

Infrastructure at Fraunhofer ISE for Molten Salt

Dr. Tom Fluri
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www.ise.fraunhofer.de

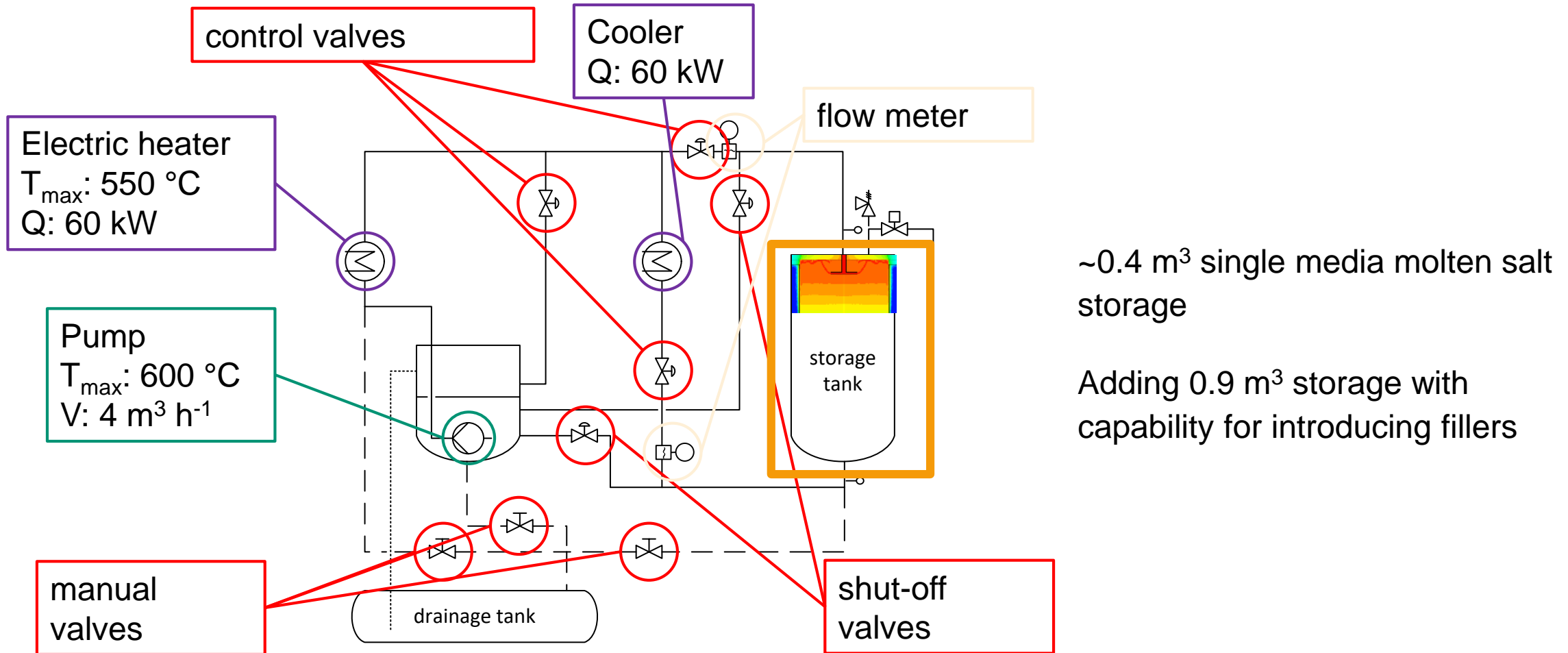
1. HTMS-Loop with molten salt thermocline sensible heat storage

High-temperature molten salt (HTMS) loop with stratified storage tank

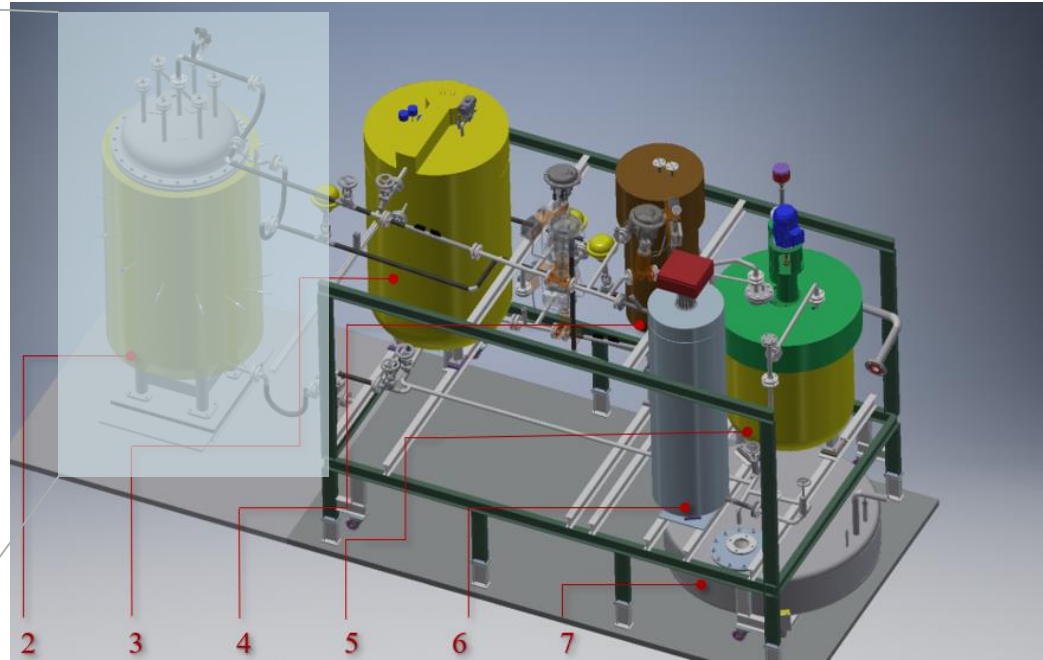
- electric heating / thermal cooling power: 60 kW
- maximum temperature: 550 °C



Molten Salt Loop - Setup



Molten Salt Loop – Extension: Vessel with Filler Material



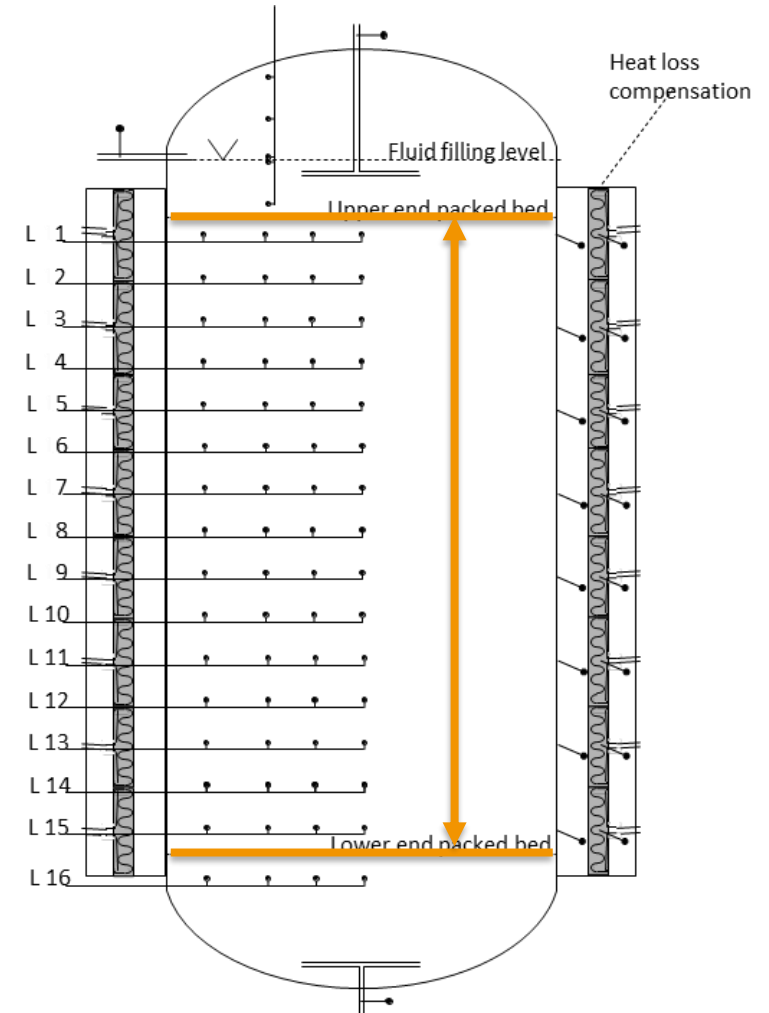
- $D = 0.8 \text{ m}$
- $H_{\text{total}} = 1.9 \text{ m}$
- $H_{\text{packed bed}} = 1.5 \text{ m}$
- No baskets, avoiding preferential flow path
→ well known boundary conditions

Molten Salt Loop – Extension: Vessel with Filler Material

■ Filling with filler material



■ Final filling level



3. Steam cycle (30 bar / 235°C max.) with eutectic nitrate salt PCM storage

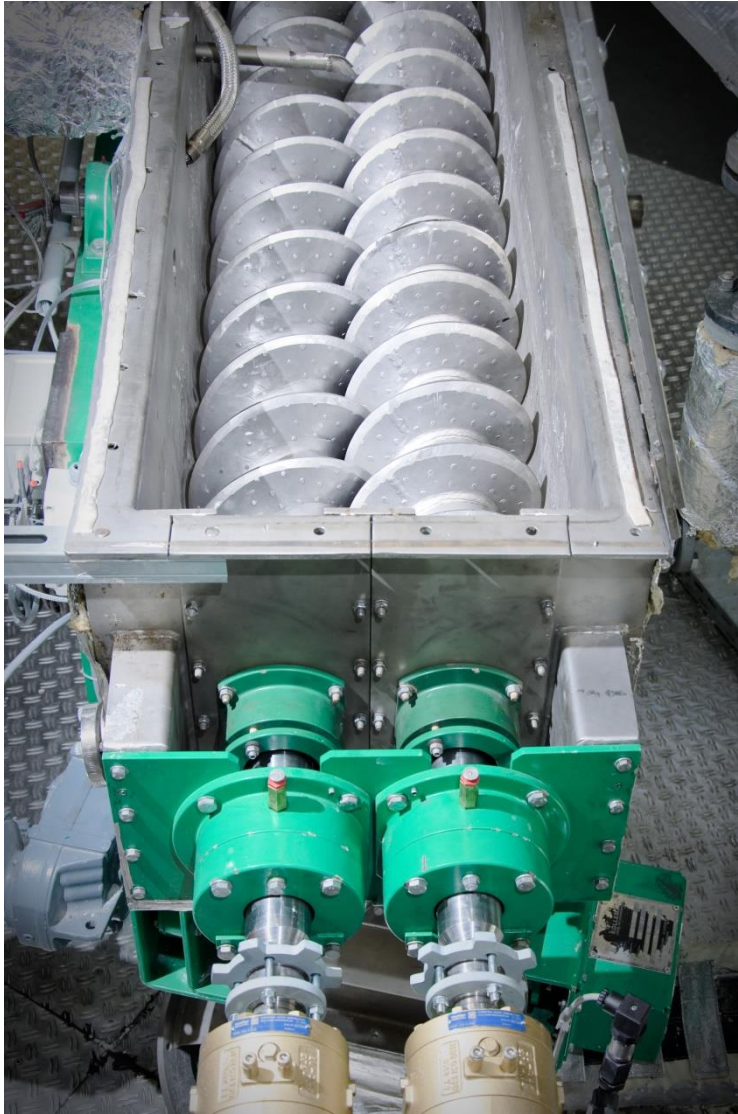
Steam facility test infrastructure



The steam facility at ISE's high-temperature lab mainly consists of:

- Evaporator / steam generator, $T_{\text{max}} = 235^{\circ}\text{C}$ / $p_{\text{max}} = 30 \text{ bar}$ / $P_{\text{th_max}} = 250 \text{ kW}$. Indirectly powered by thermal oil loop, heated by natural gas boiler
- Condenser / re-cooler for condensation of steam, $P_{\text{cool}} = 250 \text{ kW}$. Cooled by table cooler on roof

Screw heat exchanger (SHX) module (out of operation)



- Screw heat exchanger (SHX) with direct steam input / output through central helices
- Novel concept for de-coupling of storage capacity and thermal power was proven in lab-scale
- Charging procedure: Steam passes through center of helices, melting up eutectic salt mixture
- Discharging procedure: Liquid salt „poured“ over the helices produces steam from pressurized water passing through the center of the helices

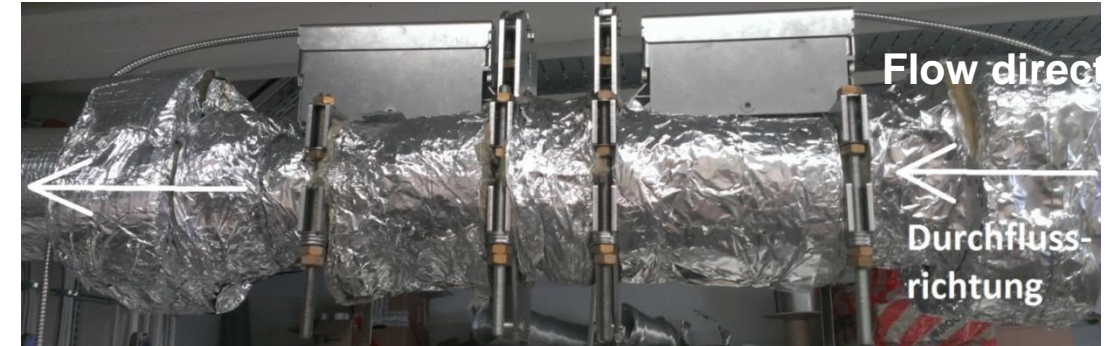
MS HT-PCM Storage (nitrate salt based)



- 2.5 m³ PCM storage module (approx. 250 kWh sensible / latent heat storage capacity)
- Charging at 30 bar / 235°C, using saturated steam from steam
- Discharging / production of steam at 175°C / 9 bar operation pressure
- Shipped to client in India

4. Salt melting vessel with pressurized air driven flow

Salt melting vessel in gauging test rig for MS flow measurement calibration



- Mobile melting vessel (500 L) for preparation of molten salt and use in batch processes
- Featuring precision valve for pressurized air inflow, allowing relatively constant MS outflow for short timespan
- Vessel used in 2019 in form of gauging test rig, i.e. for calibration of ultrasonic flow measurement device
- Volumetric flow in 1-minute time span compared to weight increase on precision scales

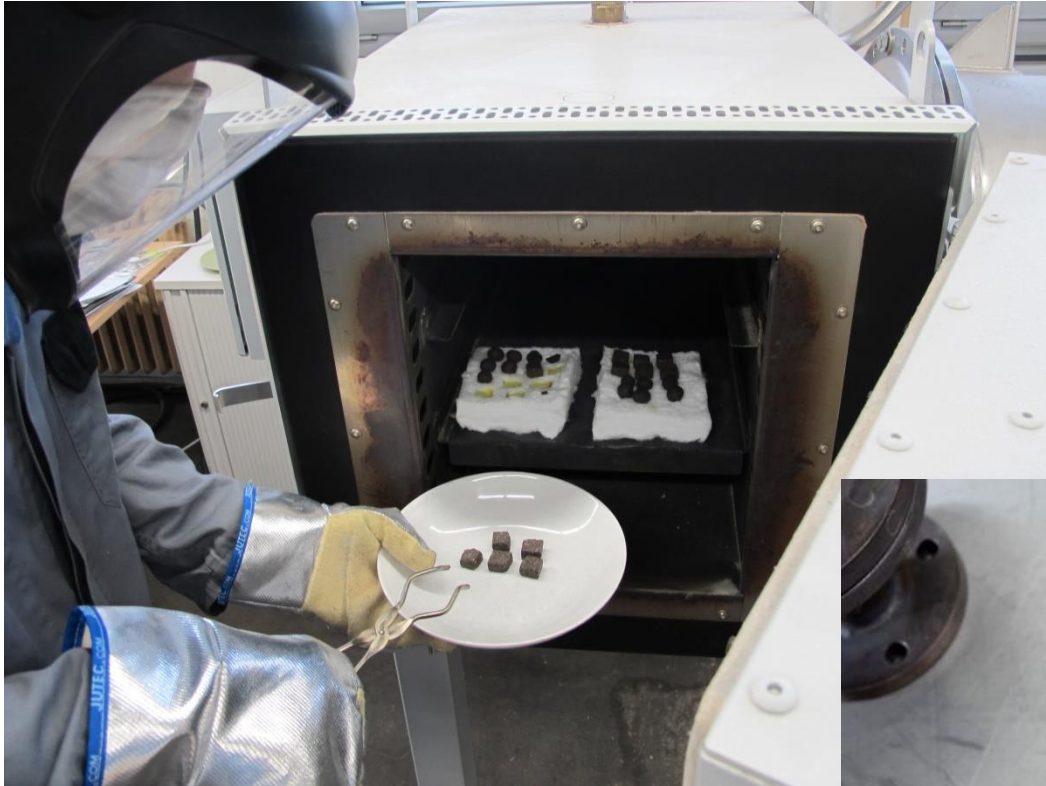
Filling procedure of salt melting vessel



- Example for (re-)filling of the melting vessel
- Pre-crushed nitrate salt (NaNO_3 and KNO_3 from 25 kg bags) in a collecting tray is put into the vessel's body via DN250 flange opening
- 3 heating circuits of 5 kW each allow melting of newly introduced, crystalline salt over night

5. HT Oven and melting vessel

High-temperature oven



- High temperature oven, e.g. for conducting compatibility tests with salt and filler material
- Max. Temperature: 600 °C



6. New test environment for component testing up to 1 MW

New test environment for component testing in MW-range

■ Molten salt loop for component testing with capacity of 1 MW

- Location: Multi-Megawatt-Lab of Fraunhofer ISE in Freiburg
- AC power availability in MW range
- Integrated steam generator

■ Project HybridKraft: development of 50–100 MW e-heater module

Testing an innovative electrical heater for solar salt

- Power of the pilot e-heater: 1.2 MW_e (690 V)
- Molten salt design mass flow rate: 2.55 kg/s
- Inlet MS temperature: 290 °C
- Outlet MS temperature: 550 °C

■ Accredited Multi-Megawatt-Lab

- In-house connection to 110 kV grid (20 kV / 40 MVA transformer)
- Highly accurate, broadband measurement up to 110 kV
- Test fields up to 7 MVA and from 260 V to 1000 V
- PV simulator (2000 V / 1.4 MW)
- High-accuracy power measurement (1000 V / 5000 A)



Contact

Dr. Tom Fluri, Julius Weiss
Climate Neutral Industrial Processes and High Temperature Storage
Fraunhofer Institute for Solar Energy Systems
Freiburg, Germany
+49 761 4588-5994
tom.fluri@ise.fraunhofer.de

Inclination angle of 3°

