CLIC X-BAND Corrector Cavity

Static structural analyses
Design possible modifications

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CERN | EN ENGINEERING DEPARTMENT

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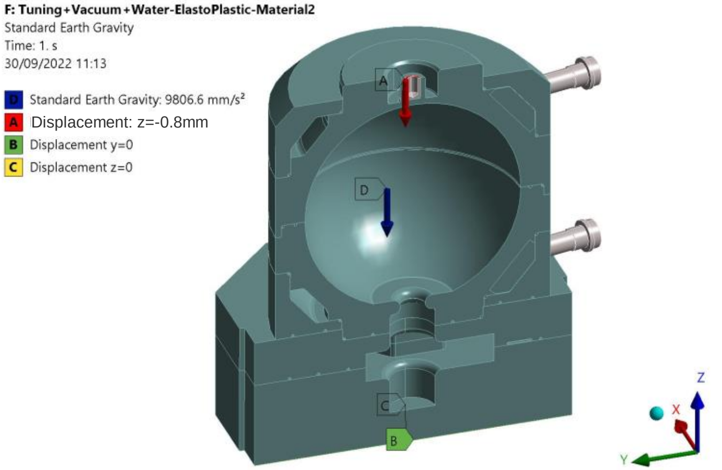
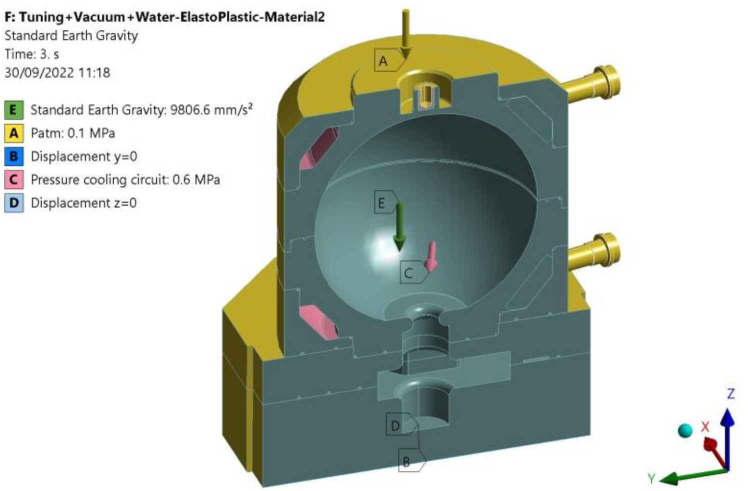
EDMS n°2782224

Model configuration

3D model: ST1592700_01

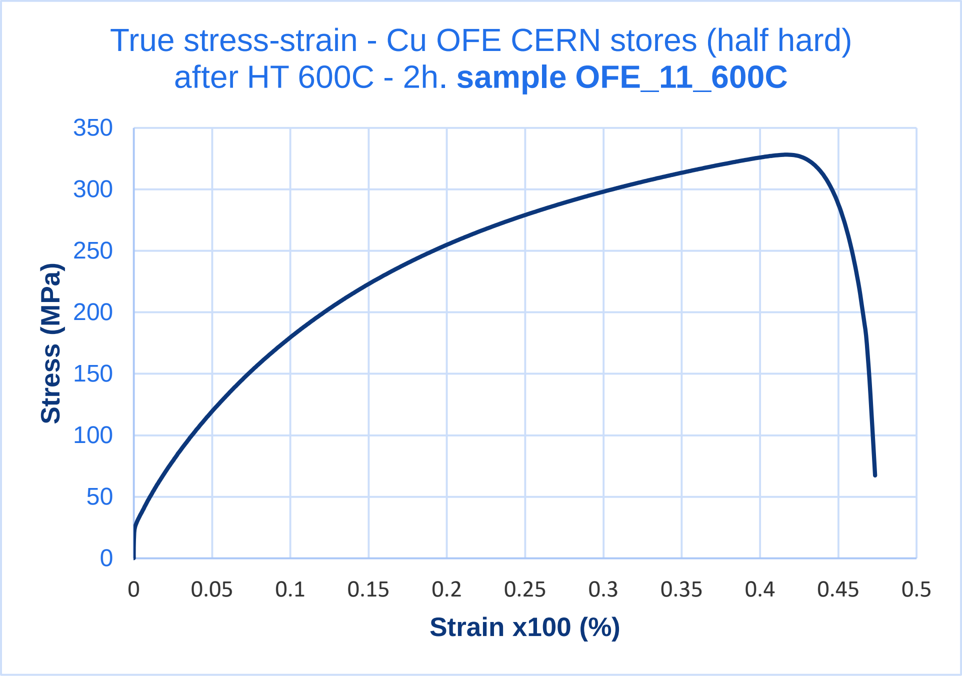
- Material behaviour: elastic-plastic
- Contacts: perfectly bonded
- Boundaries:
  - lower face blocked vertically
  - 1 middle line blocked horizontally
- Loads (besides gravity):
  - Step 1: tuning (displacement=0.8mm)
  - Step 2: removing displacement
  - Step 3:
    - P=6 bar in cooling circuits
    - vacuum in cavity (P_{atm} outside)





Cu OFE annealed properties

- Stress-strain curve



Obtained from tests at CERN

- OFE (UNS C10100) and OFS (UNS C10700) **3mm thick. sheet from CERN stores** (half-hard temper state)
- **Material certificates** available in EDMS 2436530.
- **Surfacing** RRR samples by machining (as per RF gaskets) + side cut by spark erosion
- **Mechanical engraving** of each sample individually (to avoid mixture)
- **Degreasing** before heat treatments (as per RF gaskets)
- Heat treatments in **MME brazing furnace** (as per RF gaskets), by F. Motschmann.
- **RRR measurements** by D. Richter (TE-MSC), (**V and I contacts placed on the machined faces**)
- Sample sizes:
  - RRR: 1.9x1.9x122 mm
  - Tensile specimens: ASTM E8
  - Metallo: 25 x 20 x thickness mm

Total/plastic strain

- total strain = elastic strain + plastic strain + creep strain + thermal strain
- 2 criteria: Von Mises (Equivalent) or Tresca (Intensity)

Intensity

Stress intensity is defined as the largest of the absolute values of $\sigma_1 - \sigma_2$, $\sigma_2 - \sigma_3$, or $\sigma_3 - \sigma_1$:

$$\sigma_I = MAX\left(|\sigma_1-\sigma_2|, |\sigma_2-\sigma_3|, |\sigma_3-\sigma_1|\right)$$

Stress intensity is related to the maximum shear stress:

$\sigma_I = 2\tau_{max}$

Elastic Strain intensity is defined as the largest of the absolute values of $\varepsilon_1 - \varepsilon_2$, $\varepsilon_2 - \varepsilon_3$, or $\varepsilon_3 - \varepsilon_1$:

$$\varepsilon_I = MAX\left(|\varepsilon_1-\varepsilon_2|, |\varepsilon_2-\varepsilon_3|, |\varepsilon_3-\varepsilon_1|\right)$$

Elastic Strain intensity is equal to the maximum shear elastic strain:

$\varepsilon_I = \gamma_{max}$

Equivalent Stress (and **Equivalent Elastic Strain**) and **Stress Intensity** are available as individual results.

Equivalent (von Mises)

Equivalent stress is related to the principal stresses by the equation:

$$\sigma_e = \left[\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}\right]^{1/2}$$

Equivalent stress (also called *von Mises stress*) is often used in design work because it allows any arbitrary three-dimensional stress state to be represented as a single positive stress value. Equivalent stress is part of the maximum equivalent stress failure theory used to predict yielding in a ductile material.

The von Mises or equivalent strain ε_e is computed as:

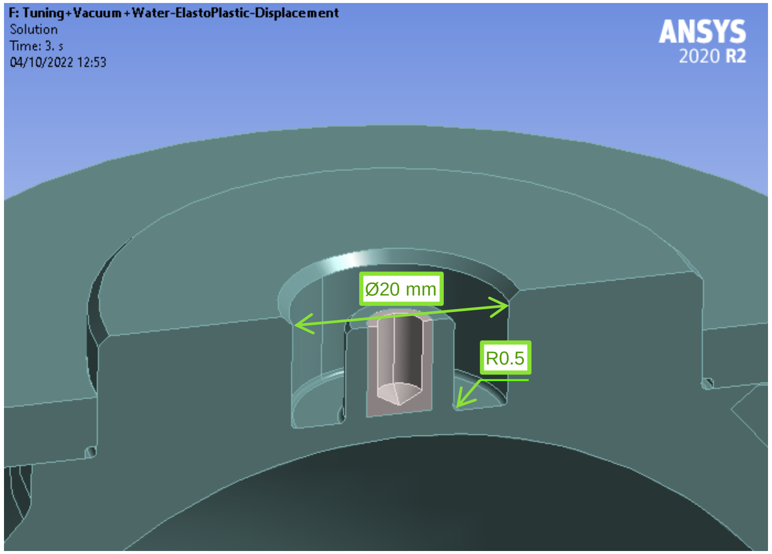
$$\varepsilon_e = \frac{1}{1+\nu'}\left(\frac{1}{2}\left[(\varepsilon_1-\varepsilon_2)^2+(\varepsilon_2-\varepsilon_3)^2+(\varepsilon_3-\varepsilon_1)^2\right]\right)^{\frac{1}{2}}$$

where:

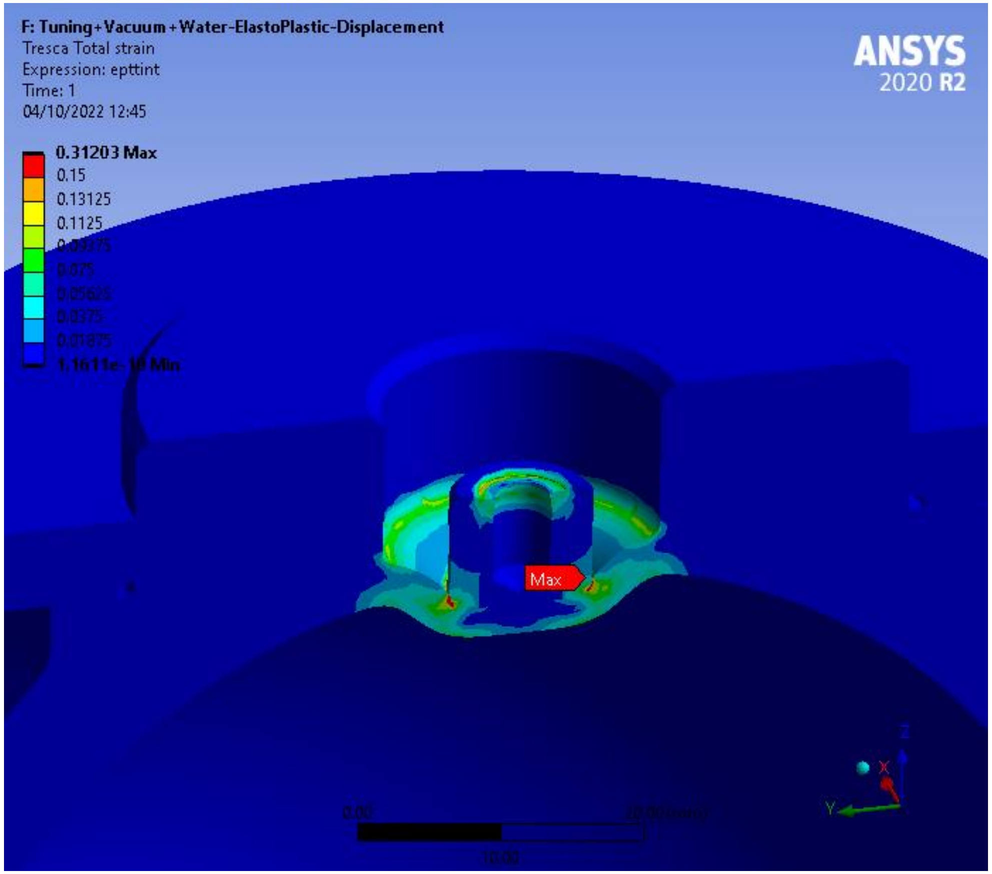
ν' = effective Poisson's ratio, which is defined as follows:

- Material Poisson's ratio for elastic and thermal strains computed at the reference temperature of the body.
- 0.5 for plastic strains.

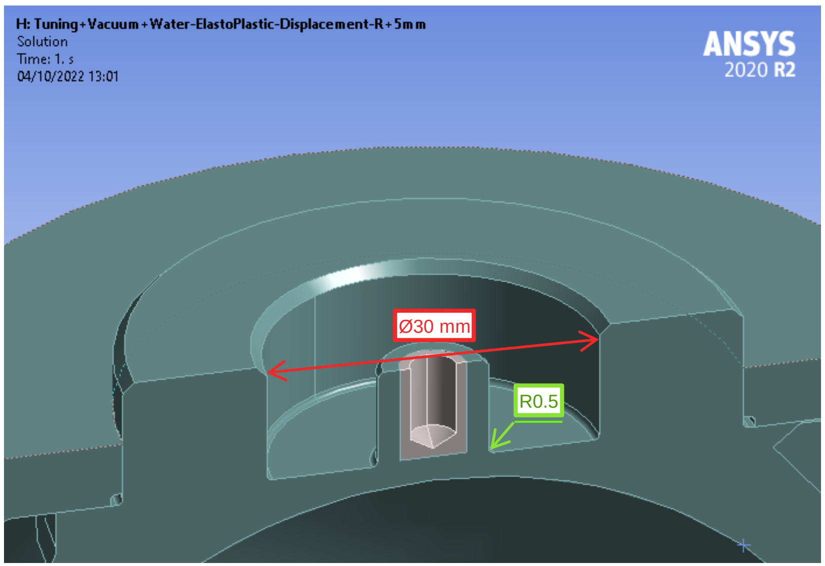
Original design (Ø20mm + R0.5)

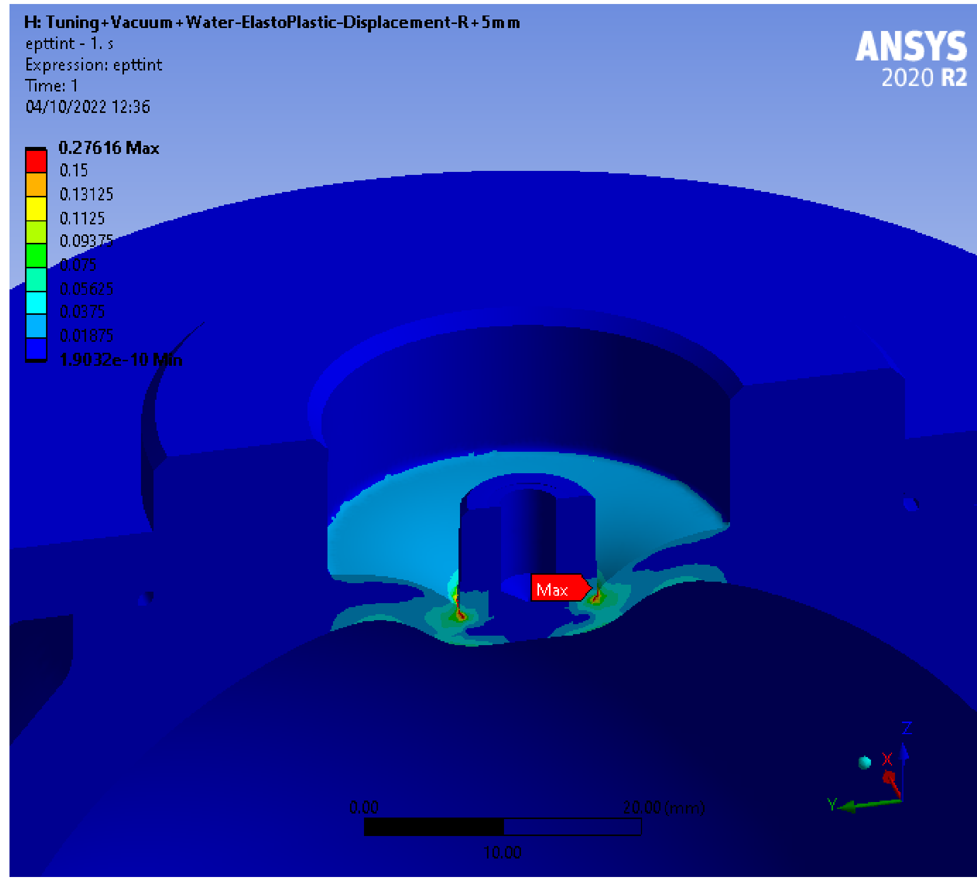


Total strain Tresca (~plastic strain because deformation almost entirely plastic)

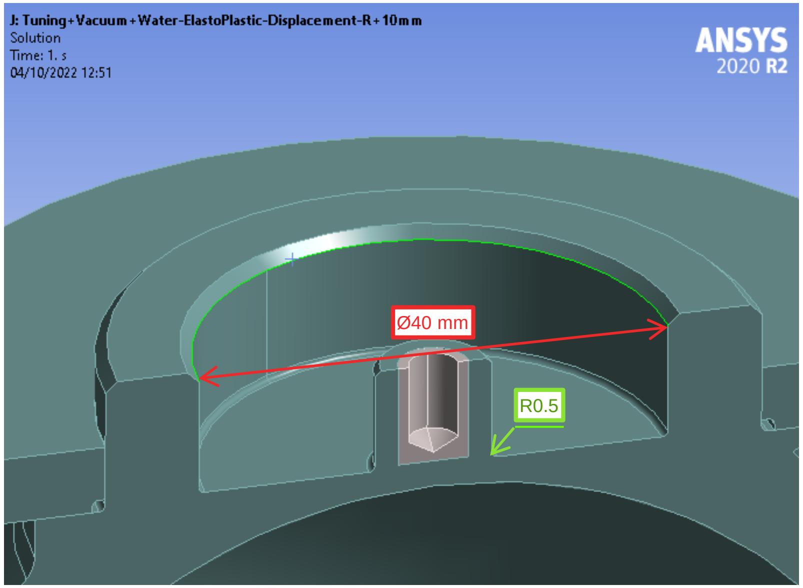


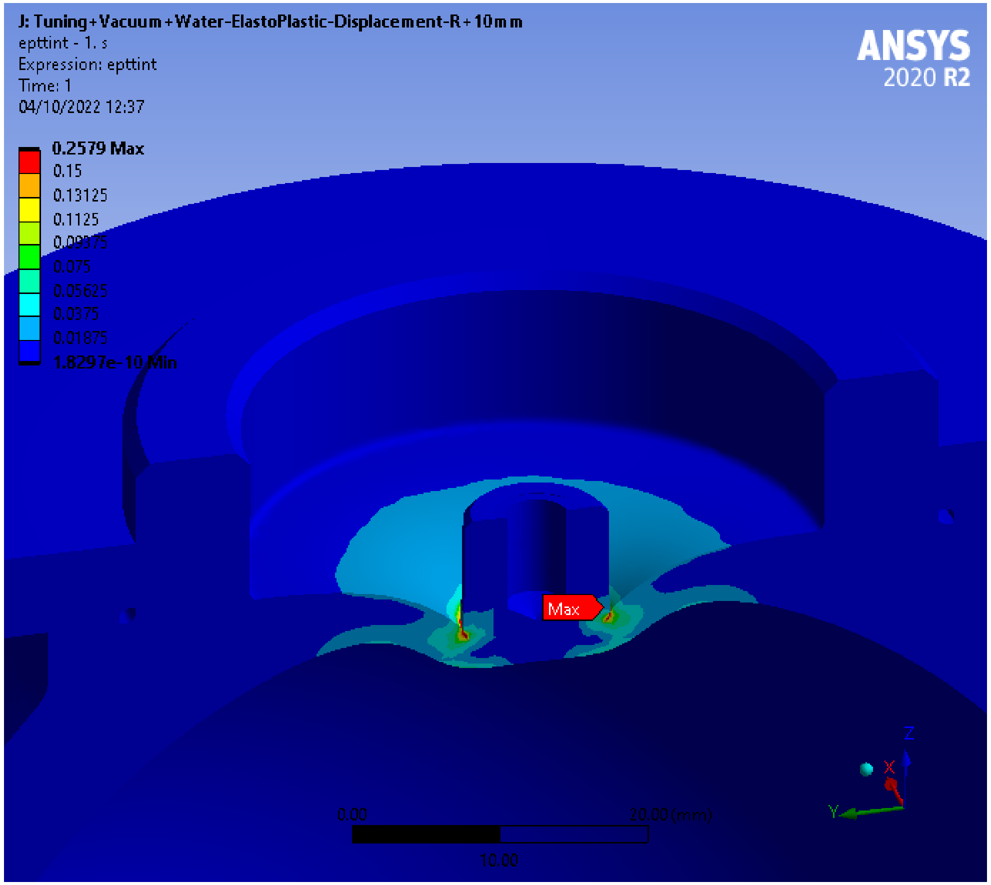
Diameter 30mm + R0.5



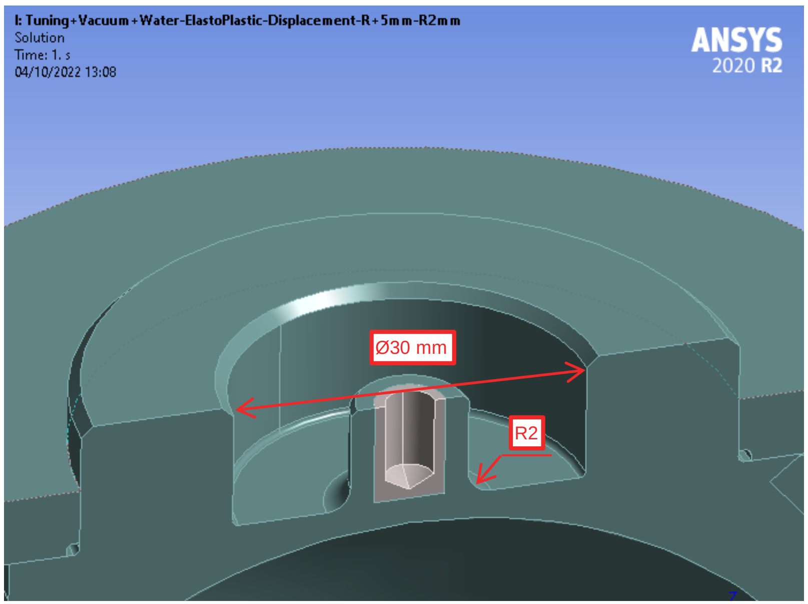


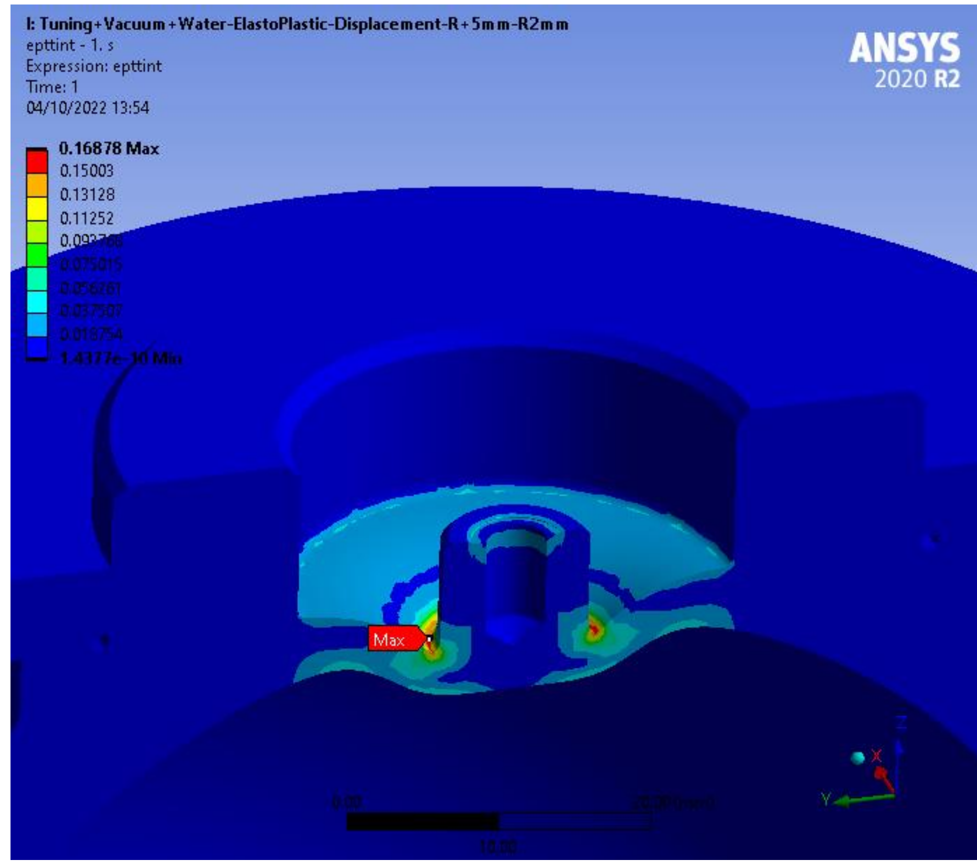
Diameter 40mm + R0.5



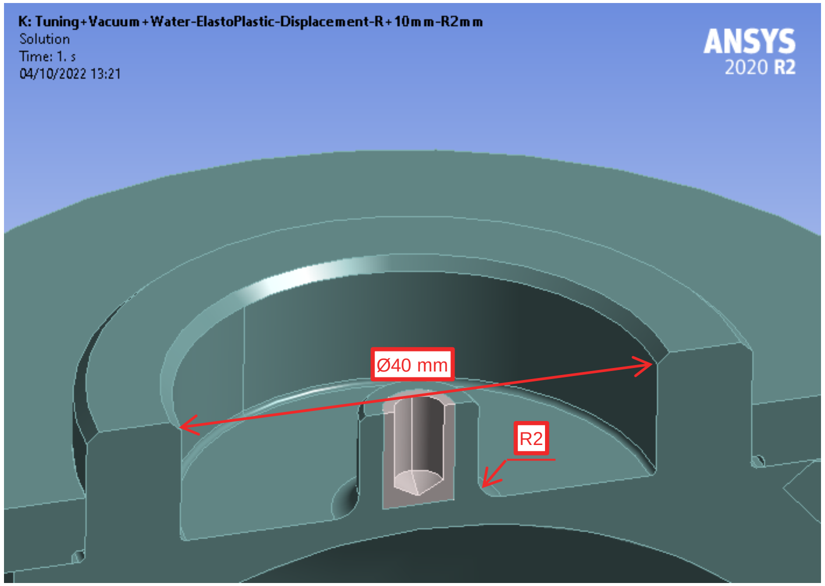


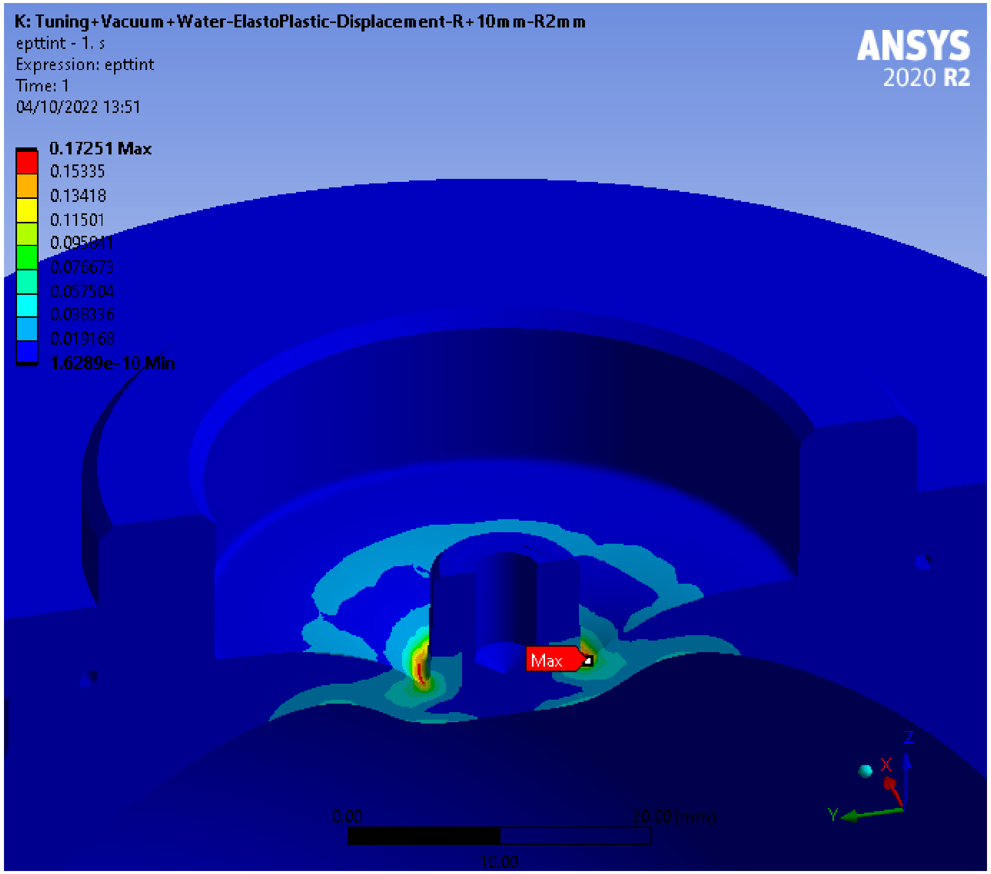
Diameter 30mm + R2



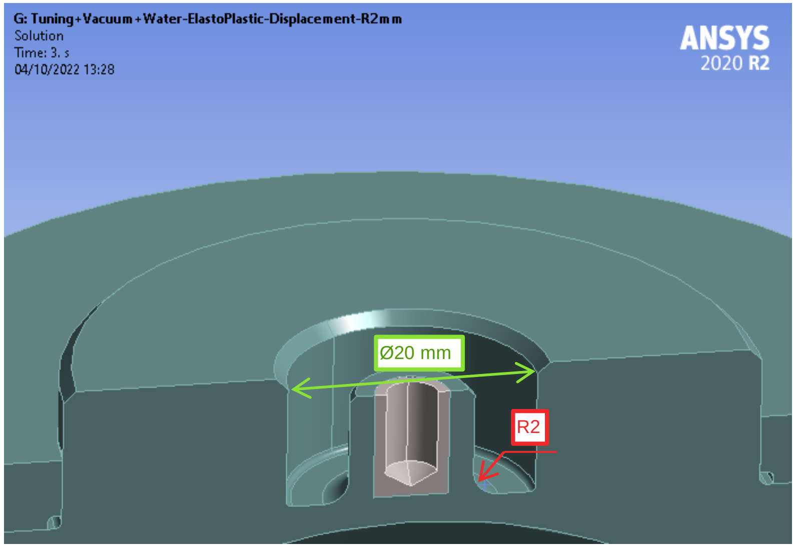


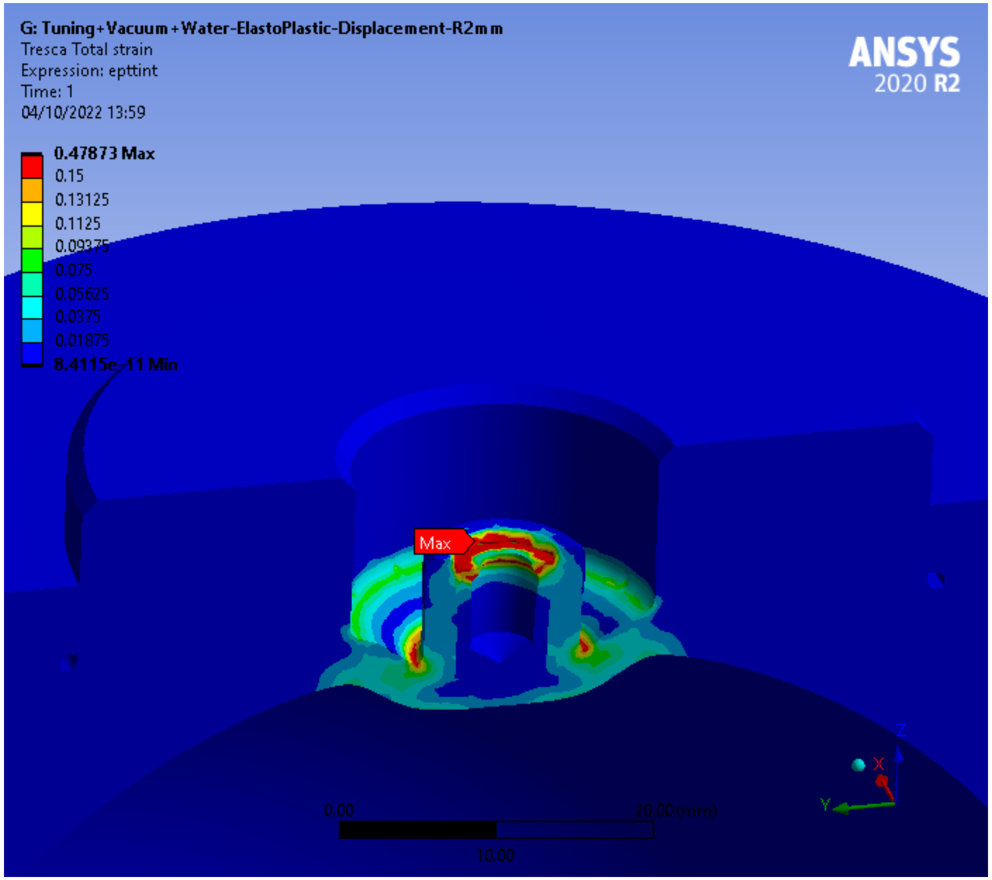
Diameter 40mm + R2





Diameter 20 + R2





Maximum total strain (Tresca)

Original design	Ø30mm/R0.5	Ø40mm/R0.5	Ø30mm/R2	Ø40mm/R2	Ø20mm/R2
31.2 %	27.6 %	25.8 %	16.9 %	17.3 %	47.9 %