The W7-X ECRH gyrotron diamond output window: oil and water cooled window performance at 1.5 MW operation

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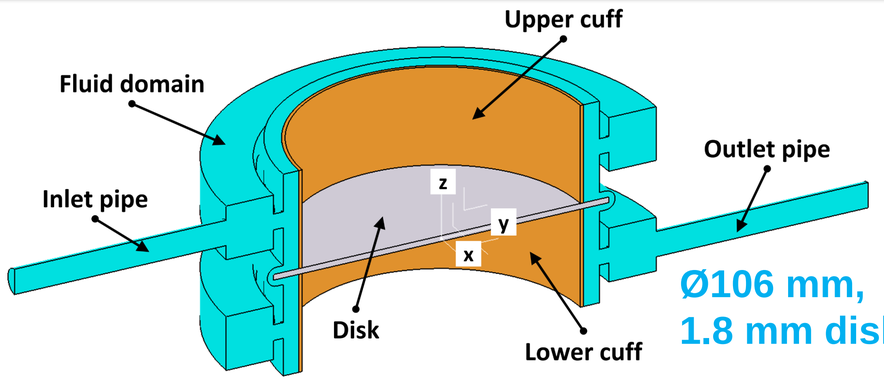
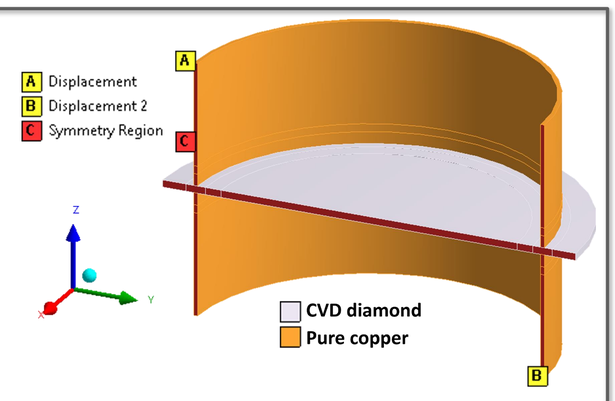
Methods

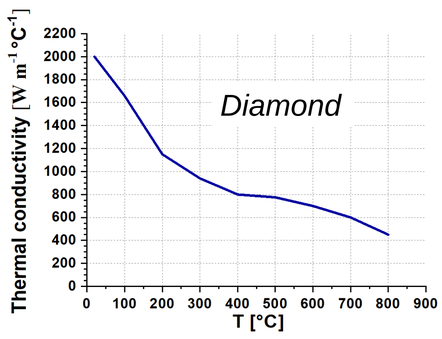


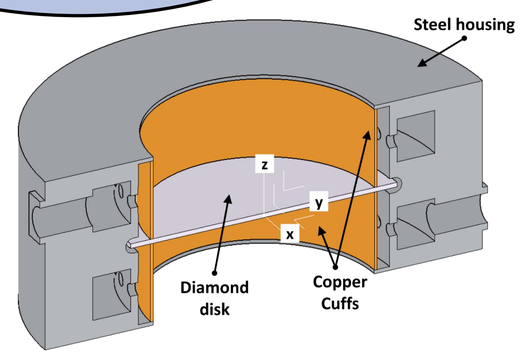
Assess window performance by water and silicon oil cooling at different absorbed powers



CFD conjugated heat transfer analysis

- Water and Silicon oil DC 200(R) with 5 cSt
- Temperature dependent properties
- 0.2 kg s^{-1} at inlet (25°C) and 0 Pa at outlet
- 1.5 MW Gaussian beam with 20 mm radius
- Runs with different absorbed power values





Structural analysis

- Plasticity - multilinear isotropic hardening
- Temperature distribution as load
- Isostatic boundary conditions

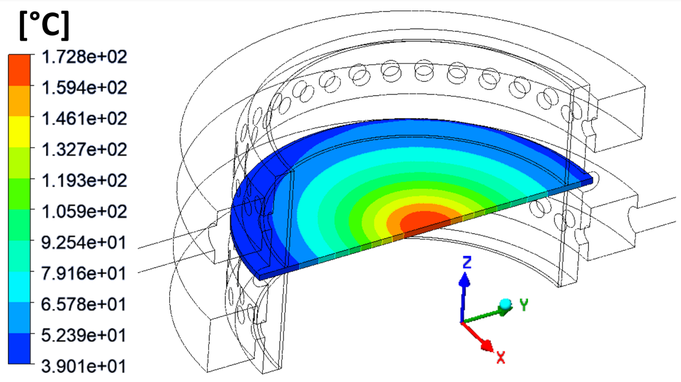
	density [kg m^{-3}]	dynamic viscosity [Pa s]	specific heat [J kg^{-1} K^{-1}]	thermal conductivity [W m^{-1} K^{-1}]
Water	997	8.90 x 10^{-4}	4182	0.607
DC200	915	45.8 x 10^{-4}	1639	0.142

$$P_{abs} = \frac{P_{beam}\,\pi\, f\, t\, tan\delta\, (1+\varepsilon_r)}{c_0}$$

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

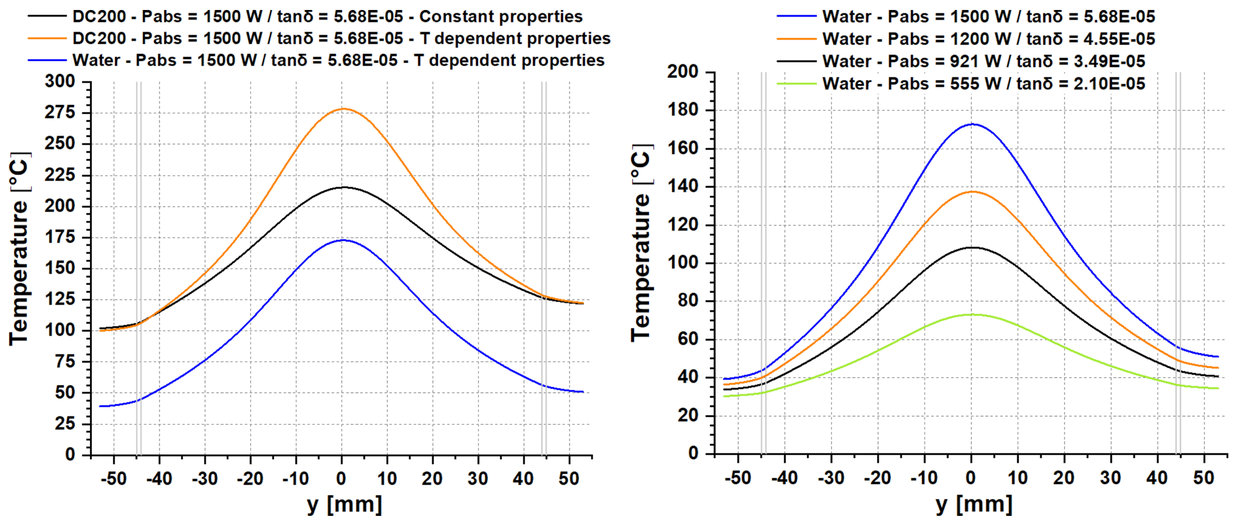
	tanδ [x 10^{-5}]	absorbed power [W]
Conservative assumption	5.68	1500
Disk 89DB1	4.55	1201
D90, average on 25 bare disks	3.49	921
D50, average on 25 bare disks	2.10	555

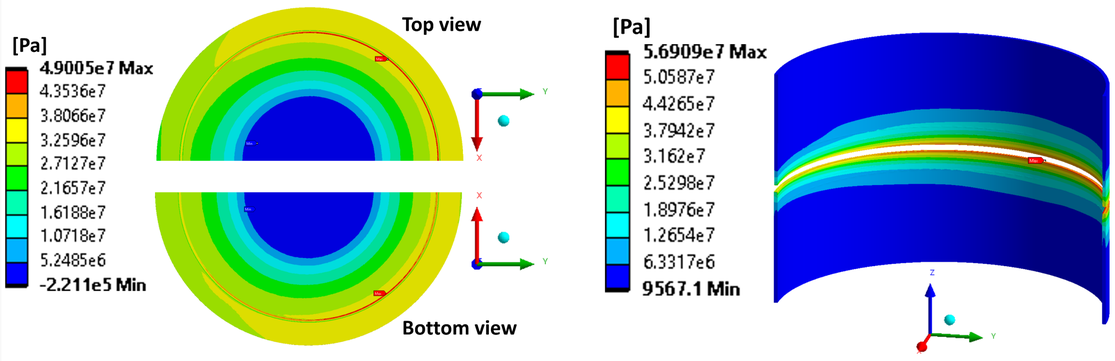
Results



water-cooled, 1.5 kW power absorption

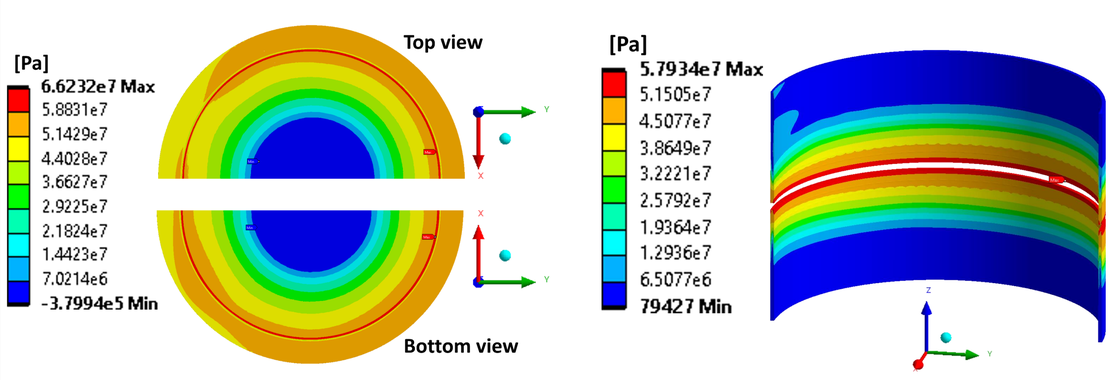
Coolant	*Pressure drop [bar]*	*ΔT fluid inlet-outlet [°C]*	*Max T in disk [°C]*	*Max T in cuffs [°C]*	*ΔT disk edges [°C]*	*Power fraction removed by diamond [-]*	*Power fraction removed by copper [-]*
Water	0.15	1.75	172.8	57.2	11.8	58%	42%
Oil	0.20	4.47	278.4	128.0	22.4	48%	52%





water-cooled, 1.2 kW power absorption

Absorbed power in disk [W]	Water		DC200	
	Max T in disk [°C]	Reserve margin [°C]	Max T in disk [°C]	Reserve margin [°C]
1500	172.8	77.2	278.4	-
1201	137.4	112.6	213.1	36.9
921	108.2	141.8	159.3	90.7
555	73.11	176.9	100.7	149.3



oil-cooled, 1.2 kW power absorption

- 250°C and 150 MPa are the limits assumed for diamond
- Temperature dependent properties (particularly for diamond) shall be used
- Water-cooling is the only option at high-power operations as providing significant temperature reserve margins

EUROfusion

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