

Performance of the W7-X ECRH gyrotron diamond output window at 2 MW operation

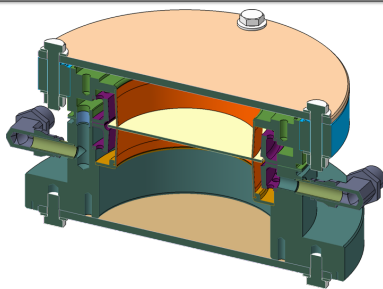
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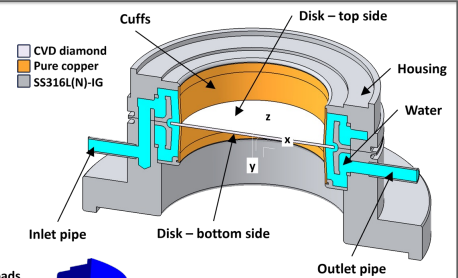
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Methods

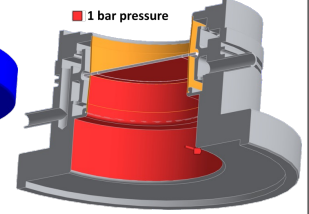
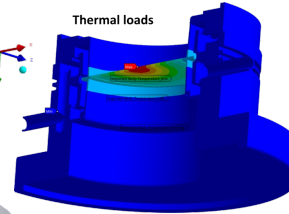
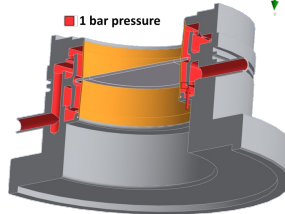


- CFD conjugated heat transfer analysis with different combinations of loss tangent and mm-wave beam radius (operational limits)
- Structural analysis with complete window assembly and all operational loads for the first time



- Conical cuffs and different cooling water path with respect to past designs
- Analyses by ANSYS CFX and Workbench
- Temperature dependent properties
- 2 MW Gaussian beam at 140 GHz
- Reference case with $r_{\text{beam}} = 20$ mm and $\tan\delta = 5.0 \times 10^{-5}$ (1761 W absorbed power in the disk)
- 0.2 kg s⁻¹ at inlet (25°C) and 0 Pa at outlet

Ø106 mm,
1.8 mm disk



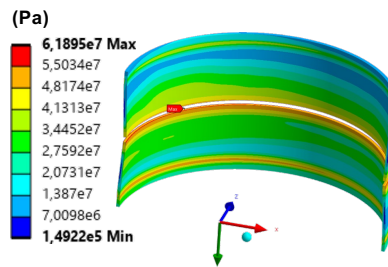
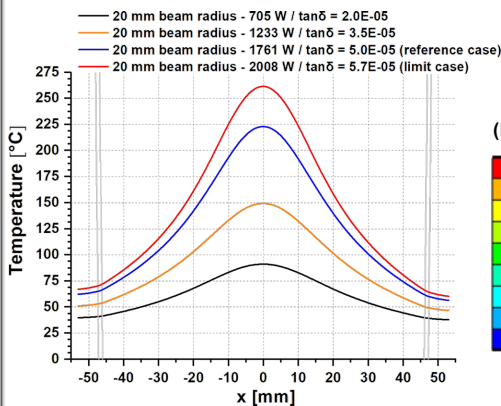
$$q'''(r) = \frac{P_{\text{abs}}}{2\pi\sigma^2 t} e^{-\frac{r^2}{2\sigma^2}}$$

Results

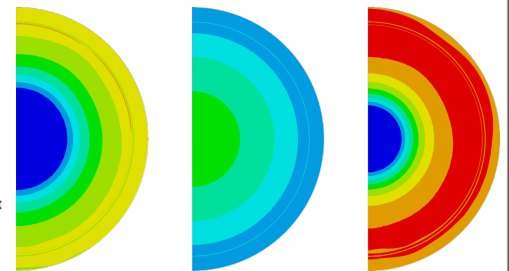
Maximum temperatures at disk center in °C

	$r_{\text{beam}} = 17$ mm	$r_{\text{beam}} = 20$ mm	$r_{\text{beam}} = 23$ mm
$\tan\delta = 2.0 \times 10^{-5} / P_{\text{abs}} = 705$ W	97.2	91.1	85.9
$\tan\delta = 3.5 \times 10^{-5} / P_{\text{abs}} = 1233$ W	162.3	149.3	138.6
$\tan\delta = 5.0 \times 10^{-5} / P_{\text{abs}} = 1761$ W	245.6	223.0	203.0

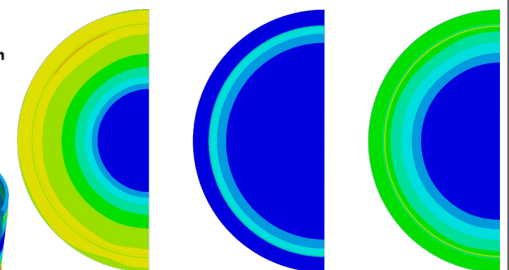
- Max T and σ are lower than the limits in the reference case
- Thermal loads rule σ distribution in the diamond disk
- The highest tolerable $\tan\delta$ value is 5.7×10^{-5} (at $r_{\text{beam}} = 20$ mm)
- At higher powers, max T can be significantly reduced by increasing r_{beam} , but within the limits given by window aperture



Stresses on disk top side



Stresses on disk bottom side



The design is verified for 2 MW operation