Karlsruhe Institute of Technology

P1-017

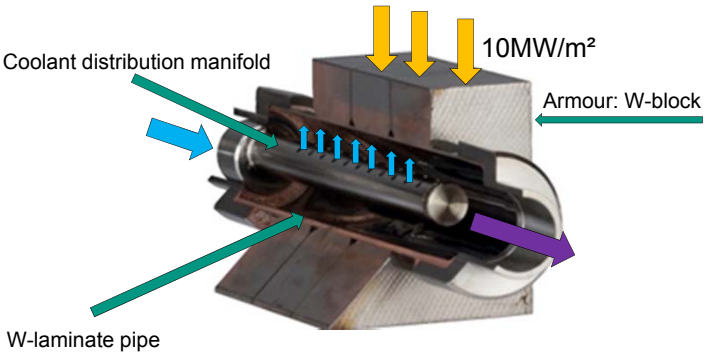
Helium-cooled Divertor: Design and DEMO Integration Studies

Bradut-Eugen Ghidersa[1], Jens Reiser[1], Yuming Chen[1],
Joon-Soo Lim[2], Namkyu Lee[2], Hyung Hee Cho[2]

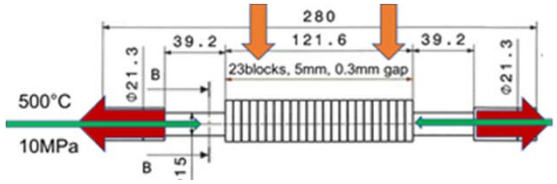
[1]Karlsruhe Institute of Technology (KIT), Institute for Neutron Physics and Reactor Technology (INR), Karlsruhe, Germany
2Heat Transfer Lab. Dep. of Mechanical Engineering, Yonsei University, Republic of Korea

KIT Helium-Cooled Divertor

- High temperature solution: T_{He} > 500°C
- Designed for 10MW/m² peak heat flux
- Uses tungsten laminates as structural material
- Simple geometry: W-blocks (armour) installed on a W-laminate pipe (similar to ITER divertor)
- Jet-impingement cooling: Helium flow is distributed through a inner manifold along the W-laminate pipe



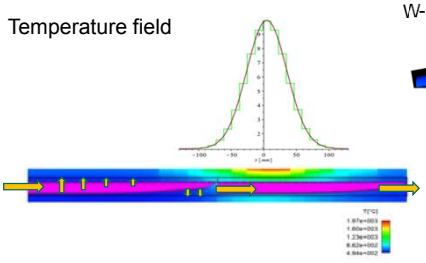
He-cooled Divertor mock-up



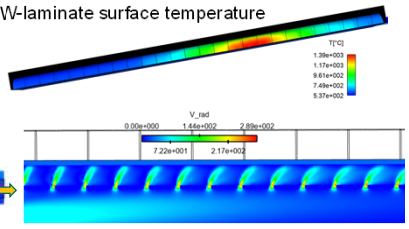
Target integration studies

- The length of the DEMO outboard vertical target is 645mm; applying the jet cooling scheme for the full length (1 module) would require ~1kg/s per row:
  - large pressure losses
  - non-uniform jet-flow rates distribution
  - Low coolant temperature increase (~7°C)
- Most of the target length see loads around 1MW/m²
- Only near the strike point the surface heat load is large
- Use a cooling scheme with several segments in series:
  - Lower flow rate needed (~65g/s per row)
  - Better jet flow rate distribution
  - Higher coolant temperature increase (~100°C)

Temperature field



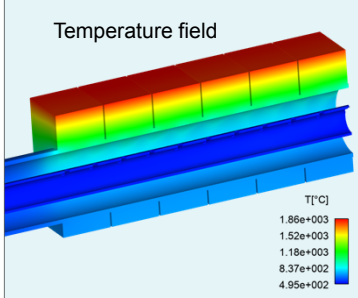
W-laminate surface temperature

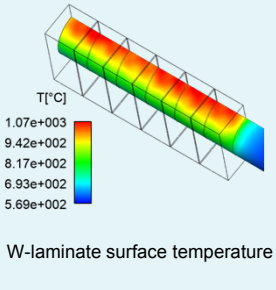


Jet velocity under the high heat flux area

CFD Analysis of the He-cooled mock-up

Temperature field

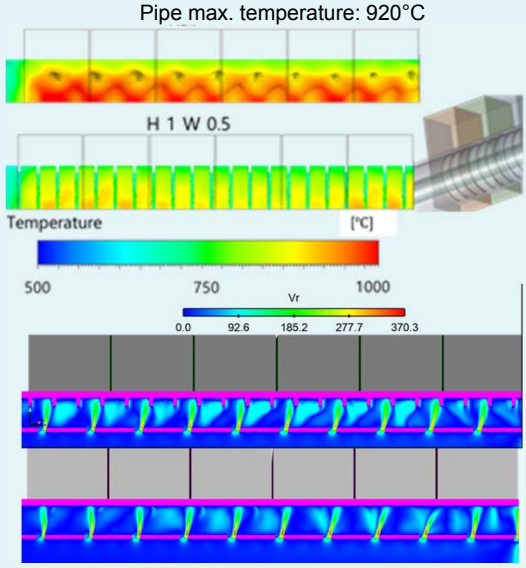




W-laminate surface temperature

Cooling performance enhancement: pipe with ribs

Pipe max. temperature: 920°C



Impingement jet pattern for the reference case (bottom) and a configuration using inner ribs (top)

Summary and Conclusions:

- Evaluation of the thermal-hydraulic performances of the new helium-cooled divertor concept
- Proposal of a target integration concept using 5 modules in series as well as an experimental plan for the validation and qualification of the concept
- Manufacturing of 1 divertor module mock-up and evaluation of the thermal performance via CFD
  - W-laminate pipe max. temperature around 1070°C
  - It is possible to decrease further this value through heat transfer enhancement techniques, for instance , ribs on the pipe inner surface
- CFD of 2 modules in series with concentrated heat flux
  - Higher temperature values in the solid parts (pipe) than for the mock-up
  - Jet tilting (~60°) could account for 20% HTC reduction
  - Further optimization for a better flow distribution and reduced jet tilting is needed
- Experiments planned for 2018 will look into evaluating experimentally the new concept performance and validate the numerical models

EUROfusion

This work has been partially carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.