THERMO-HYDRAULIC TEST OF THE MODERATOR CELL OF LIQUID HYDROGEN COLD NEUTRON SOURCE FOR THE BUDAPEST RESERCH REACTOR

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ABSTRACT

Thermo - hydraulic experiment was carried out in order to test performance of the direct cooled liquid hydrogen moderator cell to be installed at the research reactor of the Budapest Neutron Center.

Two electric hearers up to 300 W each imitated the nuclear heat release in the liquid hydrogen as well as in construction material. The test moderator cell was also equipped with temperature gauges to measure the hydrogen temperature at different positions as well as the inlet and outlet temperature of cooling he gas. The hydrogen pressure in the connected buffer volume was also controlled.

At 140 w expected total heat load the moderator cell was filled with liquid hydrogen within 4 hours. The heat load and hydrogen pressure characteristics of the moderator cell are also presented

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Thermo-hydraulic Test of the Cold of Liquid Hydrogen at the Budapest Research Reactor

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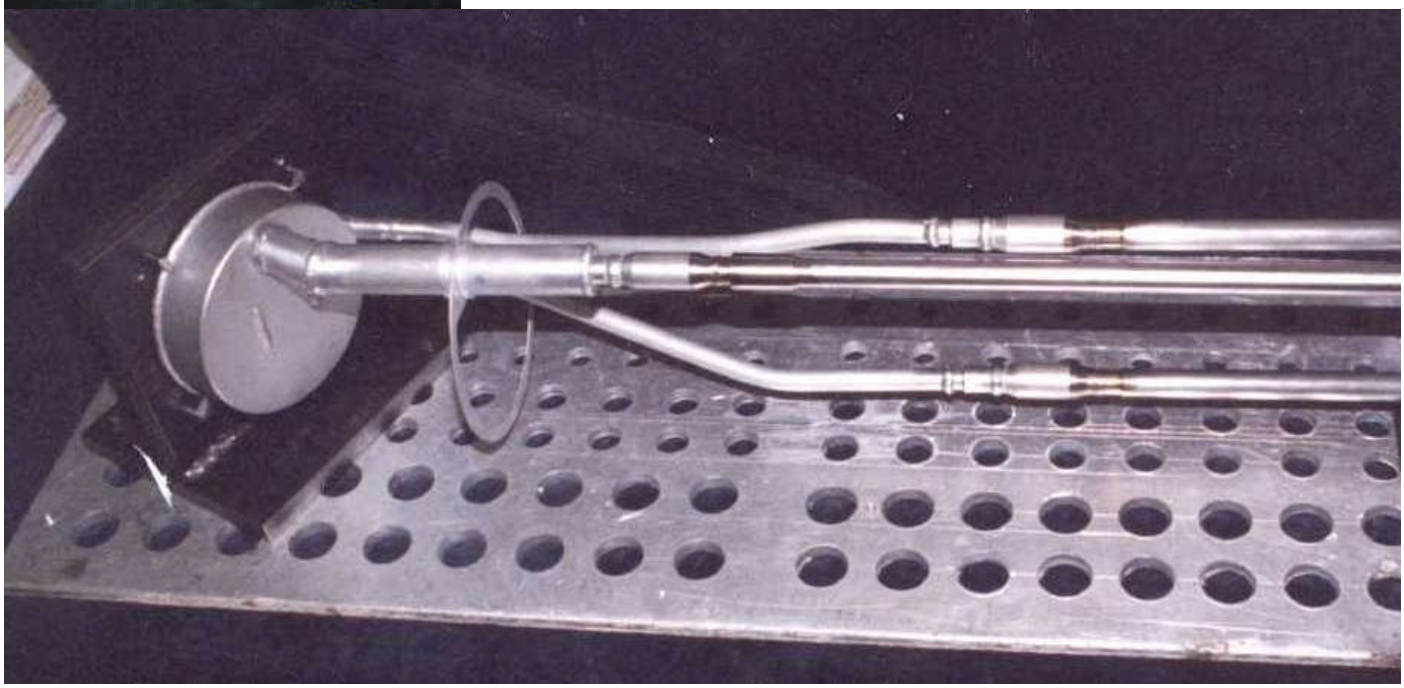
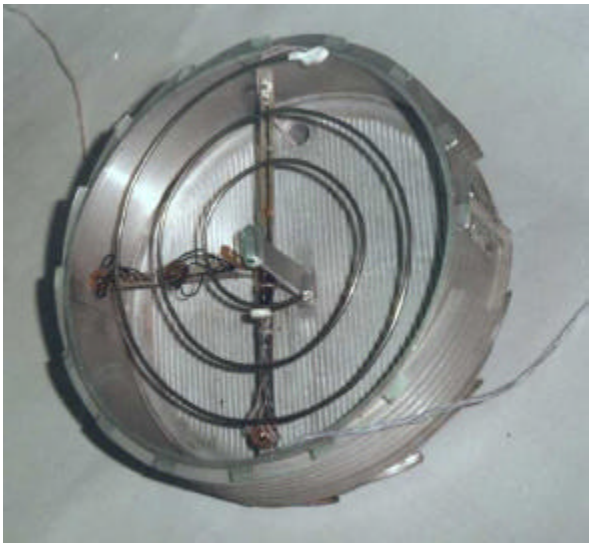


LH_2 Moderator Cell

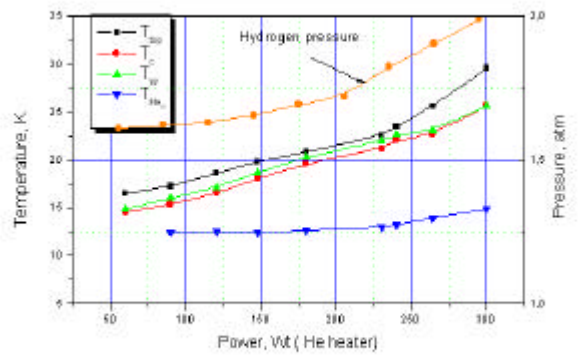
The inner part of moderator cell with electric heater of walls

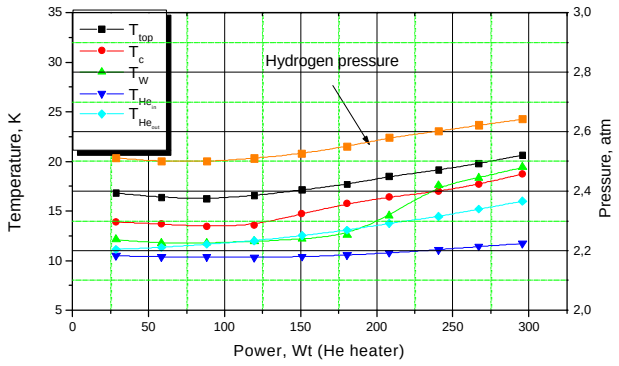


The electric heater of hydrogen inside the moderator cell

The position of hydrogen temperature gauges inside the moderator cell:

T_{top} - at the top; T_c – in the central part, T_c – near the wall

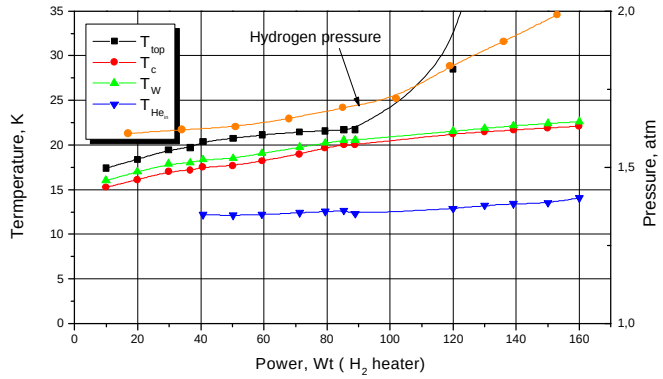


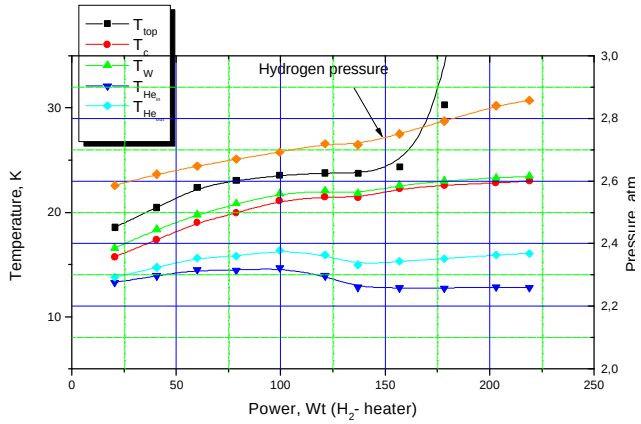


First test

Second test

H_2, He temperatures and H_2 pressure in function of heat load in cell walls

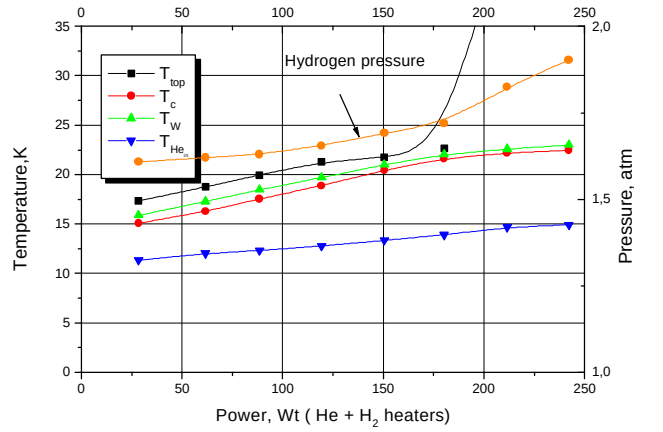


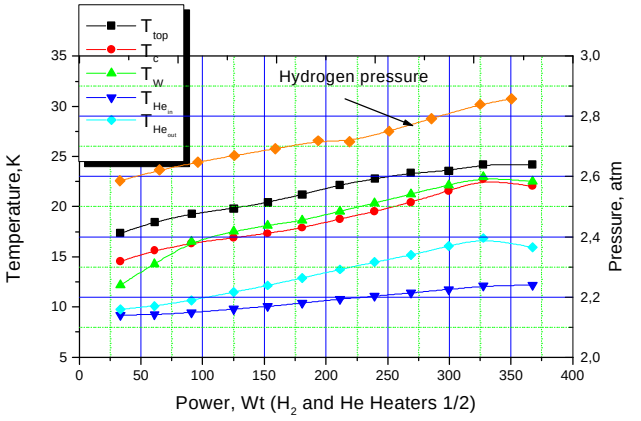


First test

Second test

H_2, He temperatures and H_2 pressure in function of heat load in H_2

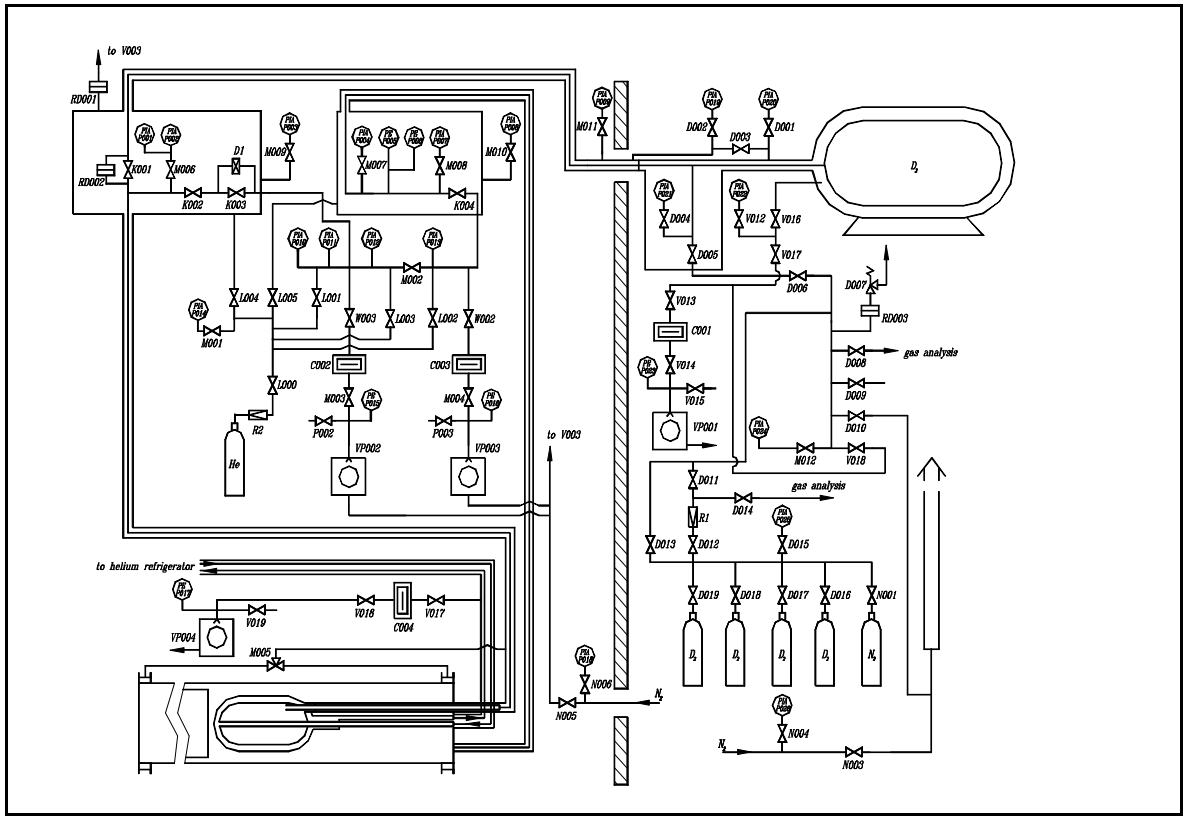




First test

Second test

H_2, He temperatures and H_2 pressure in function of heat load in walls and H_2


to V003
RD001
RD002
K001
K002
K003
K004
M006
M007
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M009
M010
M011
D1
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L001
L003
L002
M002
M001
W003
W002
C002
C003
L000
M003
M004
R2
He
P002
P003
VP002
VP003
to V003
to helium refrigerator
VP004
V019
V018
V017
C004
M005
N006
N005
N2
D002
D003
D001
D2
D004
V012
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V017
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V013
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gas analysis
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D009
VP001
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M012
V018
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gas analysis
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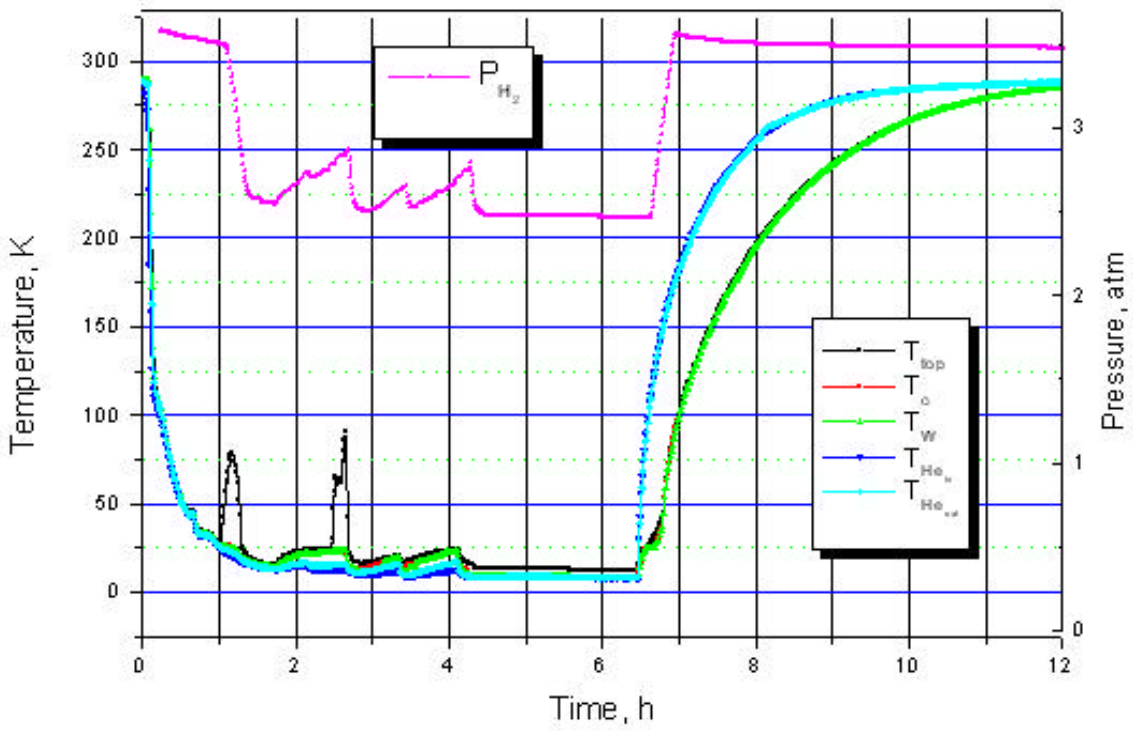
Scheme of thermo-hydraulic test setup



Change of temperatures (T_{top} T_c T_c hydrogen, T_{Hein} T_{Heout} cooling helium) and hydrogen pressure (P_{H2})during thermo-hydraulic test

Parameter		**Project value**	**First test**	**Second test**
Working medium		H_2	H_2	H_2
Volume of moderator cell,	*l*	0.35	0.44	0.44
Heath load in LH_2,	*W*	23 (49*)	50	100
Heath load in the cell walls,	*W*	40 (93*)	100	200

Total heat load,	*W*	83 (142*)	150	300
Additional heat load,	*W*		7-10	7-10
Hydrogen buffer volume,	m^3	0.5	0.48	0.24
Pressure in the vacuum case,	*torr*	1.0×10^{-5}	1.0×10^{-4}	1.0×10^{-4}
Pressure in warm H_2loop,	*MPa*	0.3	0.25	0.35
Pressure in cold H_2loop,	*MPa*	0.15	0.169	0.28
Boiling temperature of hydrogen,	*K*	21.8	22.2	24.24
Temperature hydrogen,	*K*	20.2	21	21.9
Cold helium parameters				
mass flow,	*g/s*	10.0	~8	~14
pressure,	*MPa*	0.15	0.14	0.195
inlet temperature,	*K*	14.0	13.5	11.8
outlet temperature,	*K*	15.0	17.0	16.0
resistance of the loop,	*kPa*	14.0	10	16.0

*- expected values

Thermo-hydraulic experiment was carried out in order to test the performance of the direct cooled liquid hydrogen moderator cell to be installed at the research reactor of the Budapest Neutron Center.

Two electric heaters up to 300 W each imitated the nuclear heat release in the liquid hydrogen as well as in the construction material. The test moderator cell was also equipped with temperature gauges to measure the hydrogen temperature at different positions as well as the inlet and outlet temperature of cooling He gas. The hydrogen pressure in the connected buffer volume was also controlled.

At 140 W expected total heat load the moderator cell was filled with liquid hydrogen within 4 hours. The heat load and hydrogen pressure characteristics of the moderator cell are also presented.

Conclusions

The thermo-hydraulic tests of LH_2 moderator cell resulted in the following conclusions.

– *The construction of direct cooled LH_2 moderator cell makes possible to remove up to 150 W heat load at the original design parameters assuring a large enough (double) safety margin.*

– *The heat removal can be increased up to 300 W with increased He flow rate at lowered temperature and smaller H_2 buffer volume.*

– *The direct cooled LH_2 moderator cell with minor improvements (lowered weight of cell, increased heat exchanger surface) can be applied as source of cold neutrons at medium class research reactors.*