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Experimental investigation of Vertical Electrical superHeater design for olivine particles in CSP

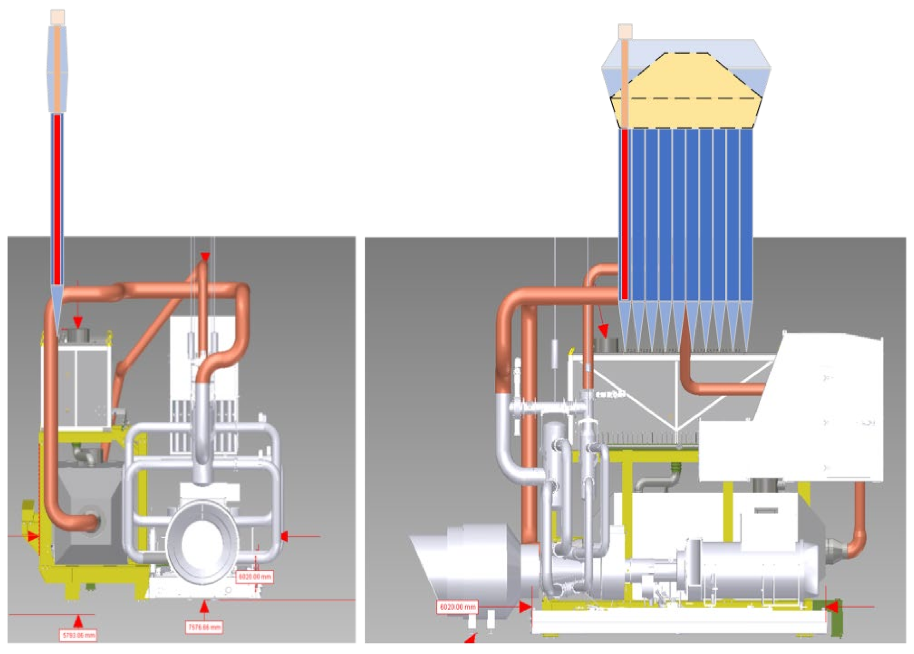
The challenges with Electrical superHeater (EH) design in the ongoing Powder2Power project are primarily related to the highly variable flow rate in the particle loop (8 to 16 t/h) and the relatively limited space for EH installation. The Vertical Electrical superHeater (VEH) design concept promised the benefits of a built-in flow adaptation, stable thermal performance for each single flow column and a flexibility of scaling up to desired total power levels.

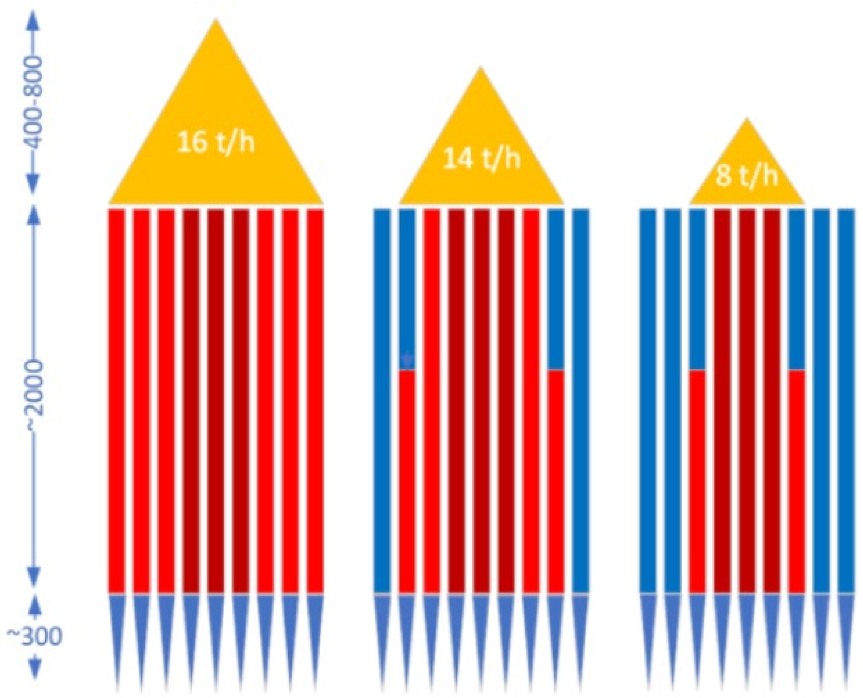
Background and VEH Concept

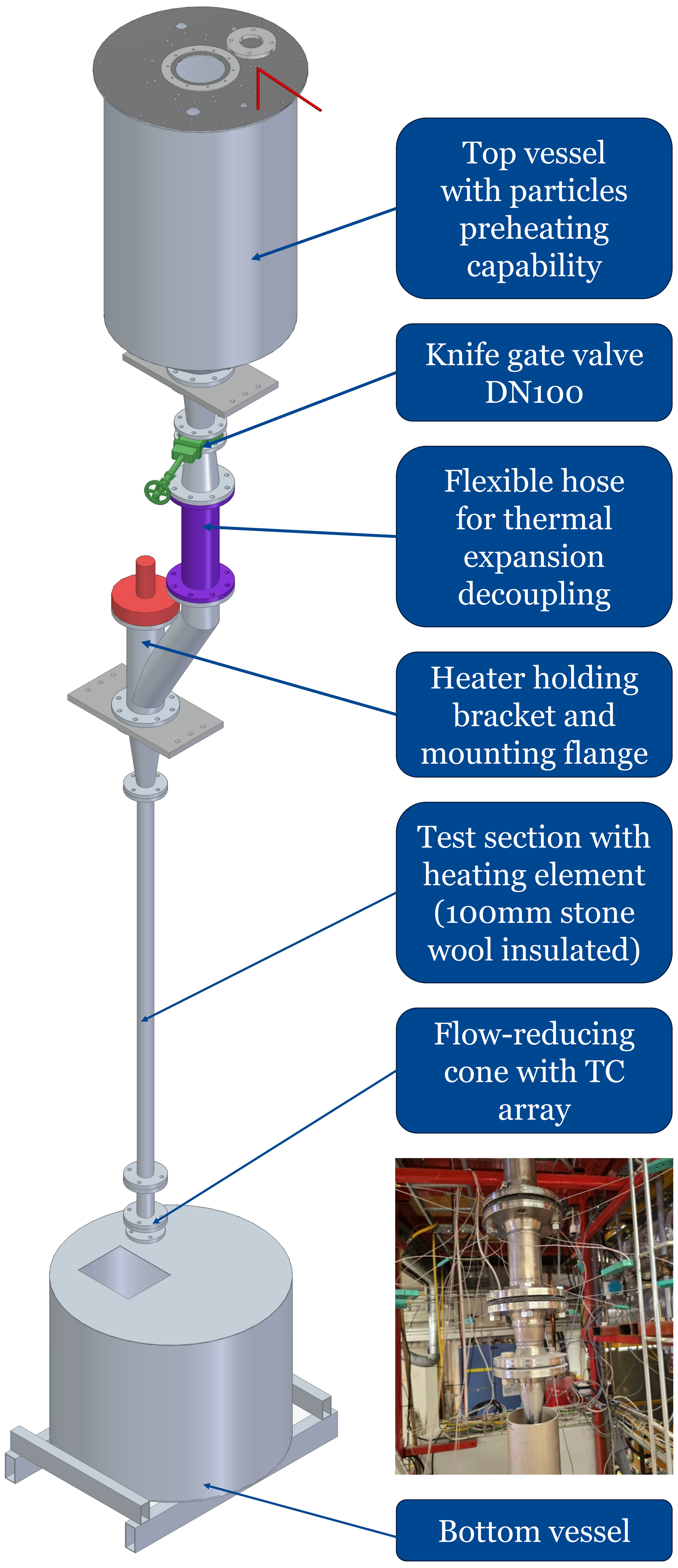
VEH comprises multiple identical flow columns made of pipes with flow restriction cones and a tubular electric heater element inside of these pipes.

VEH's dynamic flow adaptation comes from the fact that particles (discharged from the conveyor) are deposited as a pile of different sizes on top of VEH depending on flow conditions, thus engaging more or less VEH flow columns. Empty flow columns could be deactivated or partially heated, depending on the desired control approach.

The particles' moving speed in each flow column is fixed by the flow reducing cone at the bottom and thus enables stable thermal performance of each VEH column independently of the overall flow-rate.







Methodology

The main research questions of this study:

- To establish the optimal annular spacing for VEH - the gap between the heating element and pipe inner wall.
- To identify the optimal particle moving speed with the goal of reaching a desired temperature uplift of 100 °C.

The full-scale test rig of one VEH column was developed at KTH:

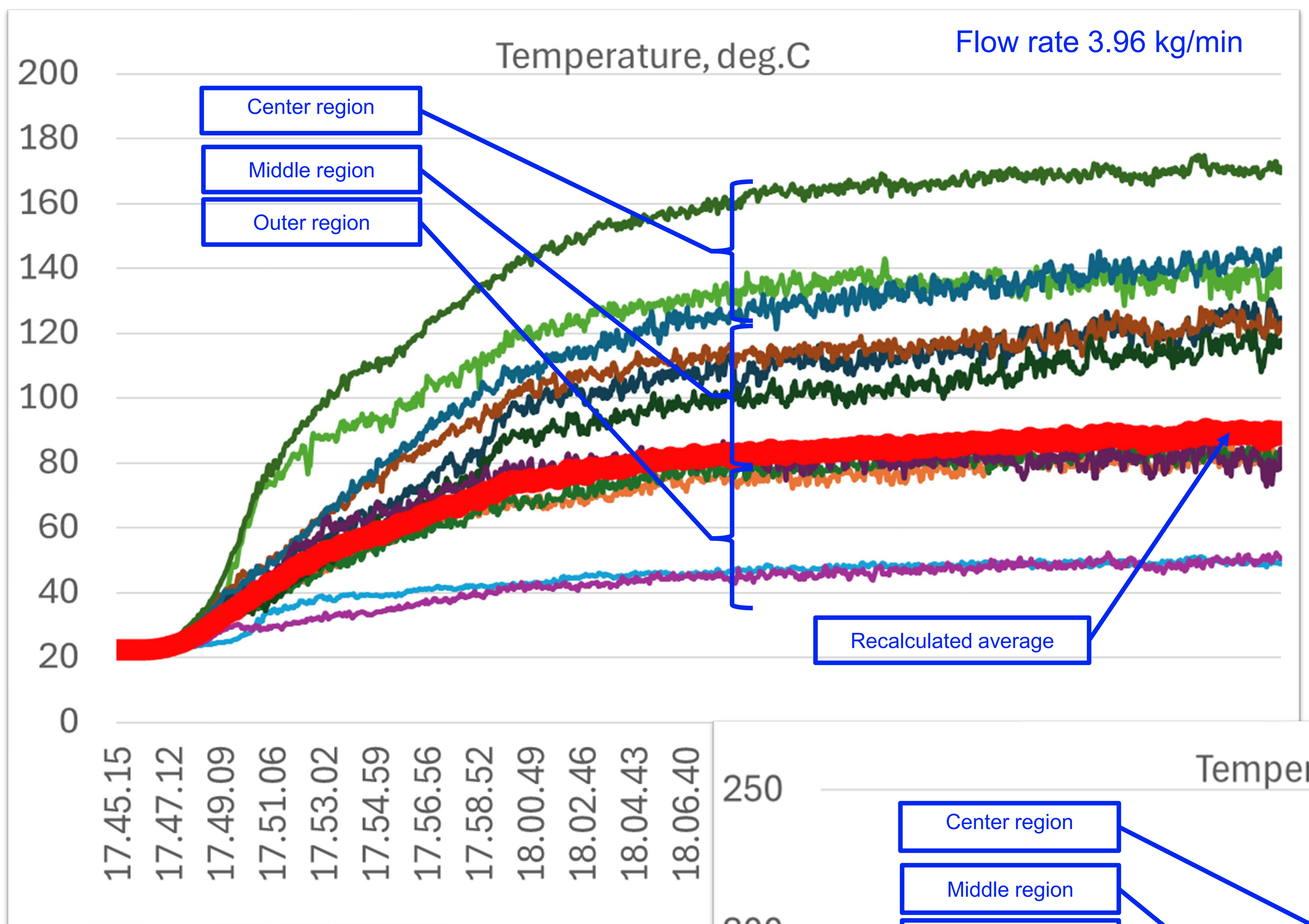
- Standard piping ISO DN65 pipe, OD=76.1mm, WT 2.9mm, SS304 1.4301
- Particles Olivine AFS 120 DS (Sibelco)

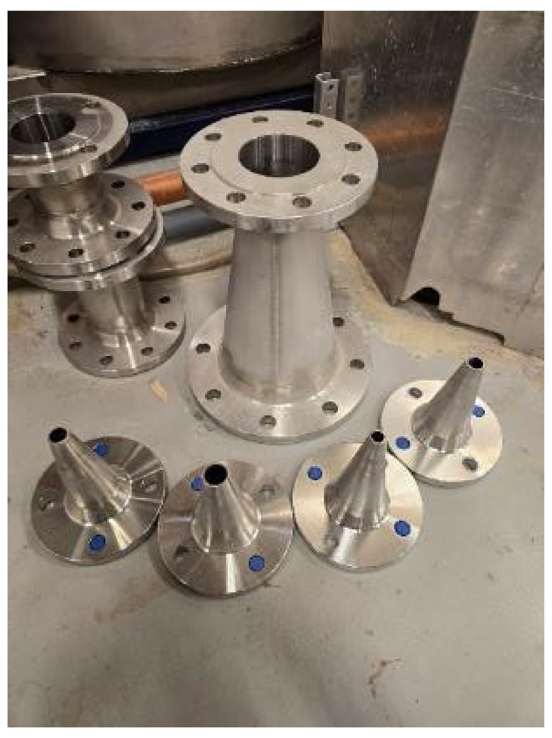
The heating element developed by SEICO:

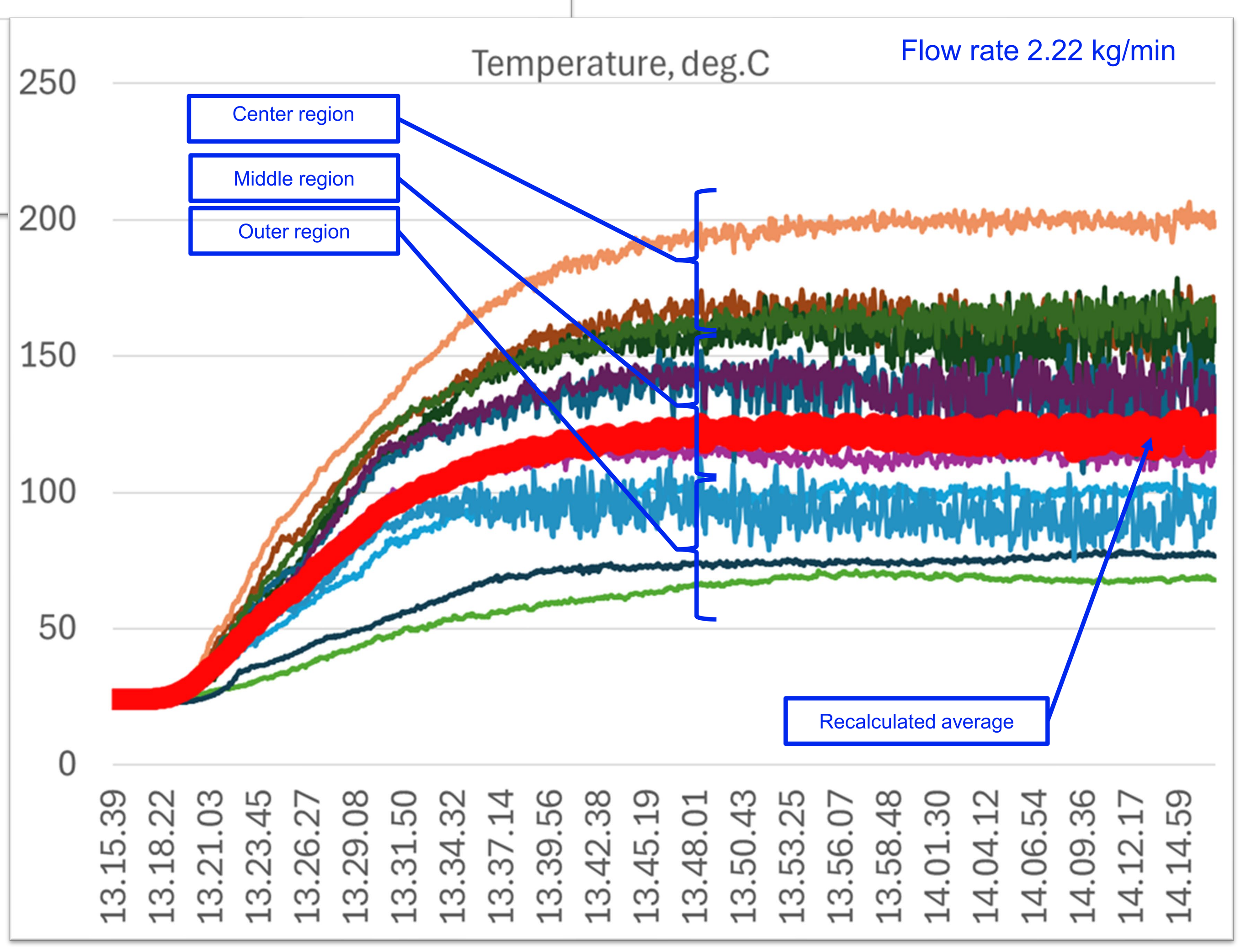
- Total length 3m, active length 1.95m
- Sheeting OD 51mm
- 3 separately controlled heating sections
- Total power of 7.65 kW
- Power density of 1.73 W/cm2

The temperature was measured using an array of type K thermocouples.

- To resolve temperature gradients in the pipe cross section, TCs were distributed across three radial regions of an equal area: center, middle, and outer regions.
- The bulk temperature is then calculated as the average of these three region's values.







Want to know more?

powder2power

Results

Representative graphs of time-resolved temperature measurements are shown for flow-reducing cones ID=17.3mm and ID=13.2mm. The recalculated average bulk temperature is also plotted.

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