Design and Development of a Particle Flow Control Mechanism for Particle-Based CSP System Applications*

*Patent Pending

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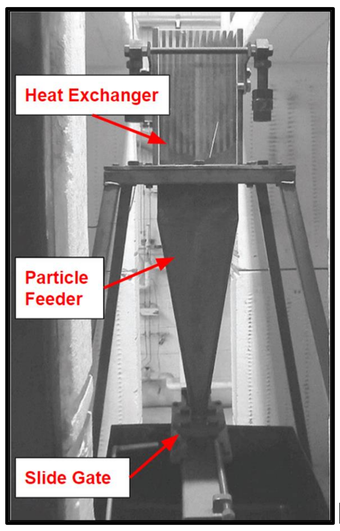
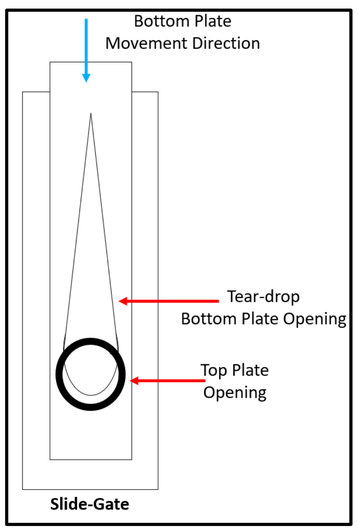
Background

- Particle-based Concentrated Solar Power (CSP) systems use solid particles instead of a typical working fluid.
- The current state-of-the-art particle flow control mechanism is the slide-gate. The slide-gate functions by linearly actuating a tear-drop shaped opening across a top-plate opening.
- The slide-gate's ability to affect the mass flow rate per millimeter movement of the plate, which is known as the sensitivity, is 0.354 g/s-mm.[1]
- The goal for a new particle flow control mechanism is to improve the response time, which is obtained through a larger sensitivity, and reduce particle clogging.

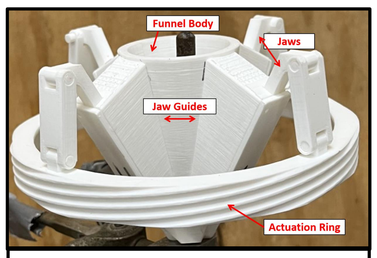


[1]

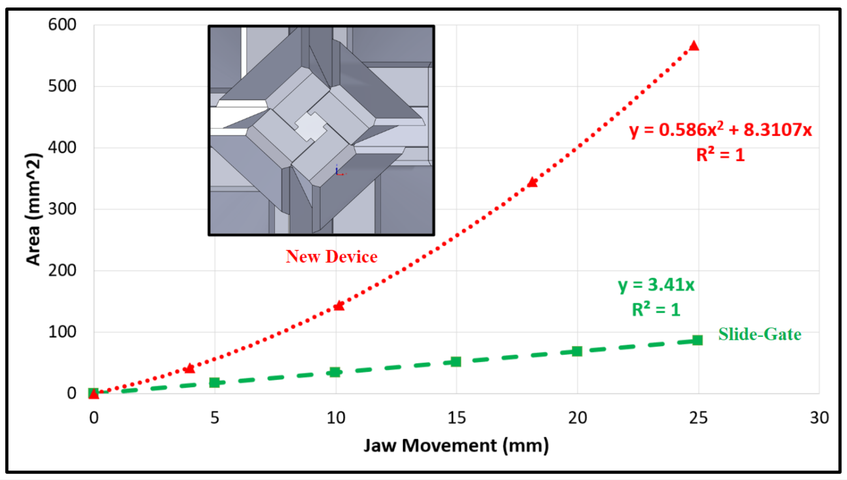


Design Approach and Validation

- The new device enables flow control through moving jaws diagonally to change the outlet area.
- The new particle flow control mechanism's area changes as a quadratic function of the linear jaw movement with the equation seen in RED. Note: 0 mm is the closed position.

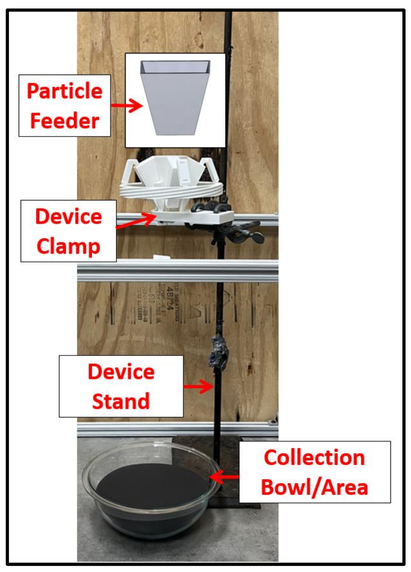


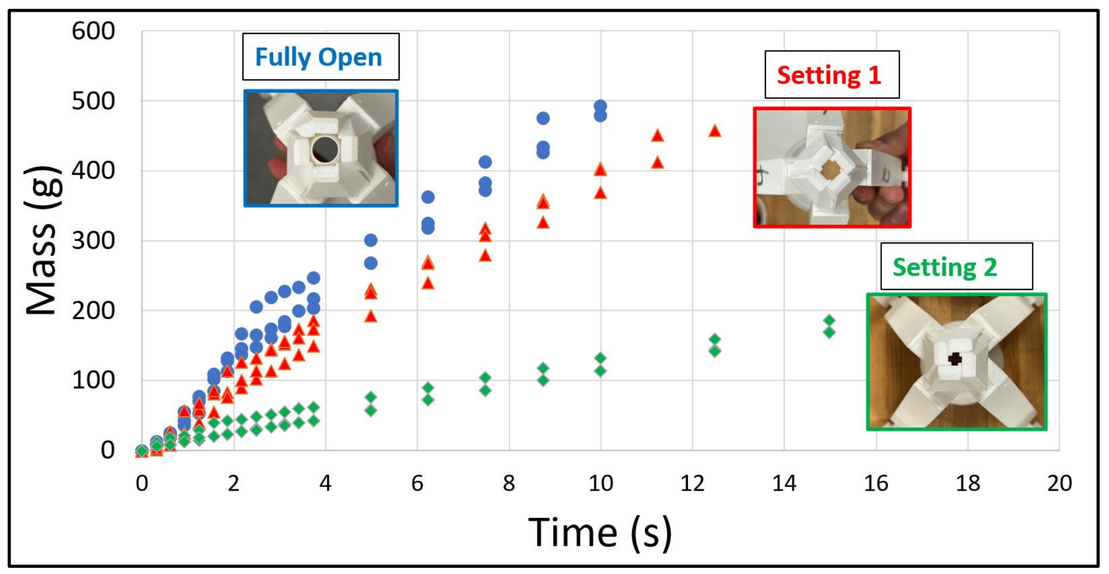
New Particle Flow Control Mechanism



Methods

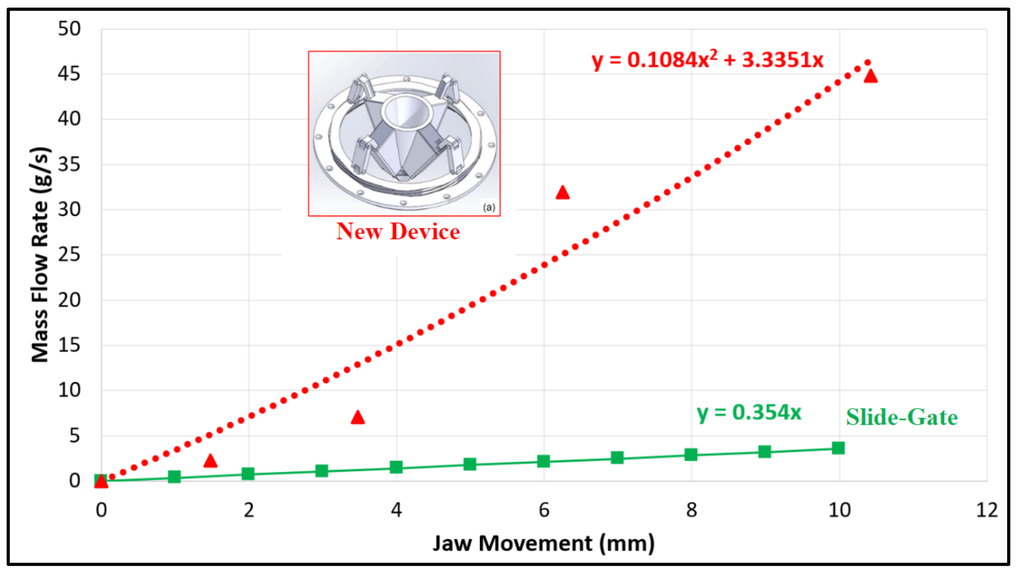
- The device was tested at room temperature by pouring a measured mass of HSP 40/70 ceramic particles (0.5 kg to 3 kg), into the particle feeder that flowed directly into the inlet of the device.
- The time that the particles take to exit the device was measured through video processing at the outlet of the device to calculate the mass flow rate.
- Some testing positions are shown in addition to data displaying the 2 second transient period.





Sensitivity Results

- The slope of the lines in the figure convey the sensitivity of the new device compared to the current state-of-the-art, where 0 mm denotes the fully closed position.
- The new devices sensitivity value follows a quadratic curved as compared to the slide-gate's linear slope over the same jaw movement.
- A larger sensitivity value is directly related to a quicker response time when utilizing the same actuator.



Conclusions and Future Work

- A new device was developed to improve the particle flow control capabilities within particle-based CSP systems.
- The sensitivity of the new particle flow control mechanism corresponds to the equation
$$y = 0.1084x^2 + 3.3351x.$$
- The higher sensitivity value was primarily due to increased change in cross-sectional area of the opening per unit vertical movement of the new control mechanism compared to the slide-gate.
- The new device will be further developed for high-temperature experiments due to its high sensitivity value while minimizing leakage of particles.
- Experimental data will be validated with the use of particle flow simulations.

Acknowledgements and References

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1. Albrecht, Kevin J., and Clifford K. Ho. High-Temperature Flow Testing and Heat Transfer for a Moving Packed-Bed Particle/SCO2 Heat Exchanger. 2018, p. 040003