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Design of two experimental mock-ups as proof-of-concept and validation test rigs for the enhanced EU DEMO HCPB blanket

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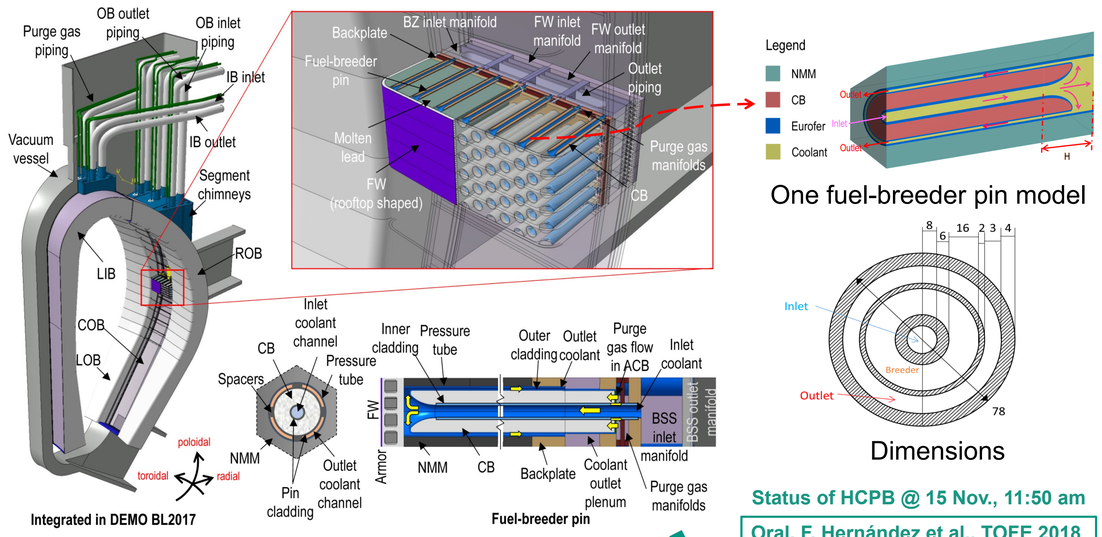
Motivations



HCPB integrated in EU DEMO BL2017 sector

Status of HCPB @ 15 Nov., 11:50 am

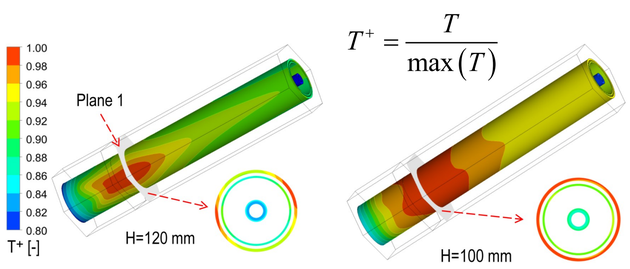
Oral, F. Hernández et al., TOFE 2018

Mock-up #1

- Gnielinski correlation and alike developed for hydraulically smooth regime not suitable.
- Few Nu number correlations ready to be used for this design.
- Experiment campaign needed to understand the heat transfer phenomenon.

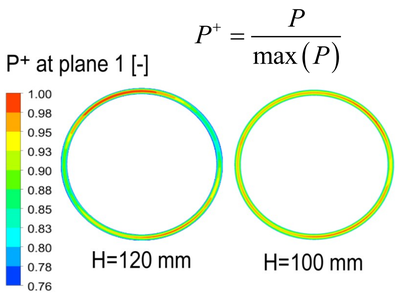
Mock-up #2

- Return flow in Annul. Chann. found non-uniform, due to gas-jet instability
- Non-uniformity affecting the temp. distribution, leading to hot spots on materials (e.g. Eurofer, CB, NMM)
- A second experiment campaign needed to obtain an optimised configuration of the reversed funnel.



$$T^+ = \frac{T}{\max(T)}$$

Dimensionless temp. comparison at different H



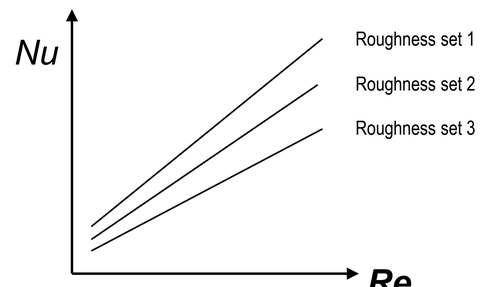
$$P^+ = \frac{P}{\max(P)}$$

Dimensionless pressure comparison

Test Matrixes

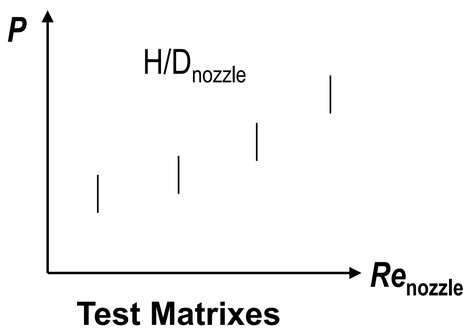
Mock-up #1

- Roughness types: tentatively 3 (hydraulically smooth, relative roughness e/D_{ann} 0.02, 0.05)
- For each, Nu as function of Re (4000, 6000, 8000, 10000, 12000)



Mock-up #2

- To investigate the influence of H (dimensionless H/D_{nozzle}) on the non-uniformity in the Annul. Chann.
- To study the impact of mass flow rate (dimensionless Re) on the non-uniformity in the Annul. Chann.



TH Parameters of Annul. Chann.

Parameters	Value
Equival. sand-grain roughness	260 μm
Mass flow rate	about 20 g/s
Velocity	about 6 m/s
Average Re number	5148
Roughness Re number	23 (transition)
Average HTC	1789 W/(m²*K)
Inlet/outlet temperature	370/520 °C

HELOKA facility characteristics

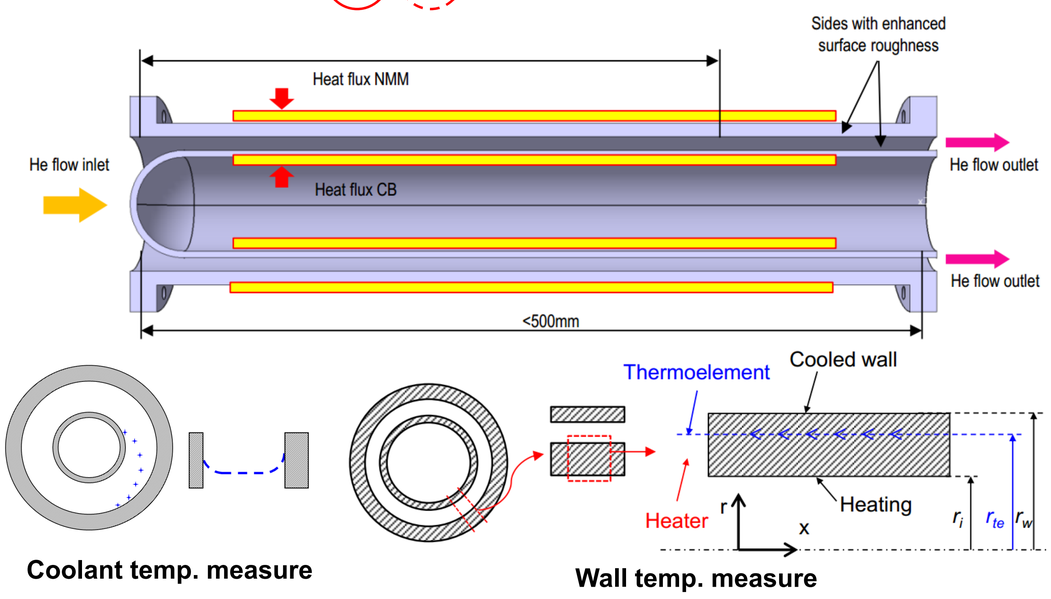
Parameters	Range
Mass flow rate for exp.	50–1400 g/s
Pressure	4–9.2 MPa
Temperature	70–500 °C
Test-object length limit	1 m

- Therefore, upscaling of the mock-ups are needed.

Design of the mock-ups

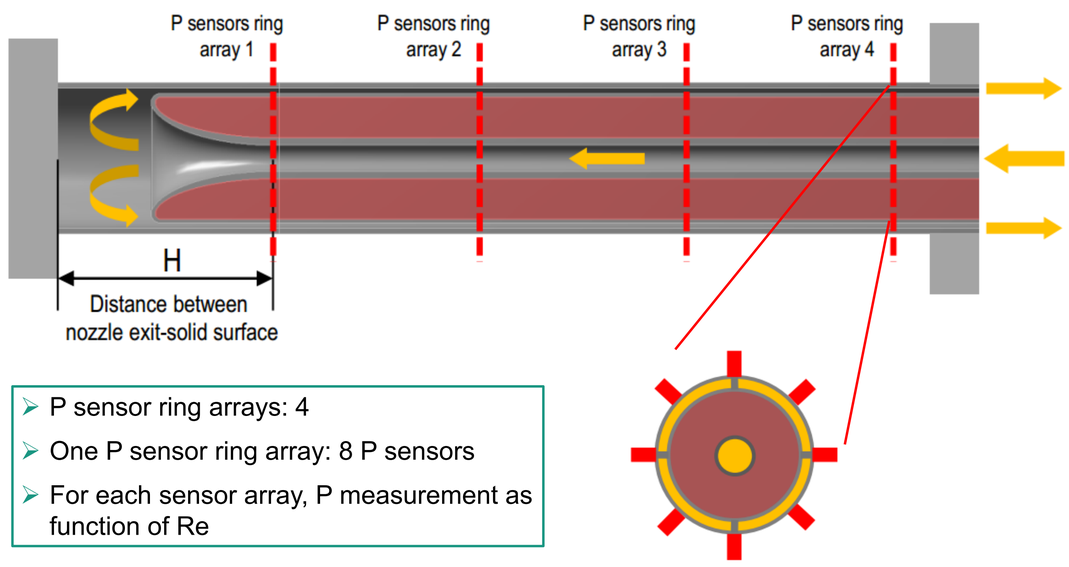
Mock-up #1

$$Nu = \frac{D_h}{\lambda} \cdot h = \frac{D_h}{\lambda} \cdot \frac{q''_w}{T_w - T_m}$$



Mass flow / Re / Standard tube	4000	6000	8000	10000	12000
DN80, DN150	28	43	57		
DN65, DN125	23.6	35.5	47.5		
DN65, DN100	21	31	41		
DN90, DN150	30	45	60		
DN150, DN200	42	63	84	104	125
DN200, DN250	54	81	108	134	161

Mock-up #2

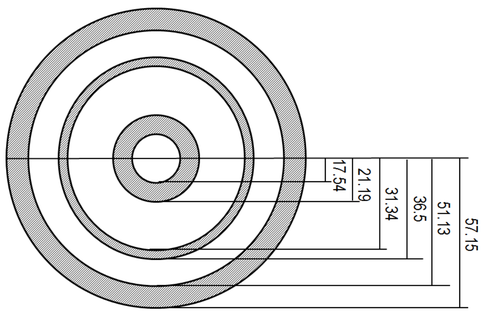


- P sensor ring arrays: 4
- One P sensor ring array: 8 P sensors
- For each sensor array, P measurement as function of Re

Upscaling

- The standard tubes DN32, DN65, DN100 are chosen.

Re_{nozzle}	30000	50000	70000	90000
Mass flow rate [g/s]	57	95	133	171
H/D_nozzle	3	4	5	6
H [mm]	105.24	140.32	175.4	210.48



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