Max-Planck-Institut für Plasmaphysik

Thermal loading test of a Wendelstein 7-X pumping gap panel

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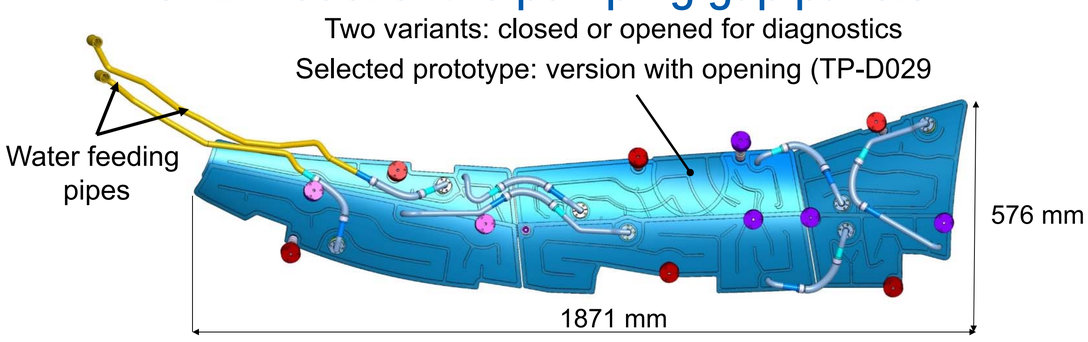
Abstract/Motivation

- For the upcoming long pulse operation phase "OP2" of Wendelstein 7-X (W7-X), new water cooled non planar stainless steel panels have been manufactured to protect the wall of the plasma vessel behind the divertor pumping gap
- A panel is made of a machined ground plate with channels which are covered by likewise machined sheets. The latter are electron-beam welded to the ground plates
- There are 60 panels of 7 different types which are designed to remove a stationary heat flux up to 100 kW/m². The specified water cooling conditions are: 2.5 MPa inlet pressure, 30°C inlet temperature, and 0.27 ℓ/s flow rate.
- A panel prototype has been manufactured and thermal loaded in the facility SIRHEX at the KIT to about 100 kW/m² to validate the design and manufacturing process.
- The results of the loading experiment and of the comparison to simulation performed with the software ANSYS® CFX are presented.

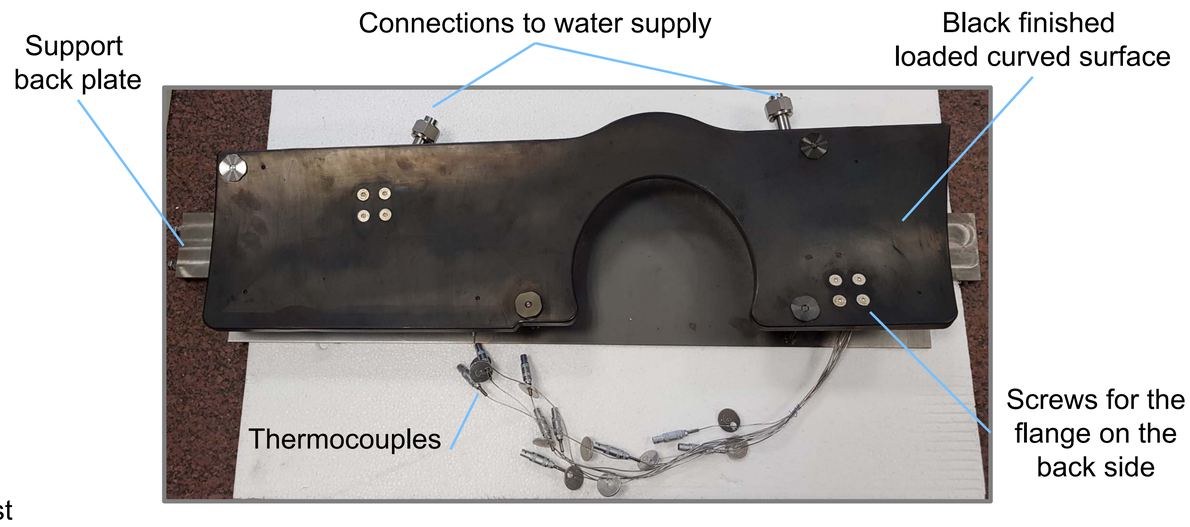
CAD Model of the pumping gap panels



Arrangement of 6 curved panels of one divertor pumping gap
The panels are hydraulically connected in series: Q = 0.27 ℓ/s, T_{in} = 30°C, P_{in} = 2.5 MPa
Designed to remove 100 kW/m², stationary

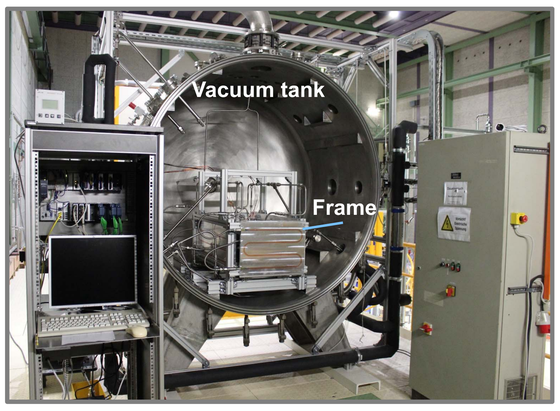
Full-scale Prototype

Back side of panel prototype TP-D029 - Preparation phase for thermal test
Cooling channel: 5 mm depth, 18-22 mm width

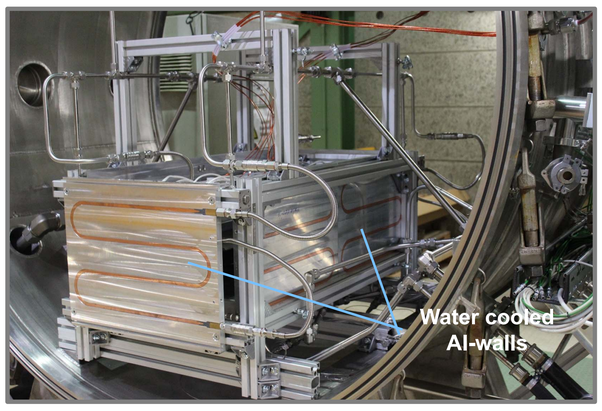


Completed panel prototype TP-D029 (0.11m²) equipped with thermocouples on the back side for testing

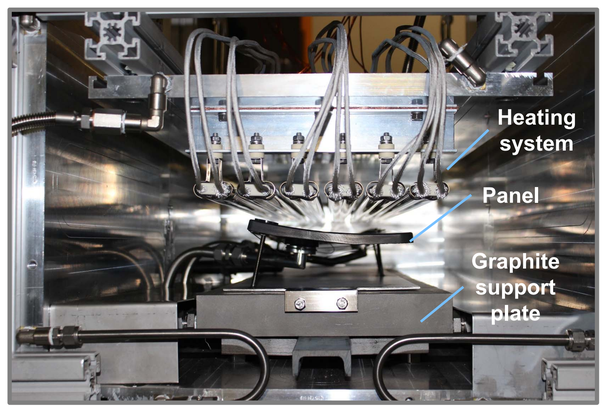
Thermal loading test in SIRHEX



SIRHEX: opened tank

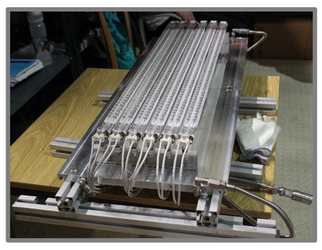


Frame in which the panel prototype is installed



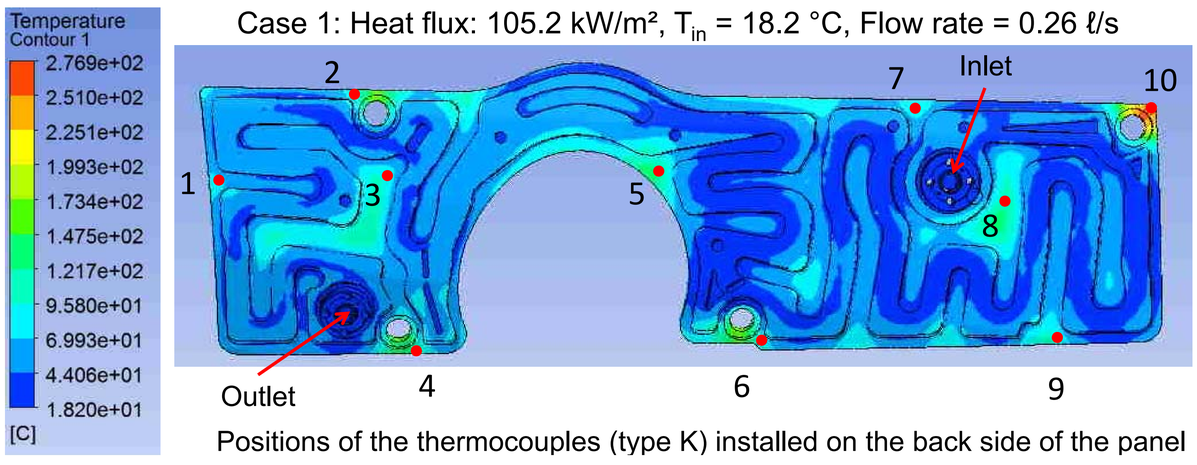
Heating system positioned above the panel

Heating system: arrays of infrared lamps (910mm long, 6x16kW)

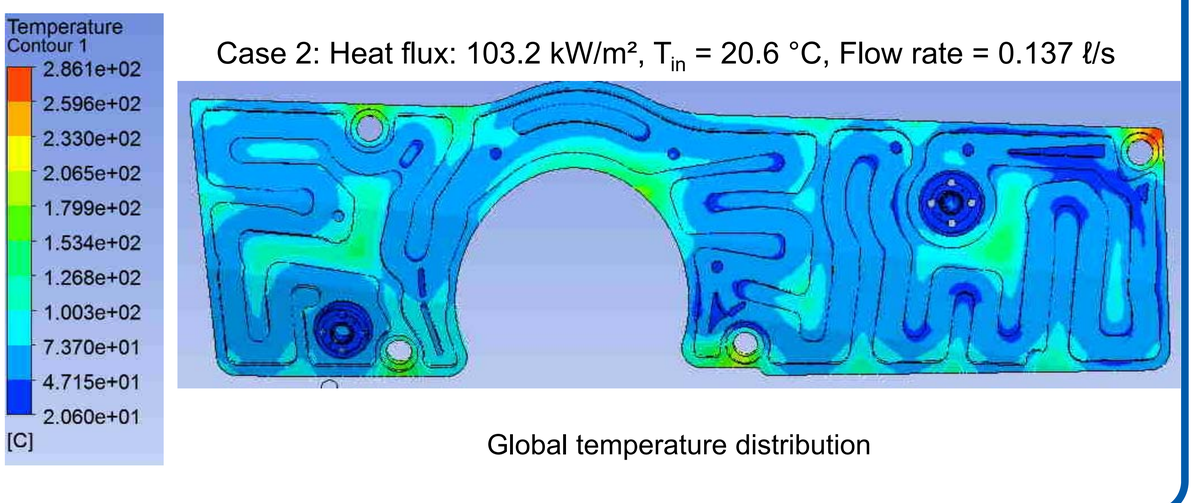


Panel positioned on its support

Comparison with simulation



Positions of the thermocouples (type K) installed on the back side of the panel



Global temperature distribution

Comparison between measurements and calculation of thermocouple temperatures

	Thermocouple [°C]	1	2	3	4	5	6	7	8	9	10
Case 1	Measurement	61	110	85	134	142	89	96	104	98	250
	Calculation	70	120	95	140	130	90	90	110	95	250
Case 2	Measurement	75	126	100	152	159	103	108	115	108	255
	Calculation	85	130	110	150	155	100	110	125	110	260

Conclusions

- A full-scale prototype has been successfully tested in the SIRHEX facility at KIT
- A good agreement between ANSYS® CFD simulations and measurements has been found
- The water-cooled panel is able to withstand 100 kW/m² under stationary conditions
- The design of the cooling channel allows a quite homogeneous surface temperature distribution and sufficient cooling at the edges
- Results of the thermal loading test validate the design and manufacturing process of the pumping gap panels for the next operation phase (OP2) of W7-X

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