

1. Context:

SOTON suggests replacing the 2-rods Invar configuration by a 4-rods Invar configuration in order to reduce observed high stresses in both the cage and the rods. The kinematics being similar, discussions are on going to understand how this limited design change affects the general design.

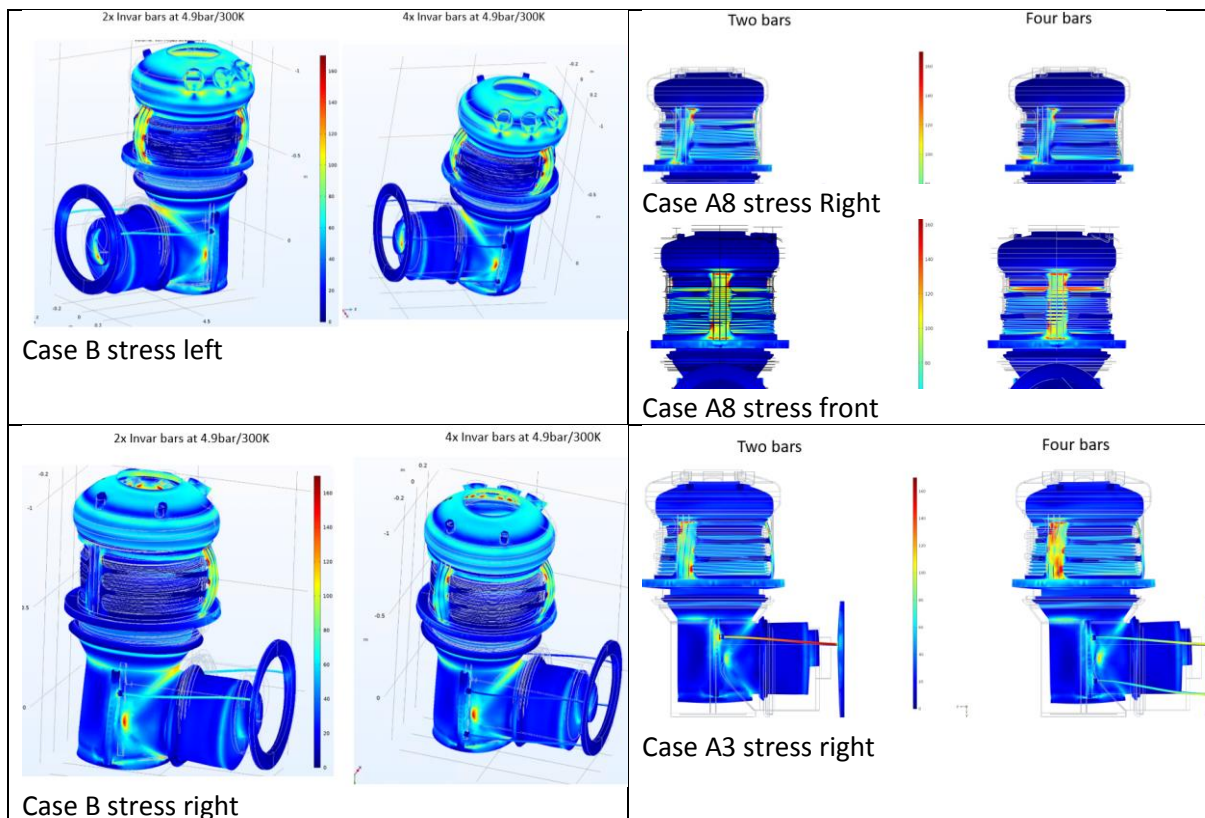
2. Orders of magnitude during cool down (CD)

Invar rods are about 600mm long → 0.1 mm length reduction over 8K-300K temp. distribution. At the rod-Elbow interface, the vertical displacement is <2.5mm over CD. The Elbow diameter reduces by 1.5 mm over CD.

- ⇒ The relative displacement between the two rods ends is 0.15mm on beam axis, 0.7mm laterally, 2.5 mm vertically.
- ⇒ An angle between the original and cold invar rods is < 0.3 degrees

3. Description of issues

Calculations performed by SOTON show that the cage and the rods experience high stresses in the 2-rods configuration while are more reasonable in the 4-rods configuration, see illustrations from email 16.01.



4. Discussion

Based on the observation of the stress distributions, the outcome is often comparable between the two configurations, which is reassuring as the kinematics is very similar. It appears that the 4 rods is not always presenting a safer stress distribution than the 2 rods, (ex Cases A8, Case A3 in cage) but in general the concern is located in the cage structure.

Observations:

- The stress level in the pillar 2-rods of the Case B stress right is unexpected. Ansys performing the integral of the pressure applied on surfaces, the results should not change. However, maybe a surface is missing in the selection of applied pressure, this demonstrates the role of the 3-pillar orientation.
- It seems the displacement of the INVAR end attached to the Elbow is quite high compared to the order of magnitude

The high variations between simulations does not clearly identify the mechanical process brought by the 2 additional rods (why it relaxes or increases the stresses).

5. Proposed iteration

Beyond the fact that 2 or 4 rods are better suited, these simulations reveal a limited margin in the mechanical design. Some proposals :

- The general stress level is (too?) close to the allowable limit → **add material ?**
- Calculations show the (too high?) importance of the 3 pillars orientation → **limit it by adding pillars ?**
- Rods stress level is high → **increase diameter ?**

Obviously the increased heat load shall be evaluated and if too high study a possible request for higher budget.

Below are some possible examples of upgrades, left a six pillars cage, right a 25mm diameter Invar rods (thanks Julien for managing to fit it in).

