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LES investigations on High Reynolds Number Helium cooled Rib structured Channels for the DEMO First Wall

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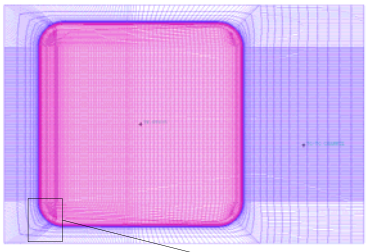
AIMS

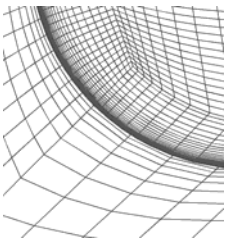
- **Using variable ribs** (different rib-height-to-hydraulic-diameter ratio e/D_h and the rib-pitch-to-rib-height ratio p/e = 10 with less as possible pressure loss to **keep the Eurofer temperature below 550°C with minimal pressure loss**
- Gain information about the feasibility and the necessary resources (processor power, RAM, time) to calculate high Reynolds large scale First Wall related CFD problems and identifying mesh coarsening possibilities to **reduce mesh count and simulation time**



Fluid:
4546934
Hexaeder +

Conformal Interface

Nonconformal interface



Solid
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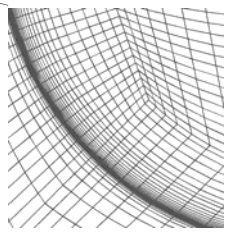
Hexaeder



Solid
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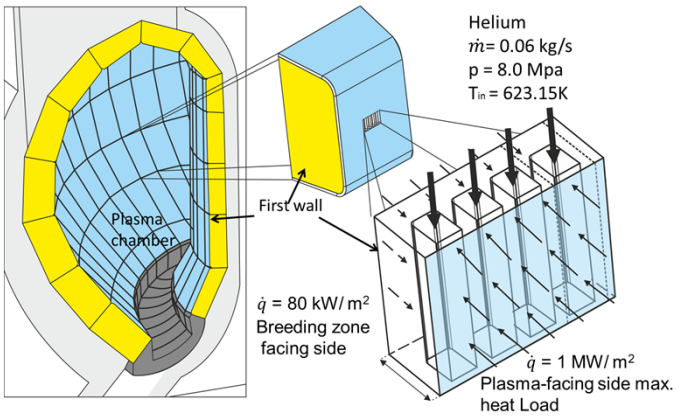
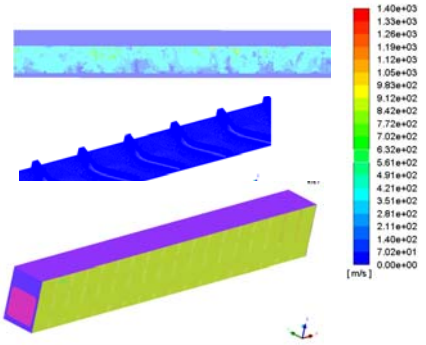
Hexaeder



*Picture modified [1]

Precursor RANS (k-ω-SST)
Steady state with fully turbulent velocity inlet profile, then Transient with periodic boundary conditions, then LES (dyn. Smagorinsky)

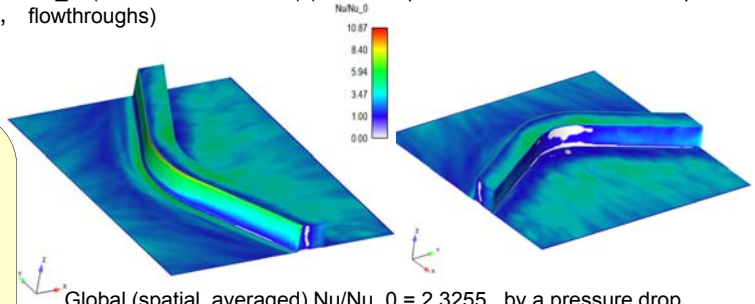
Problem: Re = 156539
requirement mesh resolution for LES [Menter] von Δx^+= 40−60, Δy^+ = 20−30 und Δz^+ = 20−30 > simulation cell count ~ Re^3 and step $\Delta t \sim Re^{-2}$, $\Delta t < CFL * \frac{\Delta x}{u_m} = 3{,}6 * 10^{-7}$ s



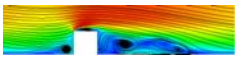
162 mm first wall piece (18 ribs)
- 100'720'000: Hexaeder
48 Processor Server of KIT needs 700 days for a single flow-throughs
(7000 timesteps/ flow-through)
- Complete first wall channel 1'333'100'000 Hexaeder
Not feasable with hardware KIT infrastructure
- single rib LES simulation to identify zones of possible mesh coarsening potential; Flowthrough time 0.5-2 days on a 16 processor Computer

Preliminary Results: (Conformal Interface Case)

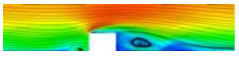
Local Nusselt number Nu normalized by a smooth channel Nusselt number Nu_0 (Gnielinski correlation) (Time sampled: 1.156E-4 s, 320 timesteps, 5 flowthroughs)



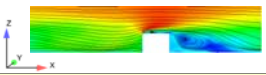
Global (spatial averaged) Nu/Nu_0 = 2.3255, by a pressure drop DP normalised by pressure drop determined analytically with Gnielinski correlation of DP/DP_0 = 4.6 for the Conformal Interface Case, only Nu/Nu_0 = 1.3



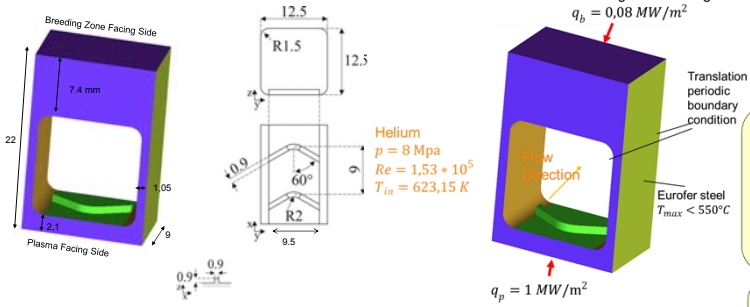
y = 0



y = 2 e



y = 4 e



Geometric details, boundary conditions

Conclusions:
The results of the LES Simulations with conformal mesh show good agreement with literature. The simulation with non–conformal interface showed bad convergence and imbalance problems in the corners and mesh needs an overwork.

Outlook (aspects that will be further investigated):
Within the fluid zones that can be coarsen should be identified and Embedded large eddy simulation seems a good option to reduce cell count.

[1] S. Ruck, F. Arbeiter, Detached eddy simulation of turbulent flow and heat transfer in cooling channels roughened by variously shaped ribs on one wall, International Journal of Heat and Mass Transfer 118 (2018) 388-401

EUROfusion
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