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The double-disk diamond window as backup broadband window solution for the DEMO Electron Cyclotron System

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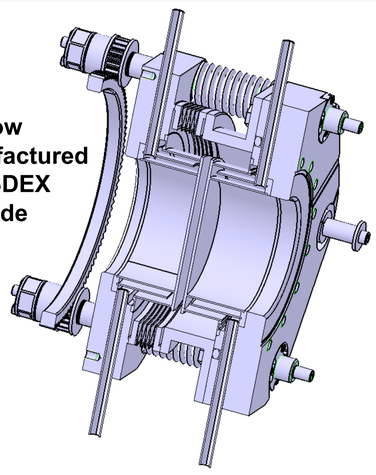
Motivation

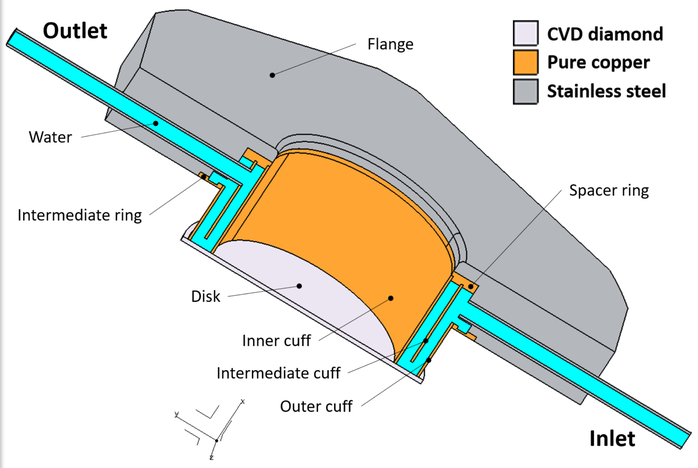


- The second variant of the DEMO Electron Cyclotron System (ECS) requires gyrotrons frequency steering
- Broadband optical chemical vapor deposition (CVD) diamond windows are thus required
- Primary choice is the Brewster-angle window. The double-disk window is the broadband backup solution

Objectives

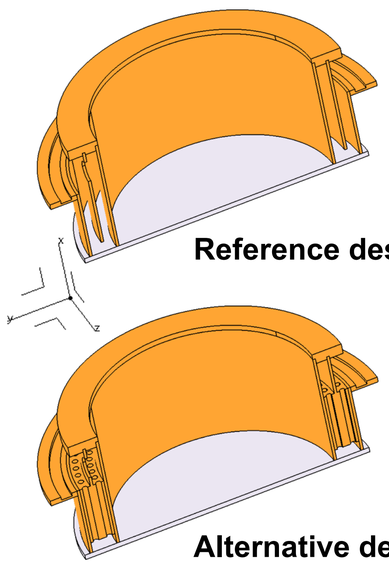
- Investigate the possibility of using the double-disk window for the DEMO beam scenarios by CFD and structural analyses
- Perform sensitivity studies with respect to mass flow rate, loss tangent, beam radius and frequency
- Explore conceptual design alternatives to increase safety margins against limits

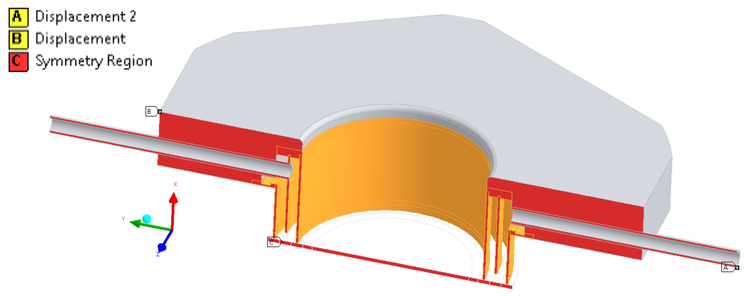
Approach



CFD conjugated heat transfer analysis

- Symmetry condition
- T dependent properties
- 10 l/min at 20°C at inlet
- 0 Pa at outlet
- 2 MW @ 204 GHz Gaussian beam
- 20 mm beam radius
- P_{abs} = 1847 W in disk (tanδ = 3.5E-05)
- Reference case and sensitivity studies

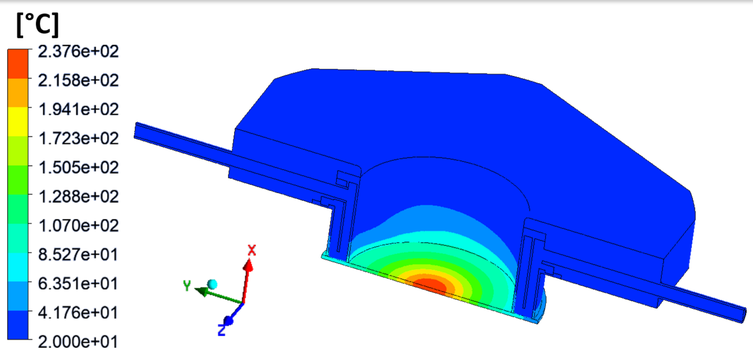




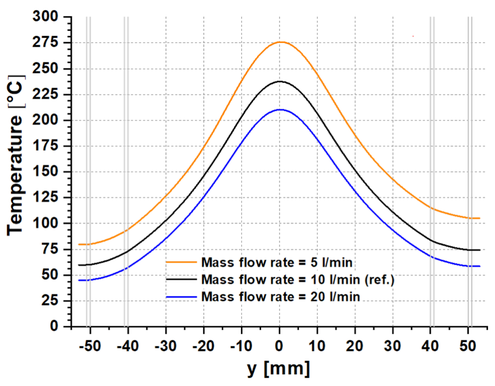
Structural analysis

- Plastic steady-state structural analysis: multilinear isotropic hardening
- T dependent material properties
- Temperature distribution as load

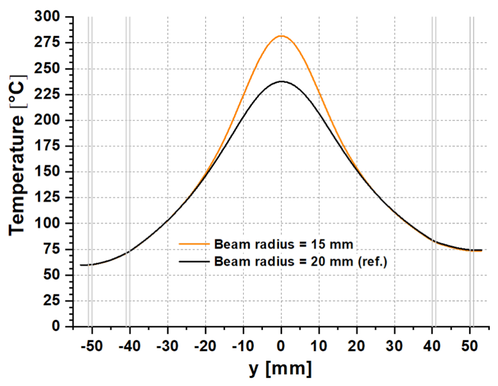
Results

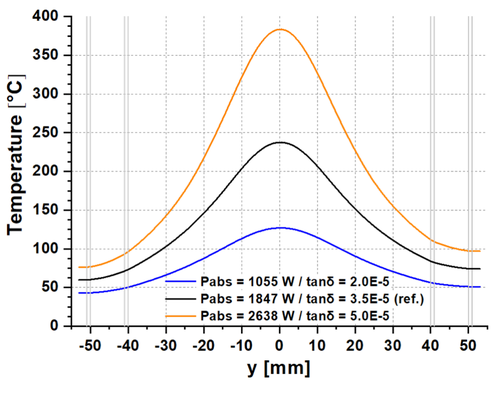


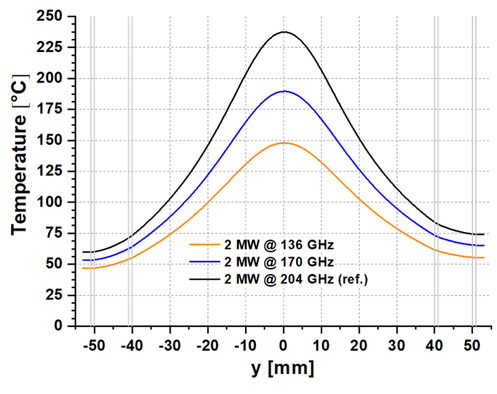
- **Max T of 238°C** at disk center (250°C limit)
- Max stress in the disk below the 150 MPa conservative limit
- Max stress in the cuffs below the minimum ultimate tensile strength (177 MPa)

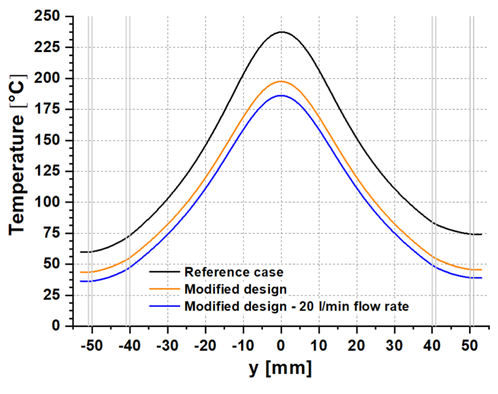


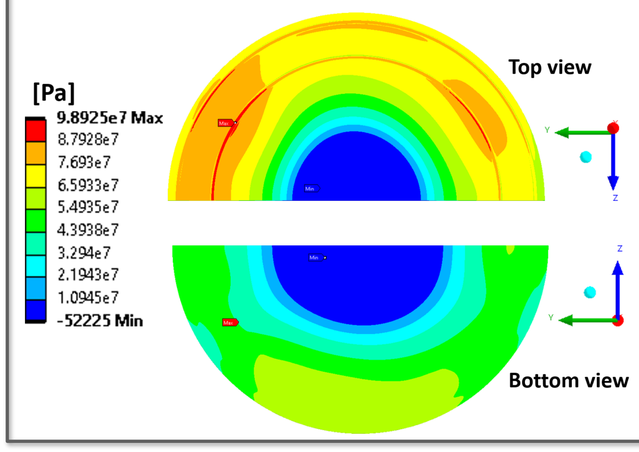
- The flow rate of 10 l/min is the minimum boundary condition
- The beam radius of 20 mm is the upper boundary limit (window aperture radius of 40 mm)
- The tanδ value of 3.5E-05 is reasonable to account for disk degradation potential factors











- The **double-disk window is a feasible solution for DEMO**, provided that safety margins against limits are increased by design features aiming to make the fluid more turbulent
- A first design change, together with a higher flow rate, led to a **max T of 186°C** in the disk
- The window shall be later characterized to determine the reflection-free resonance conditions

EUROfusion

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