



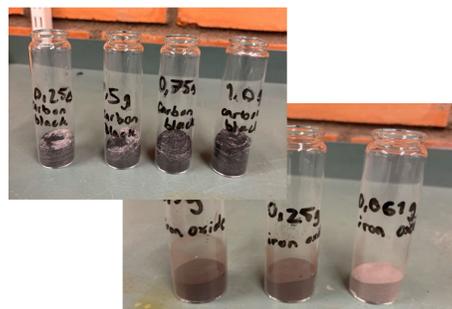
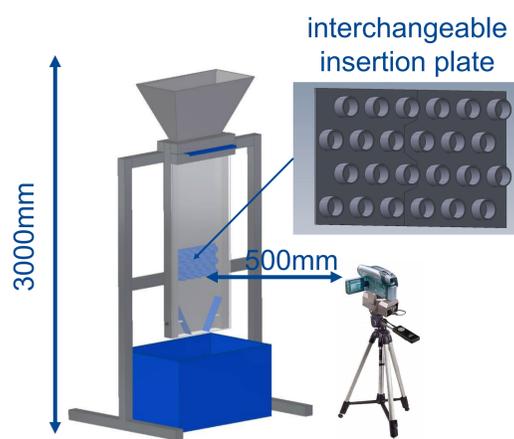
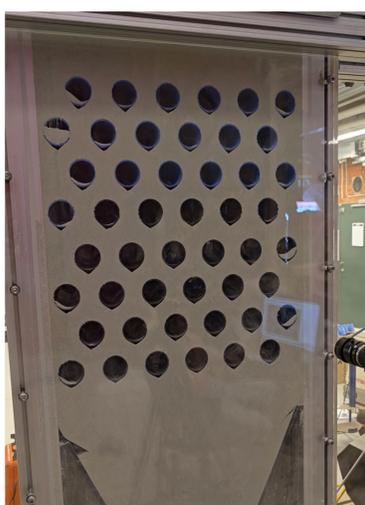
# Experimental investigation and optimisation of flow dynamics of gravity moving bed electric heater for olivine particles in CSP

Gravity-driven shell-tube heat exchangers stand out among other solid-particle HX designs due to their low cost, reduced parasitic losses, and ease of integration into various processes. For CSP applications, these heat exchangers are typically used for transferring the heat from the particle loop to the conversion cycle. However, another potential application of a heat exchanger could be for providing additional heat to the particle loop, thus increasing particle loop temperature even further. A potential method for achieving higher particle loop temperatures involves incorporating a superheater after the solar receiver, a concept explored in the MW-scale CSP prototype within Powder2Power project.

## Background

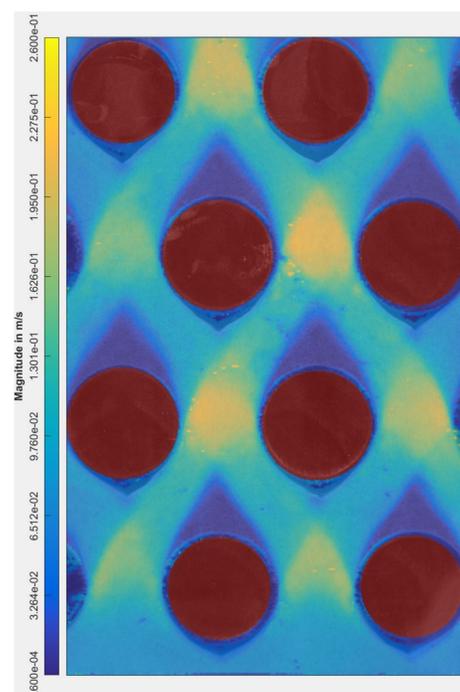
Granular or gravity heat exchangers (HX) allow for enhanced particle mixing compared to moving packed bed HX, especially in the case of horizontally placed tubular elements. In theory, this should allow for higher heat transfer coefficients. However, this comes at a cost of intermittent particle to wall contact. As a result, so-called stagnation zones on the top and void zones at the bottom of the tubular element are formed. This either lowers performance or reliability and requires costly engineering solutions, e.g. complex shaping of heating elements with airfoils.

In the reserve application of gravity moving bed heat exchangers as electric heaters for particles, the tubular elements are used as electrical heaters to transfer thermal energy to the particles. For this particular application, these stagnant and void zones lead to an even greater problem: potential overheating of the electrical heater and failure.



## Results

Representative PIV analysis result and still images or particle flow are shown below.



## Methodology

To study the flow dynamics of olivine particles, we have developed a see-through test apparatus that mimics a gravity-driven moving bed heat exchanger with horizontally placed tubular elements.

The test apparatus comprises a transparent PMMA G (Plexiglas) plate supported by extrusion profiles and 3D-printed heating tube imitations, representing a rectangular-shaped box heat exchanger.

The internal dimensions of the test apparatus are 500(w) x 1500(h) x 100(d). The top hopper above holds ~200kg of olivine particles that could be discharged (almost) instantaneously by the knife gate valve.

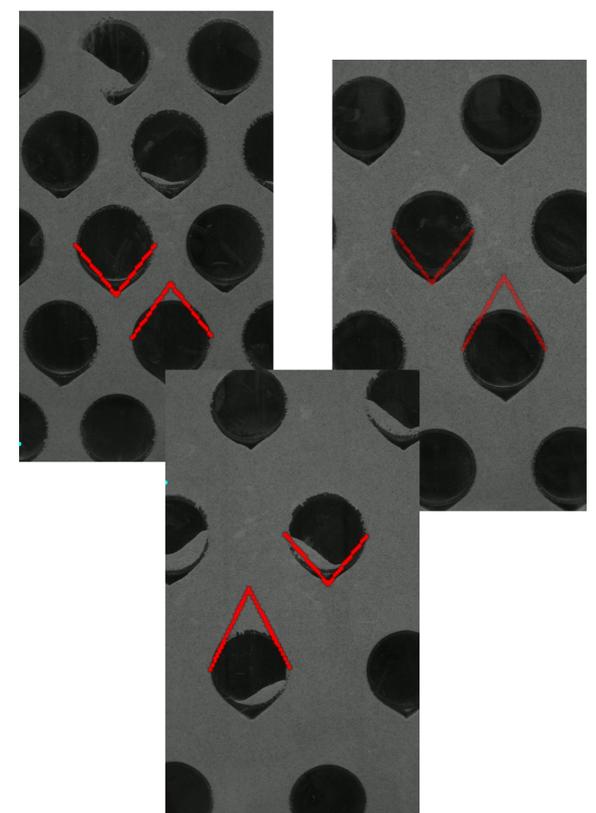
Particle flow was regulated by adjustable hinged plates at the bottom.

The test apparatus allows to adjust position and shape of the tubular elements placed on an interchangeable insertion plate.

The particle flow was recorded by a high-speed camera (TELEDYNE FLIR BFS-U3-23S3M-C with a 16mm lens) at 200 fps.

All the measurements were analyzed using the PIVLab MATLAB Toolbox implementing Particle Imaging Velocimetry techniques.

Three spacing arrangements of heating elements were tested: 70mm, 85mm and 100mm. Spacing arrangements were selected in order to meet current products range capabilities of standard 51mm OD tubular heating elements by SEICO.



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