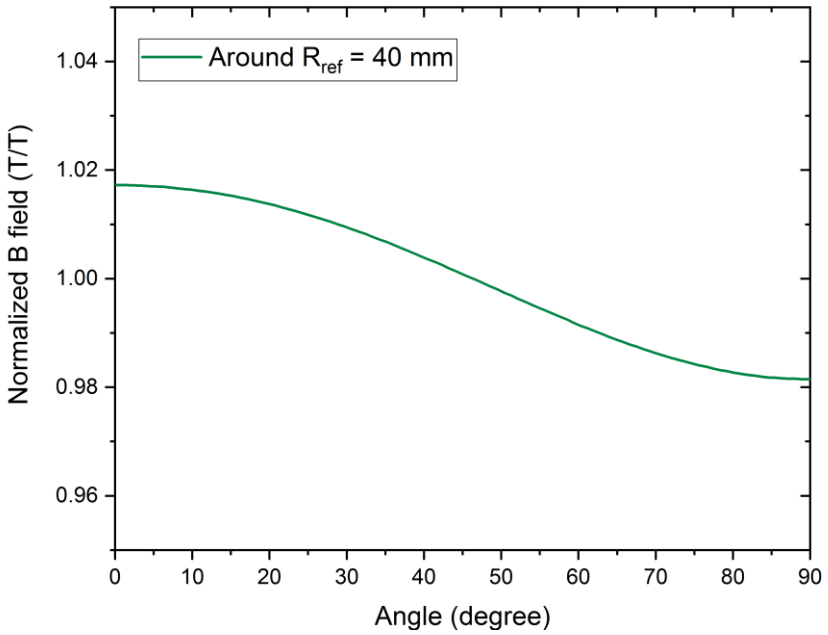
Magnetic model – field quality

- Along x and y axis: ±4%
- Around a circumference of R_{ref} = 40 mm: ±2%

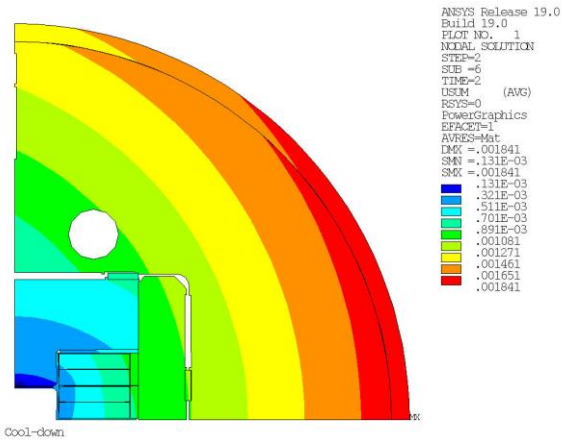




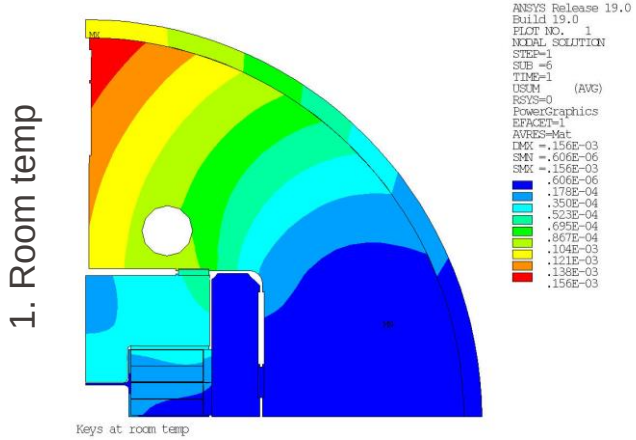
Mechanical model - Deformation

- During powering of the magnet, the iron parts experience forces in the directions highlighted by the arrows in the bottom right plot.

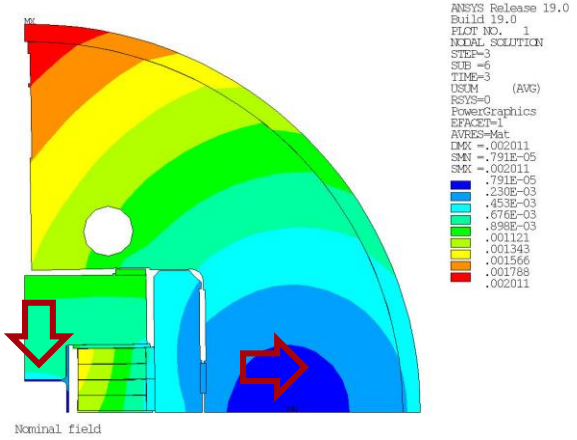
2. Cool-down



1. Room temp

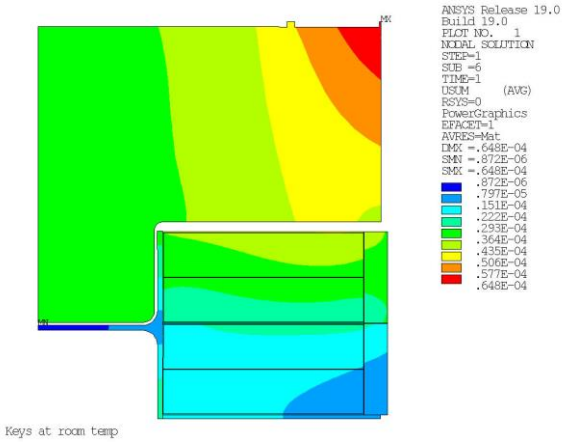


3. Nominal field

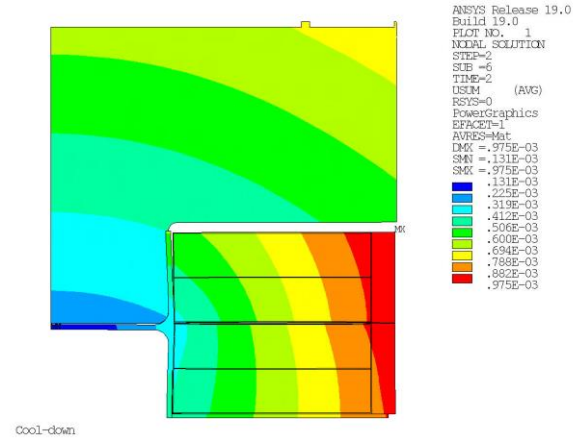


Mechanical model - Deformation (zoom)

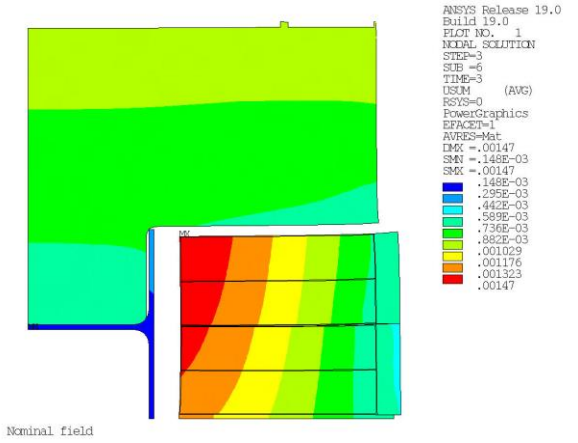
1. Room temp



2. Cool-down



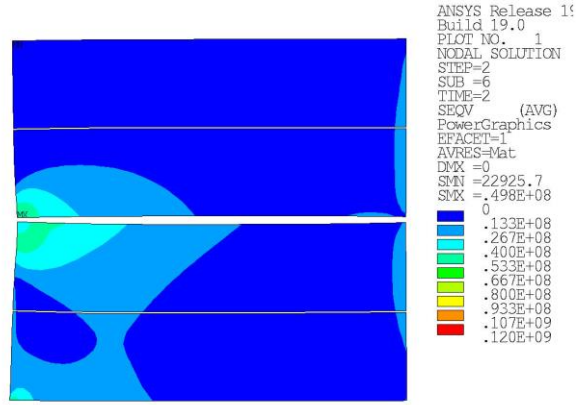
3. Nominal field



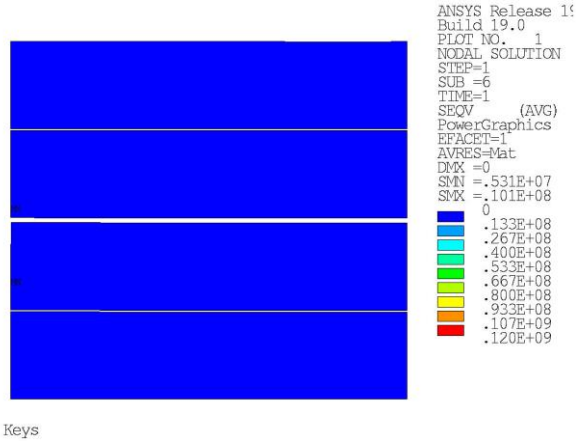
Stress in the coils (von Mises)

- Coils are essentially stress-free at room temperature (small lateral interference) and after cool down (shell is made of steel)
- After powering the **von Mises stress** remains **below 121 MPa**

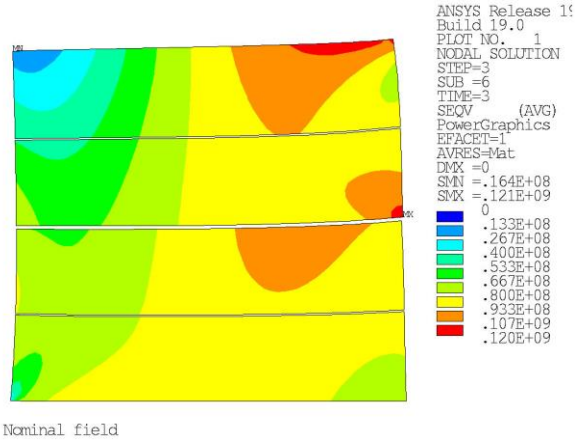
2. Cool-down



1. Room temp



3. Nominal field

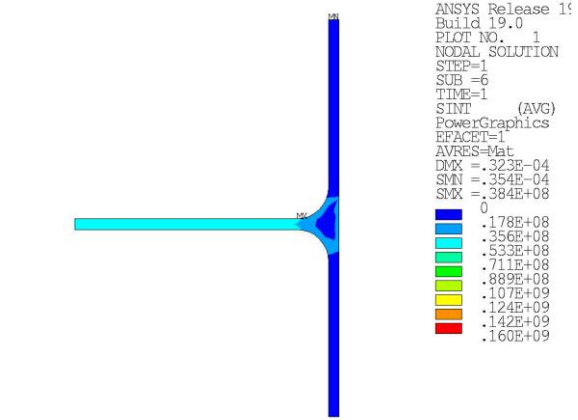


Stress in the test well

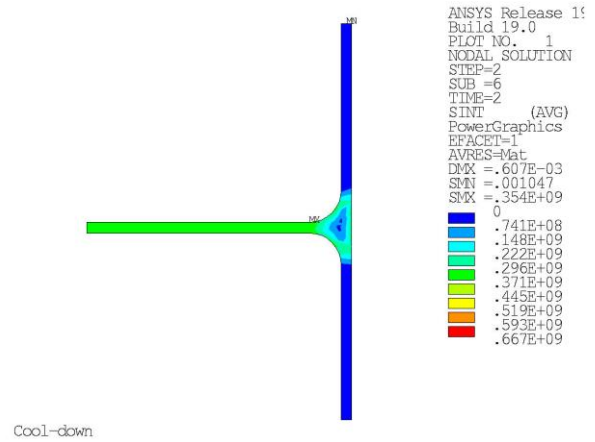
- The test well is stress-free during operation

Load step	Membrane (MPa)	Memb+bend (MPa)
Room temp	36	37
Cool-down	337	339
Nom. field	1	3.3

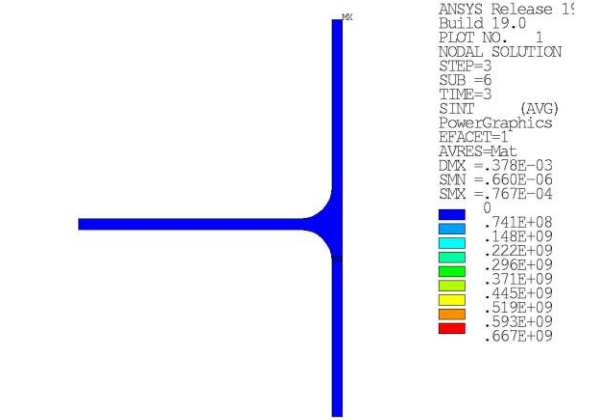
1. Room temp



2. Cool-down



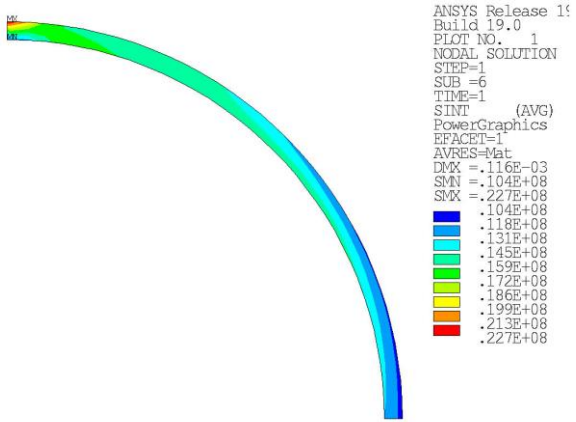
3. Nominal field



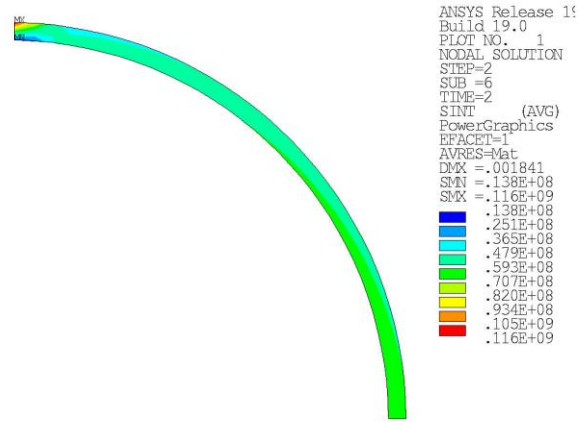
Stress in the steel shell

- The stress in the shell is always below allowable, despite of the reduction in thickness.

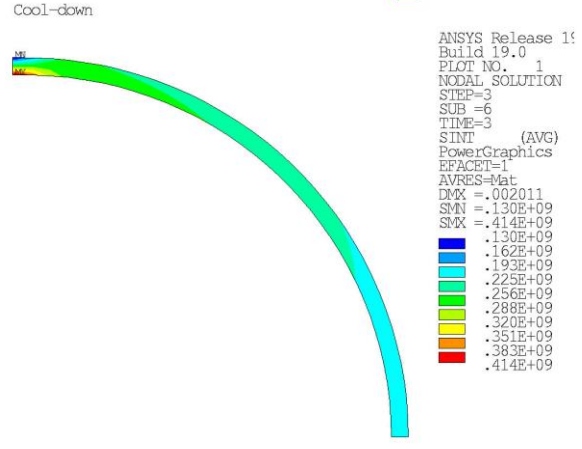
1. Room temp



2. Cool-down



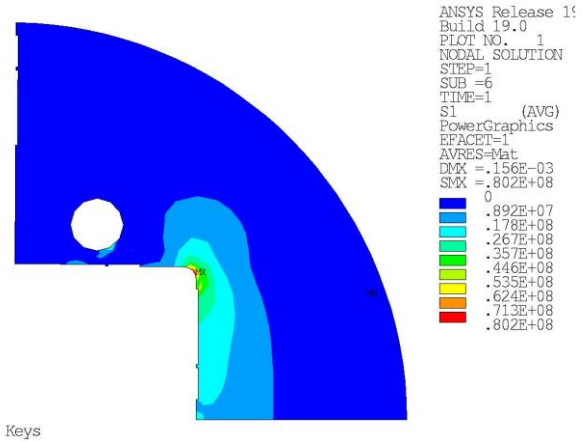
3. Nominal field



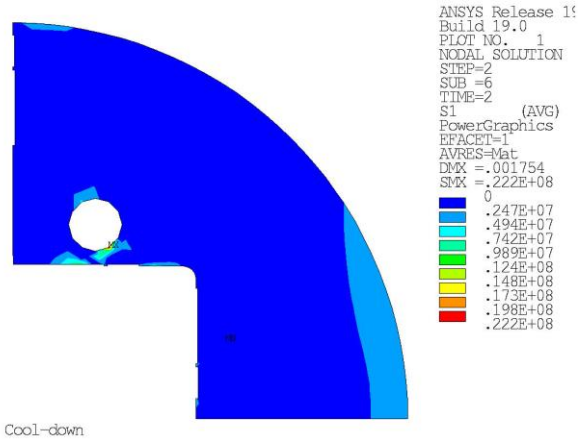
Stress in the iron yoke

- Iron yoke satisfies stress criteria

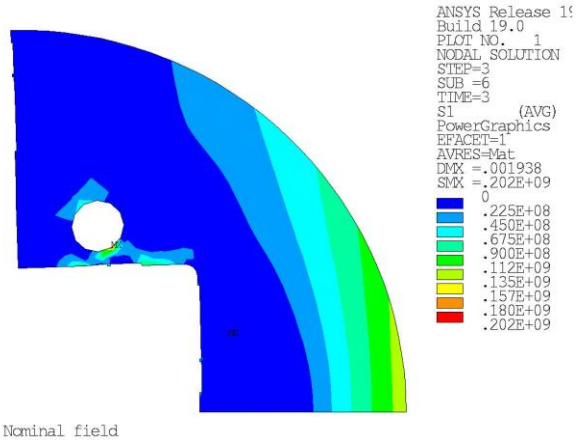
1. Room temp



2. Cool-down



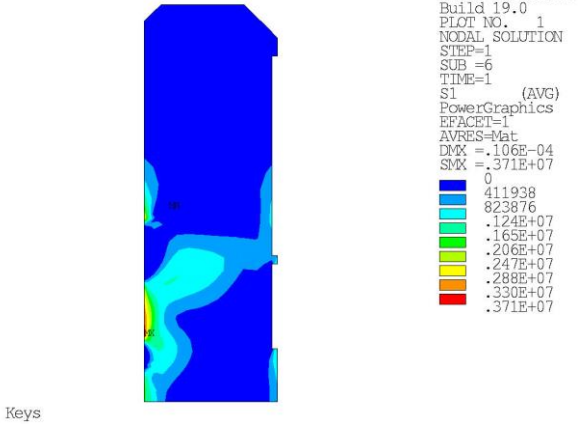
3. Nominal field



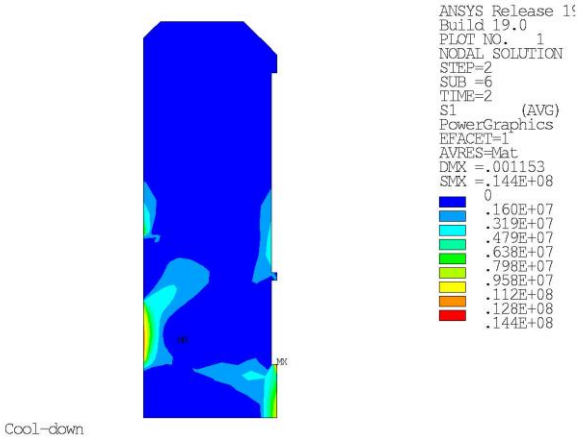
Stress in the horizontal pad

- H pad satisfies stress criteria

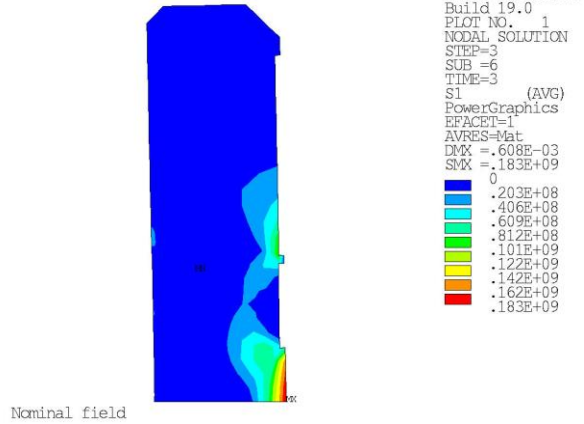
1. Room temp



2. Cool-down



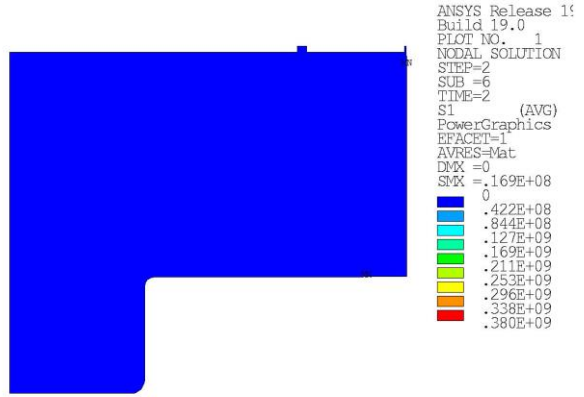
3. Nominal field



Stress in the vertical pad + iron insert

- Parameters varied to reduce the max principal stress:
  - **Location of the vertical key**
  - **Interference of the vertical key**
  - Tappering of the surface in contact with the coils

2. Cool-down



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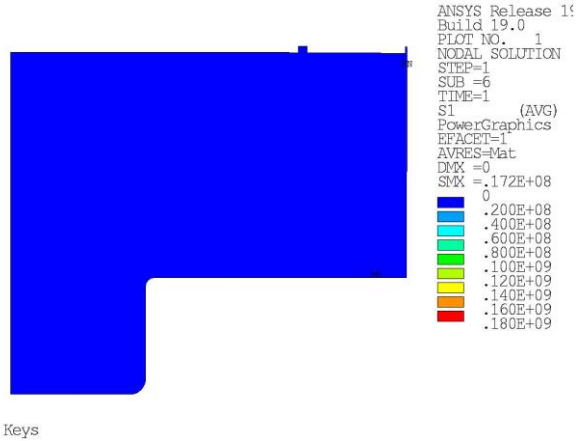
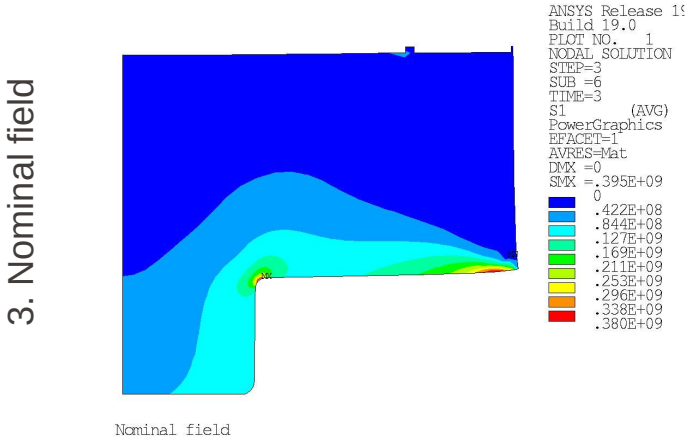


3. Nominal field



Stress in the vertical pad + iron insert

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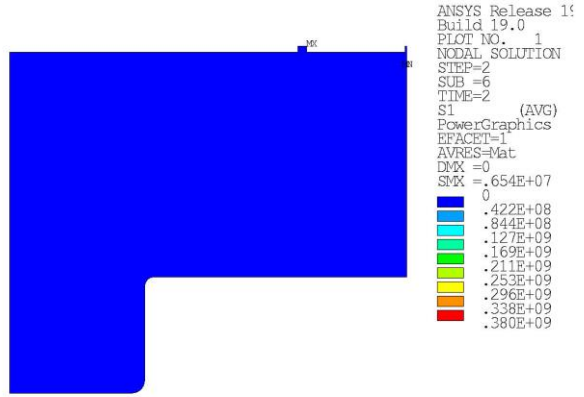
  - Interference of the vertical key
  - **Tappering of the surface in contact with the coils**

2. Cool-down

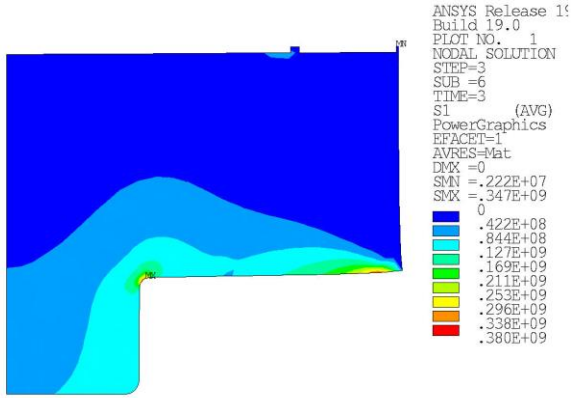


Cool-down

1. Room temp

Keys

3. Nominal field



Nominal field

Conclusions

- The use of **detachable poles** and the **elimination of the Ti pole** result in a **more efficient coil design**
- **The field quality** in the aperture **is not excellent, but acceptable:**
  - Along x and y axis: ±4%
  - Around R_{ref} = 40 mm: ±2**%**
- **Stress in the coils is always below 121 MPa**
- The **test well** is **stress-free** during operation
  - **A gap** of <1.5 mm **opens** between coils and test well (this can be reduced by increasing the lateral pre-compression)
- The stress in the steel shell is acceptable (despite of a >50% reduction in thickness)
- Issues of peak of maximum principal stress in the vertical pad can be managed

Additional slides

Stress in the vertical pad + iron insert

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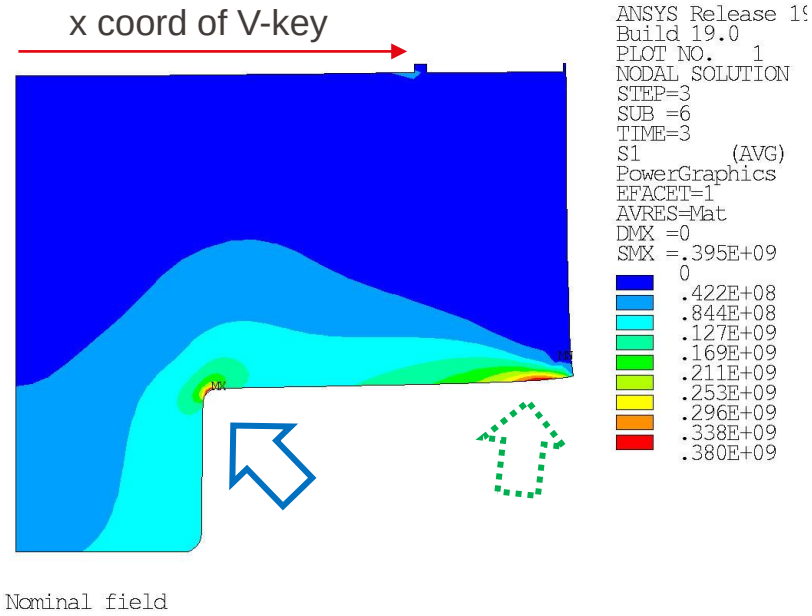

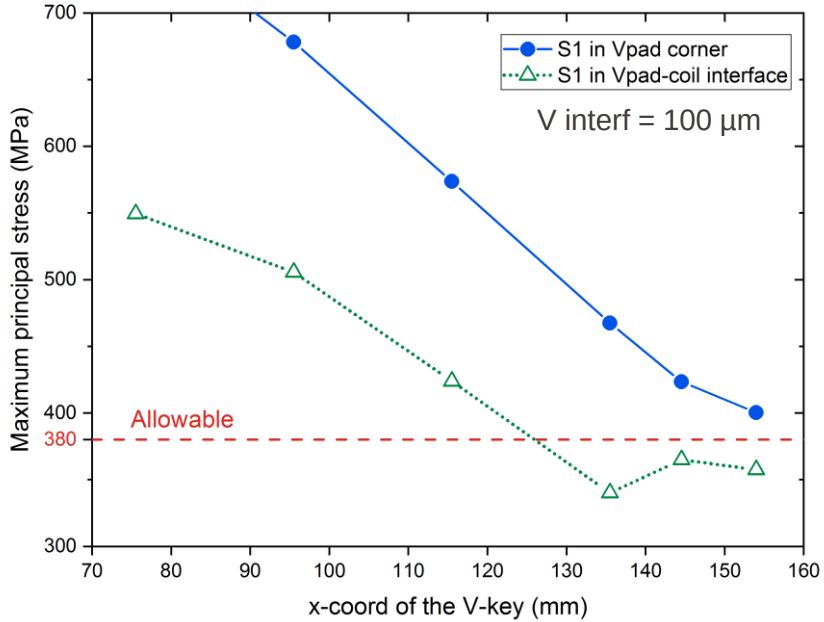

Stress in the vertical pad + iron insert

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