Karlsruhe Institute of Technology

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Steady state and transient thermal-hydraulic performance of the IFMIF-HFTM irradiation rigs and containers with modeling of nuclear heating

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Background: International Fusion Materials Irradiation Facility (IFMIF) High Flux Test Module (HFTM)

➔ a dedicated device to irradiate material small specimens with neutrons having an energy spectrum peaked near 40? MeV with annual doses in the range of 20 - 150 dpa (displacement per atoms per fullpower year) ➔ Design database for DEMO

Experiments:

HFTM "single-rig" (HFTM-SR) experiments ➔ a single 1:1 irradiation rig model is tested, the neighboring rigs were modeled with heater plates

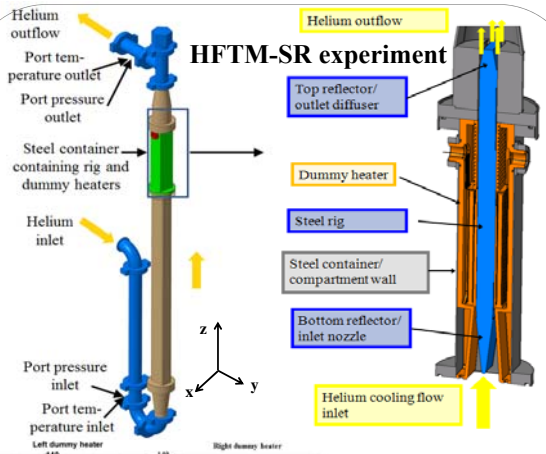
HFTM "double compartment" (HFTM-DC) experiments ➔ a fully equipped prototype with three heated rigs was tested. Heater cartridges substitute the nuclear heating.

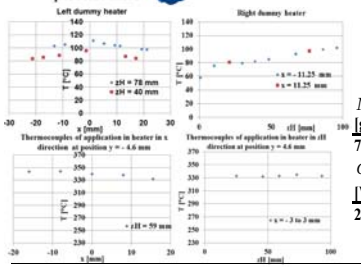
Aims:

➔**uniformity of temperature fields** under different heater and flow conditions with and without nuclear heaters

➔**temperature spread** measured should be **less +/- 3% of the nominal absolute temperature (+/- 19 K for 350 °C)**

HFTM-SR experiment

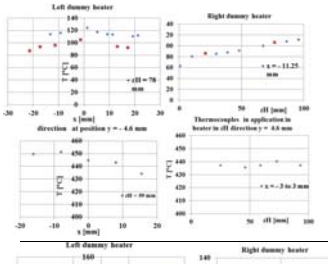




T_{Cap} = 350 °C

$\dot{M}$ [g/s]	T_{Cap} [°C]	T_{in} [°C]	T_{out} [°C]
7.93	350	32.66	79.72

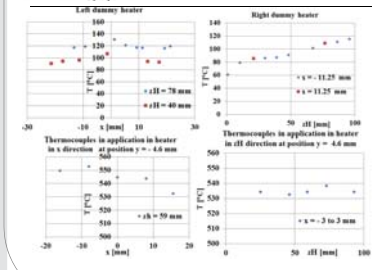
$\dot{Q}$ [W]	T_{mean} [°C]	ΔT_x [°C]	ΔT_z [°C]
2139	339.5	4.04	1.08



T_{Cap} = 450 °C

$\dot{M}$ [g/s]	T_{Cap} [°C]	T_{in} [°C]	T_{out} [°C]
7.93	450	37.07	99.01

$\dot{Q}$ [W]	T_{mean} [°C]	ΔT_x [°C]	ΔT_z [°C]
2762	441	6.08	1.52

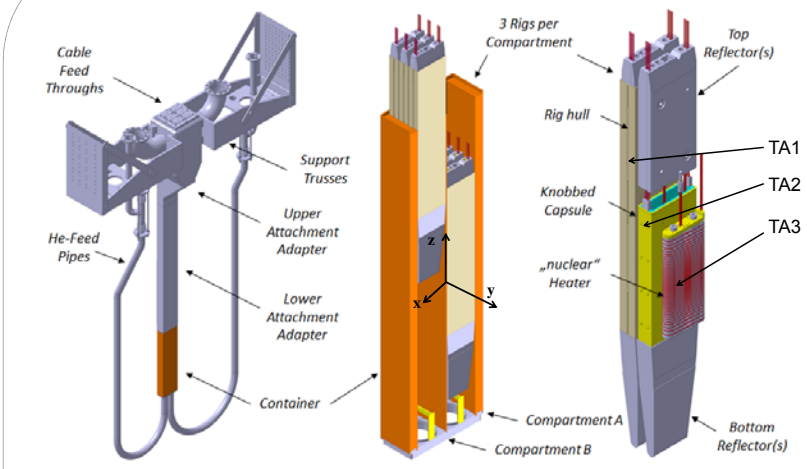


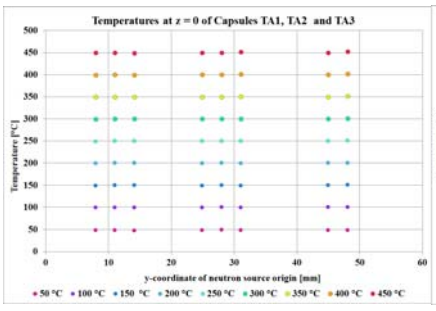
T_{Cap} = 550 °C

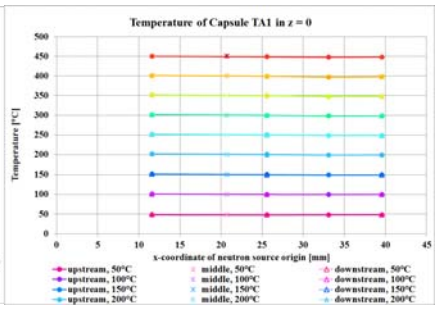
$\dot{M}$ [g/s]	T_{Cap} [°C]	T_{in} [°C]	T_{out} [°C]
7.93	450	37.07	99.01

$\dot{Q}$ [W]	T_{mean} [°C]	ΔT_x [°C]	ΔT_z [°C]
2762	441	6.08	1.52

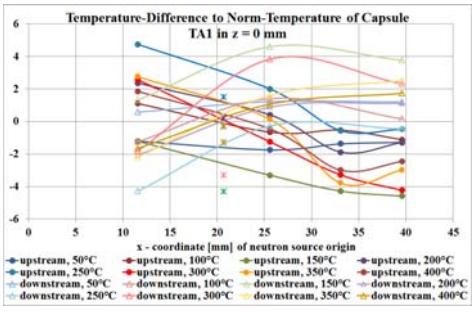
HFTM "double compartment" (HFTM-DC)



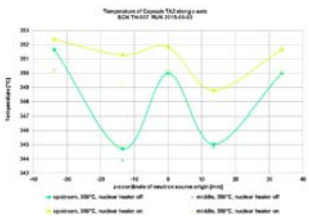




Steady state all capsules same temperature level, mass flow 14.6 g/s, pressure 2.6 bar abs



Steady state all capsules same temperature level, mass flow 14.6 g/s, pressure 2.6 bar abs



Steady state, capsule nominal temperature 350 °C , mass flow 14.6 g/s, pressure 2.6 bar abs

Conclusions:

- The full range of operation temperatures (250 - 550°C) required for the IFMIF HFTM could be well achieved and well controlled with and without "nuclear" heater power in HFTM-SR and HFTM-DC experiments
- Uniform temperature fields under different heater and flow conditions
- Temperature spread measured inside a capsule is in the range of +/-3K in the lateral x direction and +2K / -8K in the vertical z direction for the 350°C reference case for HFTM-DC experiment
- No unforeseen thermal hydraulic effects like oscillations, hysteresis etc.
- The pre-heating to 350°C: 135 sec., cool down to 50 °C roughly 315 sec.