Karlsruhe Institute of Technology

Institute for Applied Materials – Applied Materials Physics IAM-AWP

Design evolution of the diamond window unit for the ITER EC H&CD upper launcher

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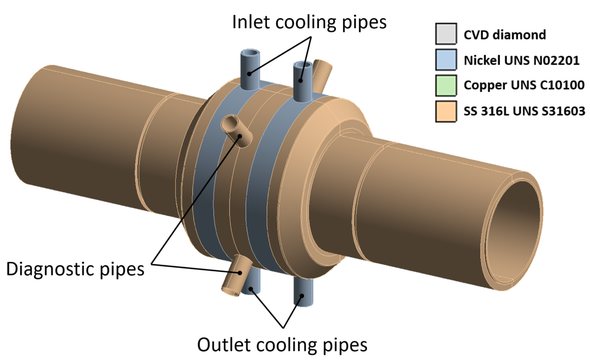
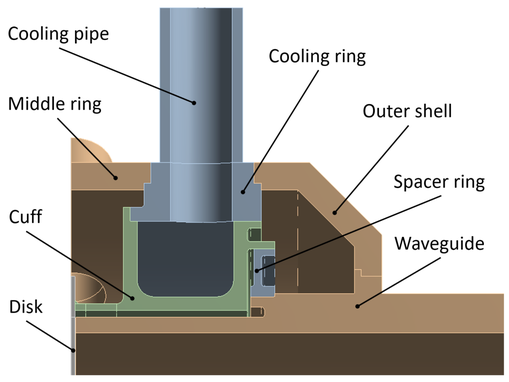
Motivation

Design of the torus window unit ready to start the prototyping and testing activity (FDR in 12/2019)

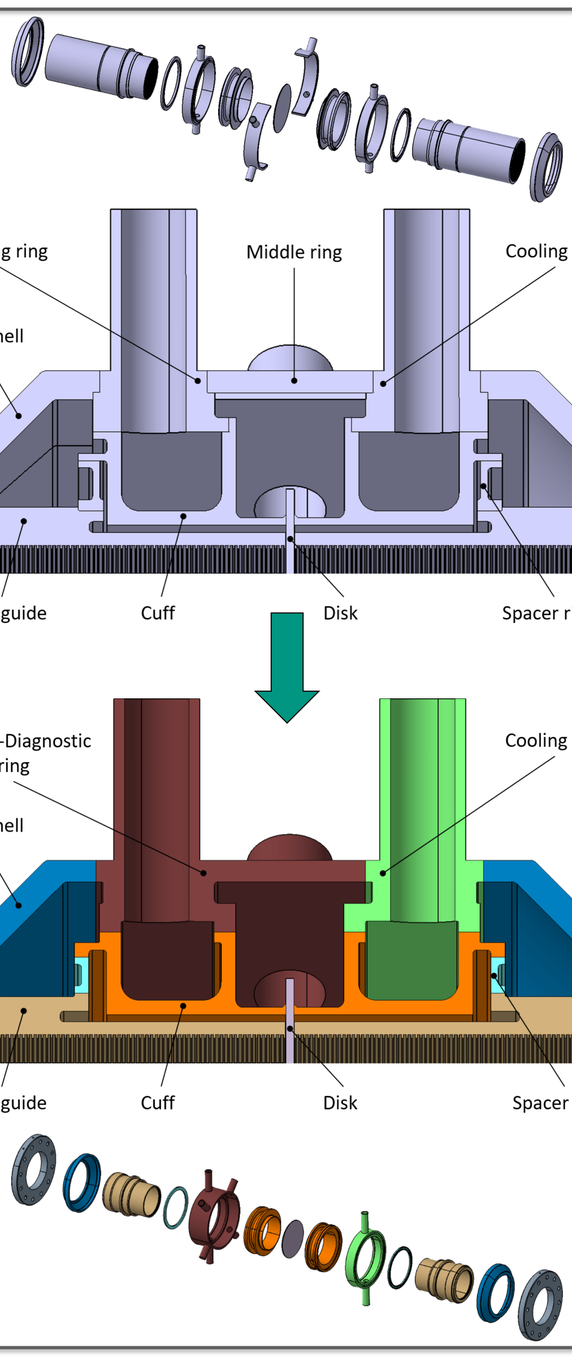




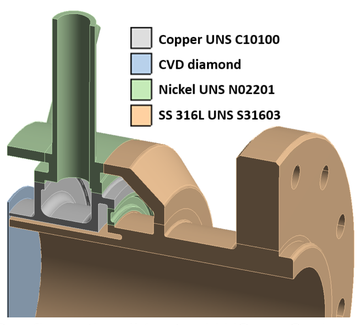
Objectives

- More feasible and simpler manufacturing and assembling sequence
- Compliance with the requirements of the applicable ASME III-NC code
- Adaptation to the ITER decision of changing the WGs inner diameter from 63.5 to 50 mm (power density in the Cu-coated WGs 2.6 times greater)

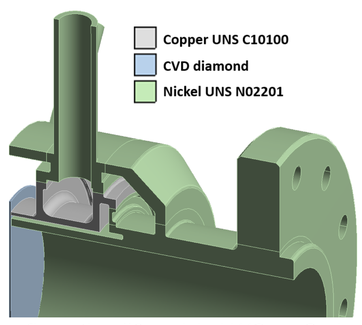
Approach



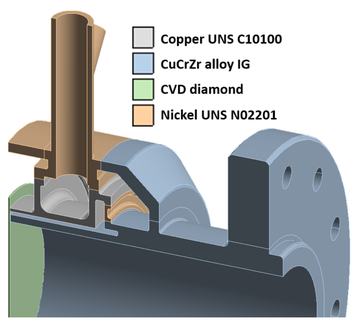
- Removal of all steps in the EB welded joints and more margin for the heat affected zone
- Smaller material thickness for radiographic inspection
- Lower number of welded joints after the brazing disk – cuffs and reduction of some welding thicknesses
- FEM steady state thermal and structural analyses with four material configurations with respect to the 1.31 MW design beam and also to the off-normal event of hot spot



Configuration #1: steel WGs + Cu layer



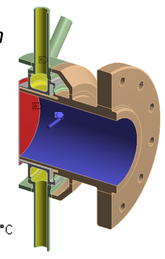
Configuration #2a: nickel WGs + Cu layer
Configuration #2b: nickel WGs



Configuration #3: CuCrZr alloy IG

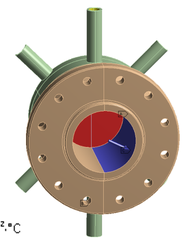
Thermal analysis: 1.31 MW design beam

Material configurations	Heat flux to the WGs inner wall [W m^{-2}]
Configuration #1 (steel WGs + Cu layer)	4070.7
Configuration #2a (nickel WGs + Cu layer)	4070.7
Configuration #2b (nickel WGs)	7800
Configuration #3 (CuCrZr WGs)	4070.7

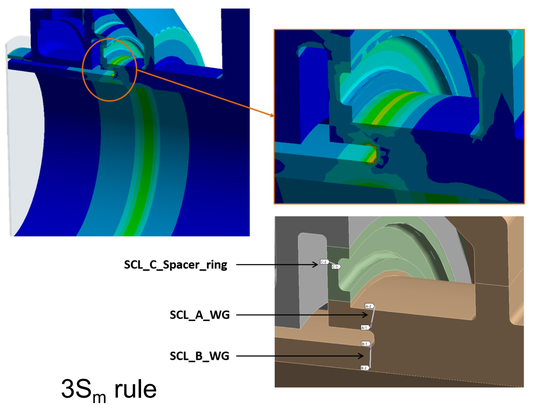


Thermal analysis: hot spot case

Material configurations	Heat flux to half of the inner WG circumference [W m^{-2}]
Configuration #1 (steel WGs + Cu layer)	10421
Configuration #2a (nickel WGs + Cu layer)	10421
Configuration #2b (nickel WGs)	19968
Configuration #3 (CuCrZr WGs)	10421

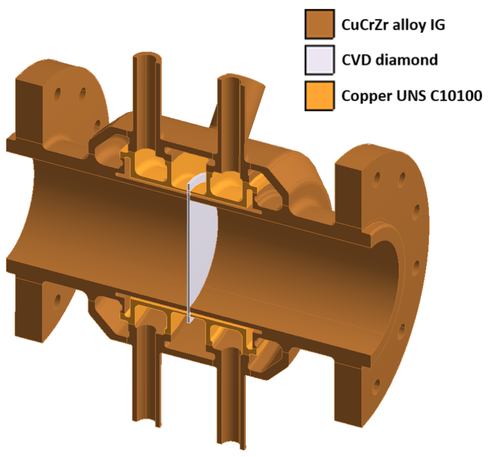


Structural analysis: SCLs in the stress intensity distribution



$3S_m$ rule

Results



- High safety margin against allowable limits and uncertainties of hot spot thermal loading
- No inner Cu-coating in the WGs
- Minimum number of welds, materials and low weld shrinkage

Outlook

- Prototyping and testing of the window unit
- 12/2019: window Final Design Review (FDR)
- Qualification of the 56 diamond disks and torus window units for the ITER UL and EL plugs

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