Thermocycling tests by inductively heated sodium in the high temperature SOLTEC-2 facility

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SOLTEC facilities

- 1000K sodium loops SOLTEC (SOdium Loop for TEst materials and Corrosion): Material investigation and qualification for high temperature applications in CSP field
- SOLTEC-1: Steady-state/transient investigation of creep fatigue in circulating Na
- SOLTEC-2: Experimental investigation of steel erosion and corrosion
- Main technical data:
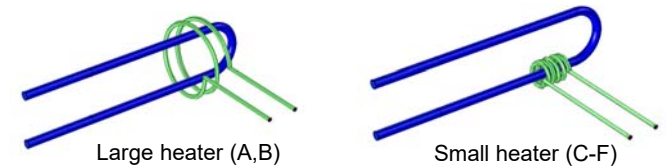 SOLTEC -1, -2: cold side 450°C, hot side 720°C @ 3.5 bar, ~14L Na, ~300 kg/h

Temperature ramp
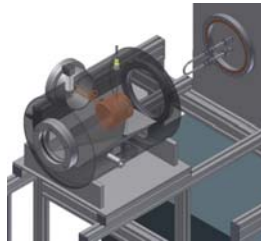
Test chamber SOLTEC-2
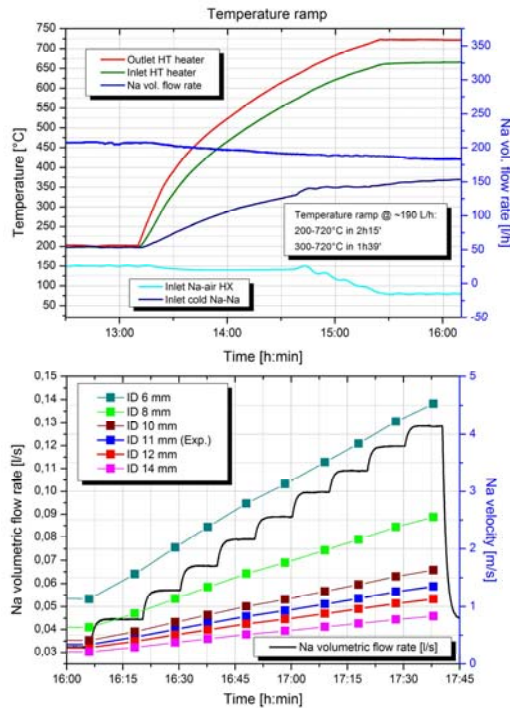
Inductive heater

- frequency range: 150-400 kHz;
- maximum voltage: 300 Vrms;
- maximum active power: 6 kW;
- maximum reactive current: 500 Arms

Large heater (A,B)   Small heater (C-F)

COMSOL simulation

- Calculation of electromagnetic field and induced currents for test tube and inductor (cases A to F) inside vacuum chamber → selection of case F
- CFD calculation of Na flow using SST turbulence model
- Calculation of transient heat transfer

Case	Coil parameters				Operational parameters				Heat load
	input			output	input	output			output
	R_c, mm	N	a, mm	L, µH	f, kHz	U, Vrms	I_q, Arms	P, kW	Q_m, MW/m²
A	50	5	21	1.75	150	300	180	5.2	0.03
B	50	2	21	0.61	150	221	385	6.0	0.07
C	15	2	11	0.22	150	104	500	2.3	0.49
D	15	5	11	0.44	150	195	472	6.0	0.84
E	15	5	11	0.42	400	274	256	6.0	0.59
F	15	5	8	0.45	150	200	472	6.0	1.04

Results for $\dot{V} = 200$ L/h and $T_{in} = 500$ ℃

temperature distribution in stationary stage:
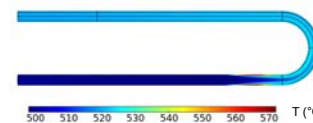

zoom to heated section:
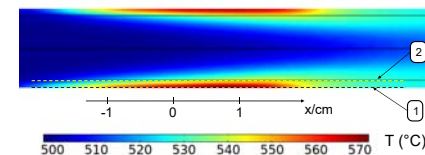
Input parameters		Results			
$\dot{V}$	T_{in}	T_{max}	T_{out}	$\Delta T/\Delta r$	$\partial T/\partial t$
400 L/h	500 °C	557 °C	510 °C	~30,000 K/m	~145 K/s
200 L/h	500 °C	569 °C	519 °C	~30,000 K/m	~155 K/s
200 L/h	700 °C	767 °C	713 °C	~25,000 K/m	~150 K/s

Conclusions

- Simulation campaign performed for the optimization of the setup of the inductive heater
- SOLTEC-2 loop with inductive heater is promising for fast thermocycling tests of receiver materials and designs under relevant conditions

T profiles during heating:
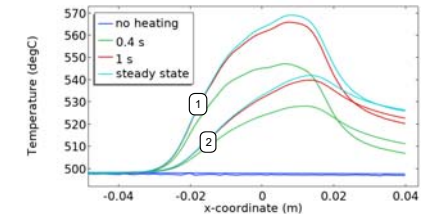
T evolution during heating/cooling: