Institute for Neutron Physics and Reactor Technology (INR)

Karlsruhe Institute of Technology

Thermohydraulics of helium cooled First Wall channels and scoping investigations on performance improvement by application of ribs and mixing devices

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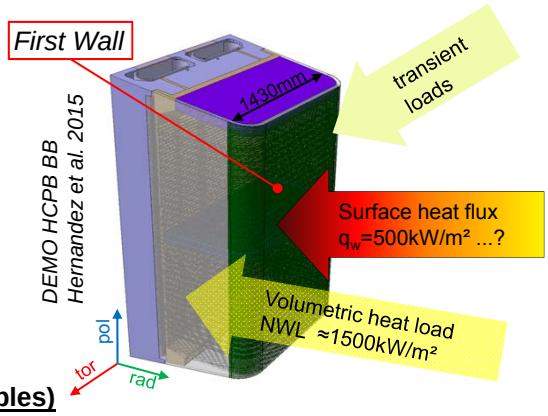
Up to date helium cooled FW designs are designed for steady-state heat loads from the plasma of 500kW/m² .

In **DEMO**, cumulative loads from radiation and particles from the SOL can result in **peaks** conceivable in the range **500 – 1000 kW/m²** in the top region of the plasma chamber (detailed modelling still required).

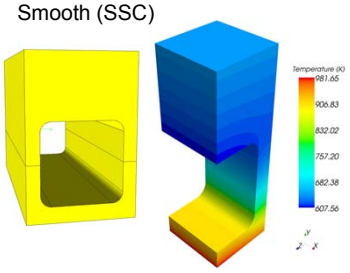
➔ **What range of wall heat loads can be handled with helium cooling?**



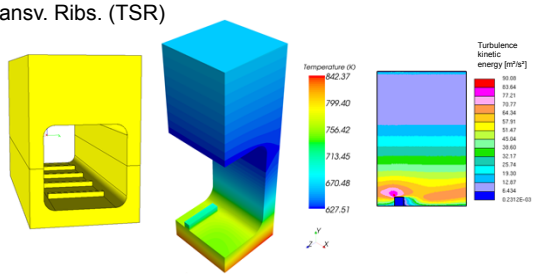
CFD investigations on heat transfer enhanced surfaces (selected examples)

Common conditions: 49g/s helium, 8MPa, 340°C, 750kW/m², 15x15mm², Eurofer.

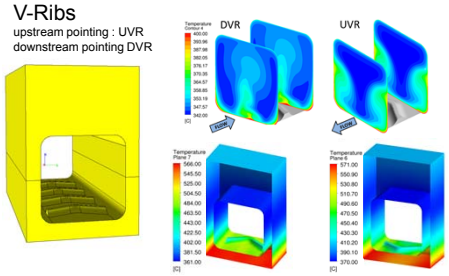
Smooth (SSC)



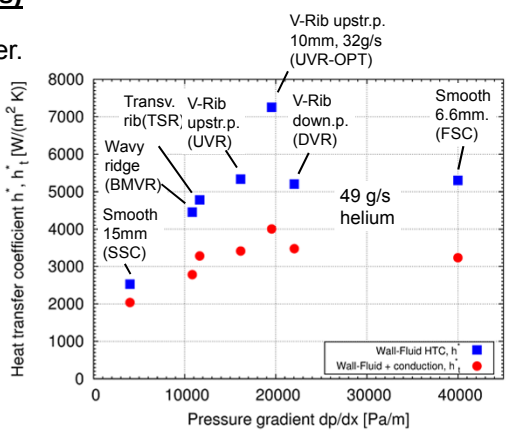
Transv. Ribs. (TSR)



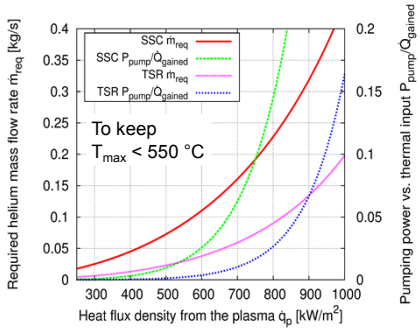
V-Ribs
upstream pointing : UVR
downstream pointing DVR



- *Ribs induce turbulence & vortices*
- *Transversal ribs:*
  - o *T_{max} decreases by 140K !*
  - o *ΔT decreases by 160K*
- *V-Ribs :*
  - o *induce also secondary flows*
  - o *increase HTC even more*
- *Mixing can be forced by swirl tapes or waved ridges.*



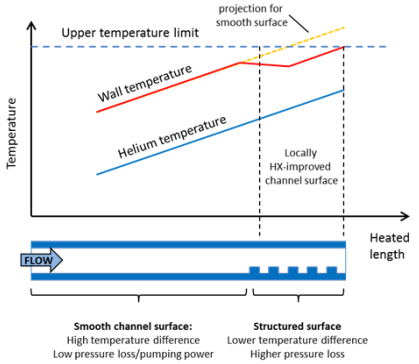
Comparison of performance of FW channels



Required mass flow rate and pumping power

Impacts of heat transfer enhancement on First Wall design

- At the same mass flow rate, we can **drastically reduce the wall temperature**. and **increase component lifetime** (creep, fatigue).
- The range of **permissible heat flux densities** is extended to **about 1MW/m²**.
- **Thermal stresses** can be **reduced** by decreasing ΔT in the component.
- **For a specified wall heat flux, only ~20% of the pumping power** are required compared to the smooth surface channel (due to flow rate reduction).
- Fabrication feasibility has been demonstrated. (Neuberger et al., 2015).



Optimized application of enhanced HTC f. FW

Outlook

- CFD simulations with Reynolds Averaged Navier Stokes approach are significantly challenged by the involved fluid dynamics : **High quality methods** like Detached Eddy Simulations to be employed (See 3.002, P0302, S. Ruck).
- **HETREX experiments** series at KIT to validate CFD methods and designs.
- Optimized **application to the First Wall** in helium cooled DEMO BB designs.