Karlsruhe Institute of Technology

Institute for Neutron Physics and Reactor Technology (INR)
Karlsruhe Institute of Technology (KIT), Campus Nord
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldschafen, Germany
http://www.inr.kit.edu/

Divertor Plasma Facing Component concept for European DEMO based on Heat Pipe technology

Wen Wen[a], Bradut-Eugen Ghidersa[a], Hering Wolfgang[a], Jörg Starflinger[b], Robert Stieglitz[a]

a: Institute for Neutron Physics and Reactor Technology, Karlsruhe Institute of Technology , Karlsruhe, Germany
b: Institute of Nuclear Technology and Energy Systems , University of Stuttgart, Stuttgart, Germany

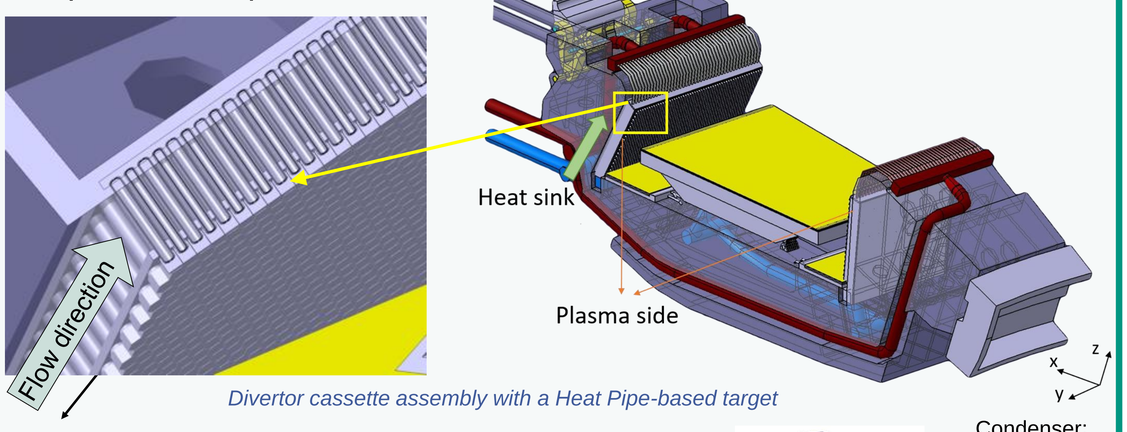
Objectives

Investigate the possibility of using water-based heat pipes in conjunction with a new divertor target concept including:

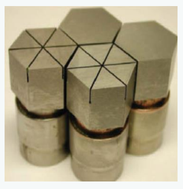
- dimensioning a variable conductance heat pipe that should be capable of dealing with heat fluxes as high as (at least) 20MW/m^2
- evaluating experimentally its heat transfer performances

DEMO-Divertor Concept

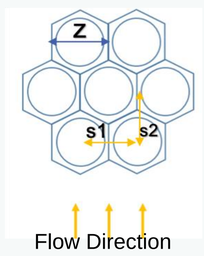
- Divertor target made out of parallel cylindrical Heat Pipes(HPs) installed in a water cooling channel. The Heat Pipe rods form a staggered structure (HP condenser).
- The Heat Pipes penetrate the plasma facing side of the cooling channel, having a hexagon W-armor at that particular end (HP evaporator side).



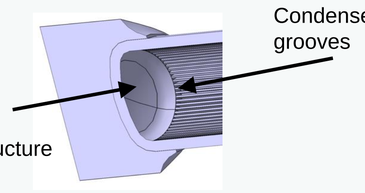
Divertor cassette assembly with a Heat Pipe-based target



W-armor

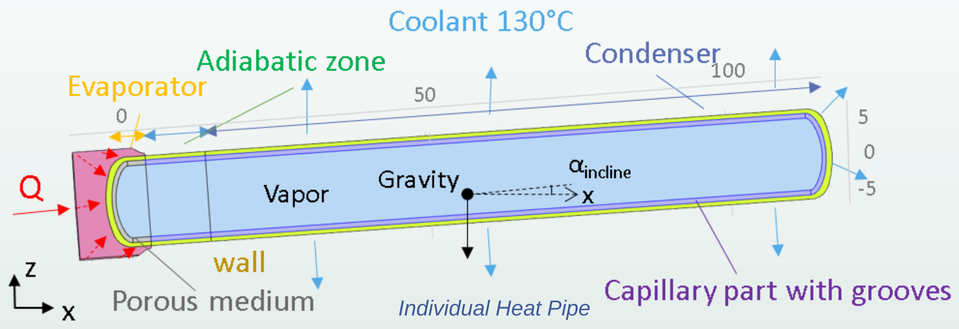


Heat pipes arrangement (cooling channel side)



HP Evaporator end with porous

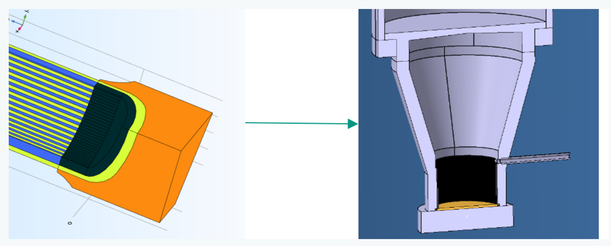
- Orientation 7.8º (depends on divertor target).
- HP has cylindrical body with 15mm outside diameter, while the vapor space is 12mm in diameter;
- HP material: CuCrZr
- HP total length is 230mm, the length of the evaporator and adiabatic part being 7mm and, respectively 23mm.
- Combined wick structure: sintered porous--- evaporator
  grooves --- adiabatic zone and condenser



Experimental heat transfer performance evaluation

Capillary limit well above the operating power.
Critical boiling limit:
→ Focus on the performances of sintered porous structure of evaporator under high heat flux conditions.

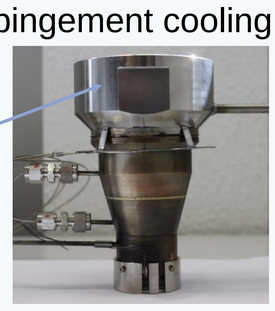
➢ Experimental mock-up

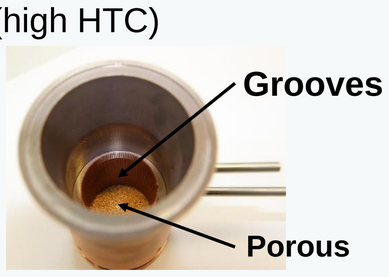


Demo Heat Pipe evaporator and Experiment mock-up model

- Reproduce the evaporator level as the same as in HP for DEMO
- Condenser with jet impingement cooling (high HTC)

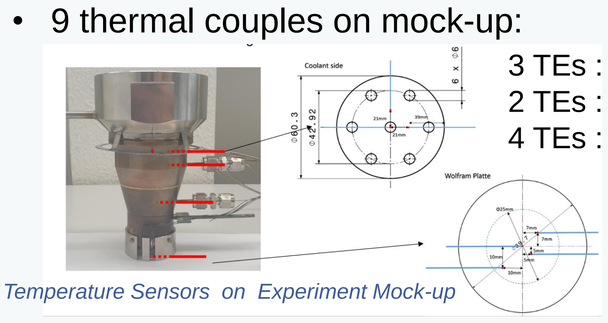
Impinging Jet coolant





Experiment mock-up : outside and inside

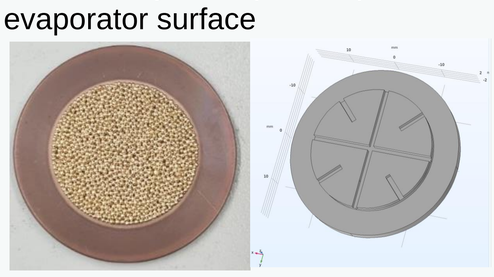
- Evaporator below condenser – increase capillary limit
- Material: CuCrZr for mock-up body; Bronze for sintered porous
- 9 thermal couples on mock-up:



3 TEs : 5mm under the condenser surface
2 TEs : in FHP body for vapor temperature
4 TEs : evaporator surface

Temperature Sensors on Experiment Mock-up

- Same wick area as in HP for DEMO
- 2 porous structures for 2 mock-ups :
  - one normal sintered porous
  - one sintered porous with grooves



Sintered porous structure: normal shape; with grooves

➢ Method

- 2 mock-ups test : one normal sintered porous as comparison
  one sintered porous with grooves as optimize model
- Input power from 1MW/m^2 up to 20MW/m^2 or when there are indications of burn-up
- Screening study on HP water inventory

➢ Futures works

- Validation the experiment and investigate the evaporator performance with mock-ups with 2 different sintered porous structures.
- Find the boiling limit of these 2 porous and make a comparation.
- Apply and verify the better sintered porous structure on the DEMO HP

Conclusions

- **Solution:** Preliminary engineering study indicates that a water based heat pipe **230mm** long made out of CuCrZr, from which the condenser should be at least 200mm long, should be capable for peak heat flux of 20MW/m^2.
- **Verifying test :** Before going to have a target mock-up, the boiling limit characterizing the operation of the evaporator of an individual HP is assessed experimentally.

EUROfusion

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