High efficiency solar thermochemical fuel production using the UF 10 kW Solar Reactor

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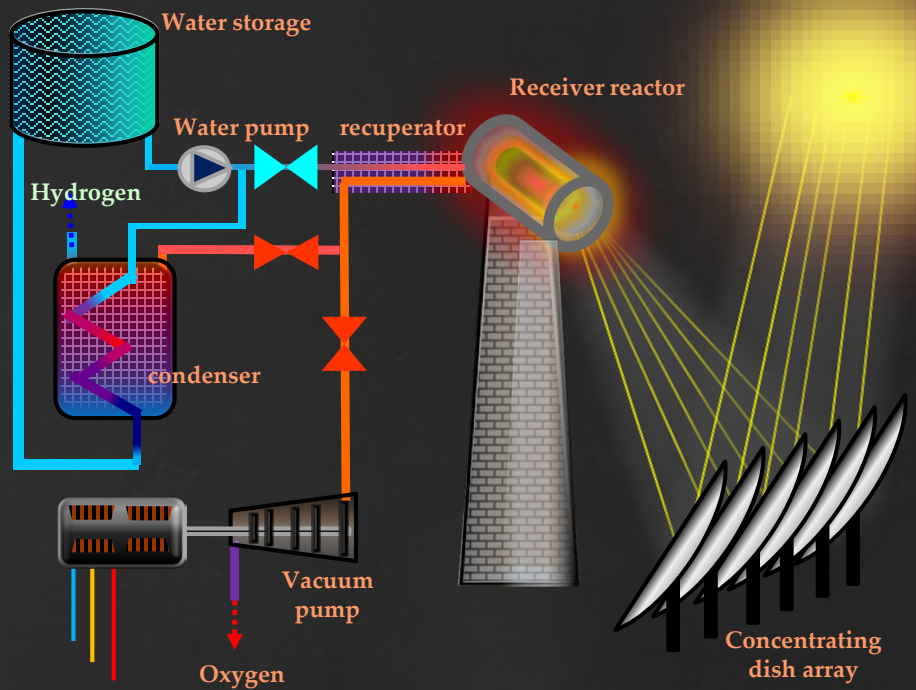
Concept of solar fuel production



Thermal reduction

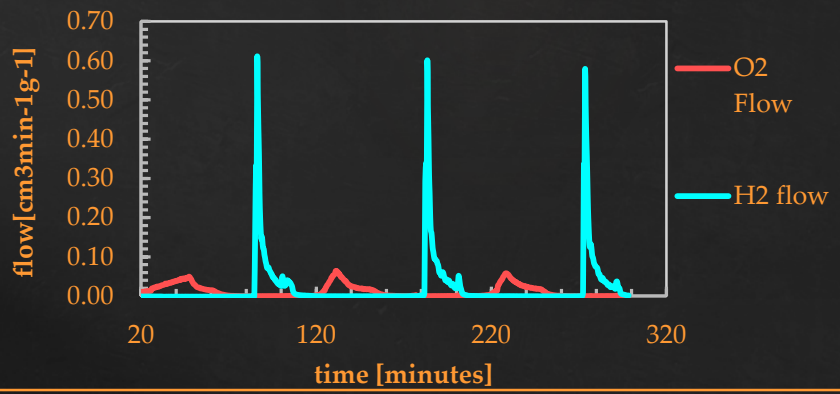
$$CeO_2 \xrightarrow[vacuum]{heat} CeO_{2-\delta} + \frac{\delta}{2} O_2$$

Oxidation

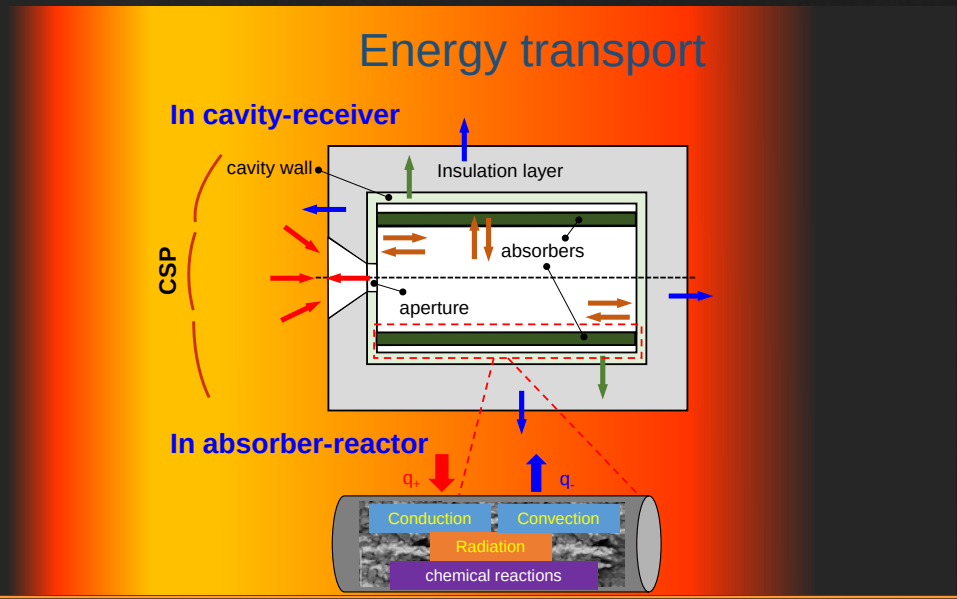
$$CeO_{2-\delta} + \delta H_2O \longrightarrow CeO_2 + \delta H_2$$

$$CeO_{2-\delta} + \delta CO_2 \longrightarrow CeO_2 + \delta CO$$

$$\eta_{\text{solar to fuel}} = \frac{n_{H_2}.HHV_{H_2}}{Q_{solar} + Q_{pump}}$$



Energy transport



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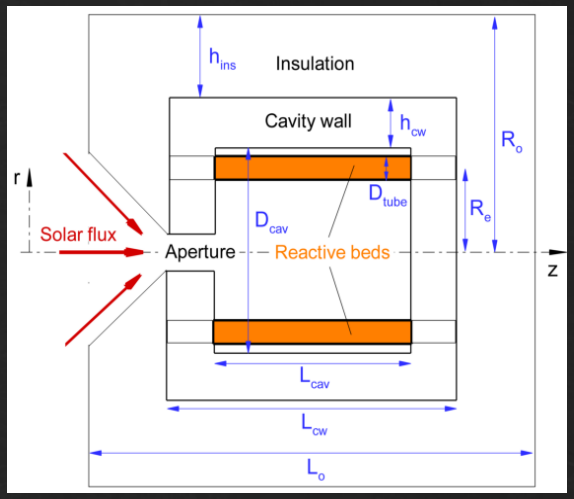
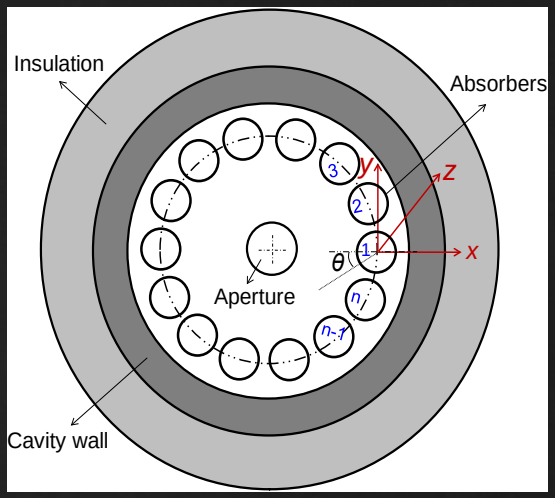
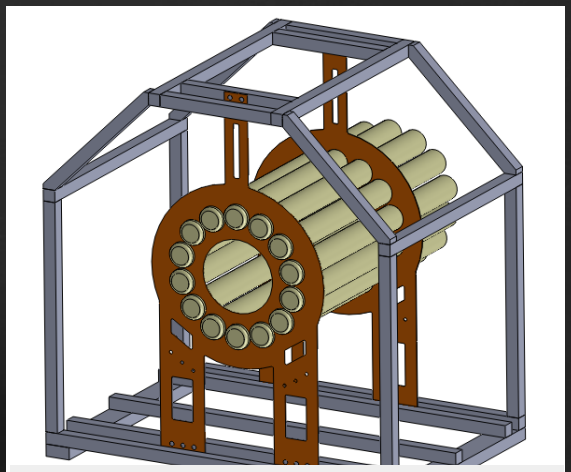
UF 10 kW Solar Reactor and testing facility

Solar simulator

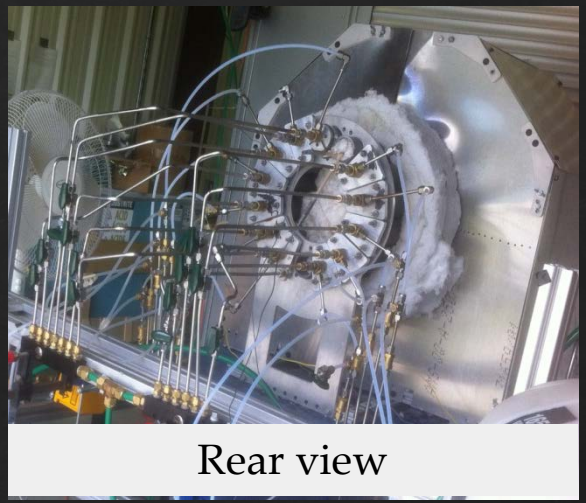




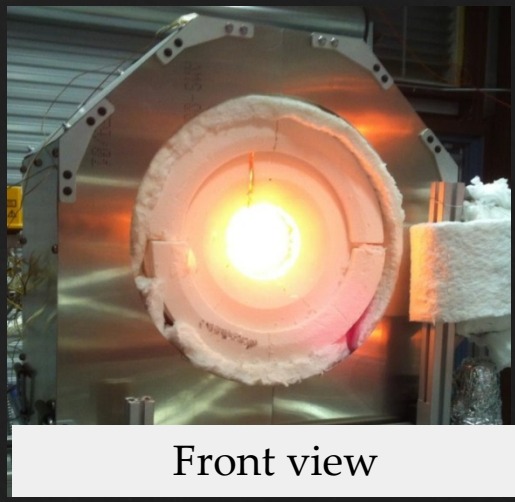
Schematic depiction : cross-sectional view and front view



Reactor without insulation



Rear view



Front view

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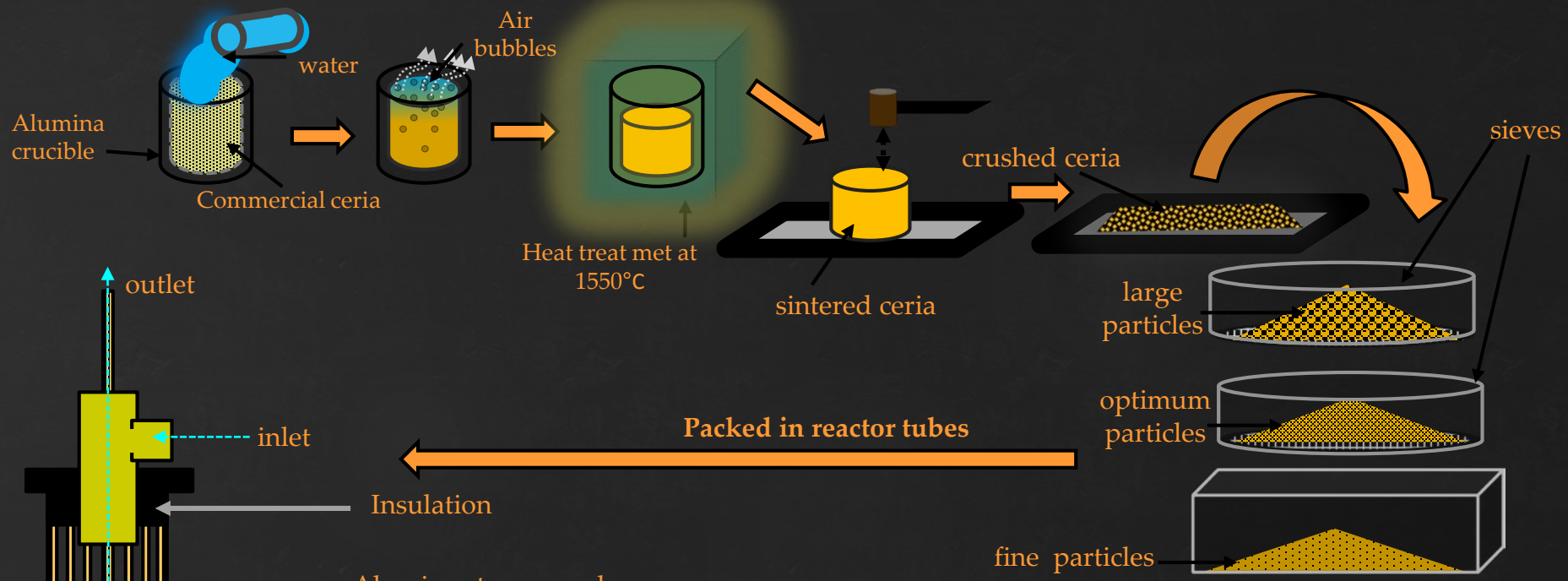
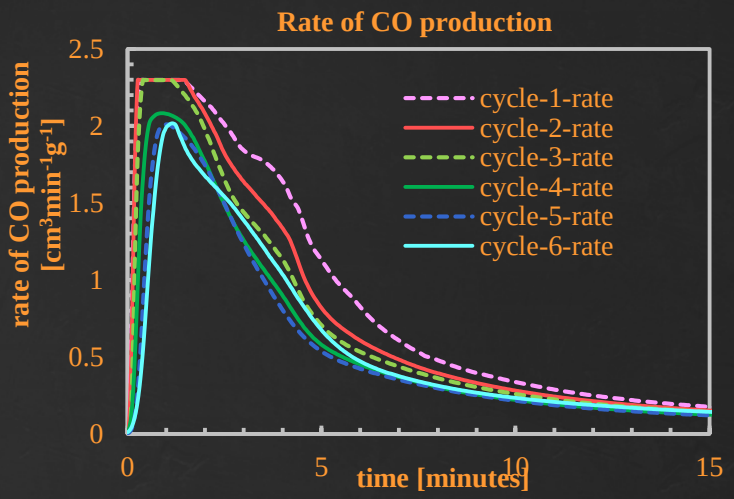
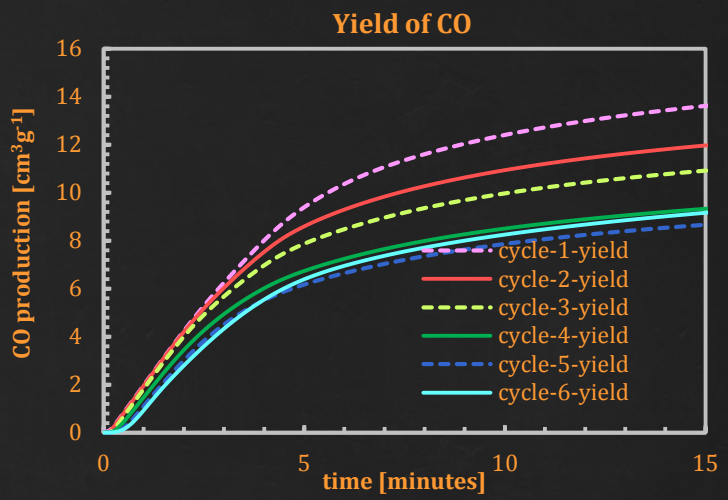
Material preparation and reactive tube packing



- Tubes are packed rigorously with stabilized ceria by vertically pounding the tube with materials against a soft surface.
- Bottom end of the center tube is slotted and surrounded by a 1 " slotted tube. The space between these two tubes is stuffed with insulation. This arrangement reduces the pressure drop and acts as a filter.
- Alumina stopper rods are placed on top of the bed between layers of insulation to prevent loose particles from moving.
- Particle size range of 355µm - 1000µm has been selected to minimize the pressure drop.

Test run for CO_2 splitting on 11 tubes

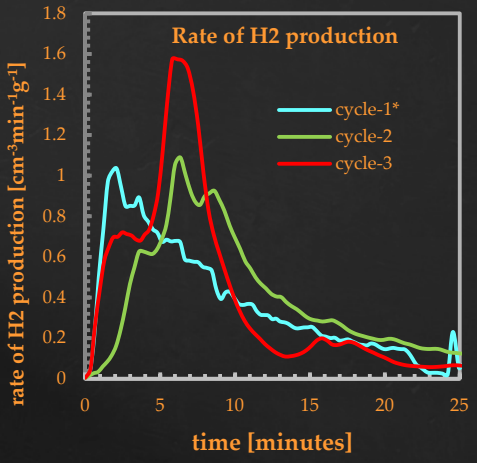


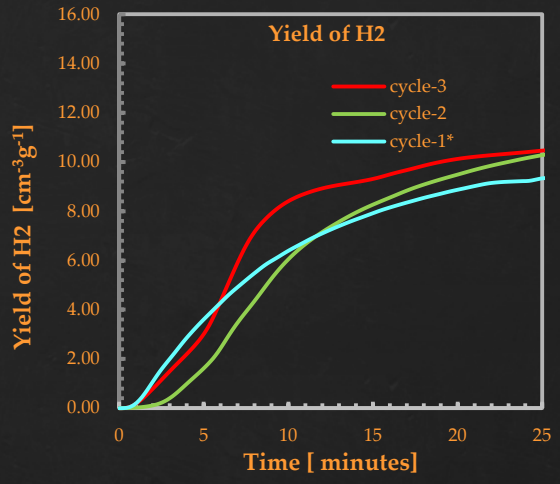


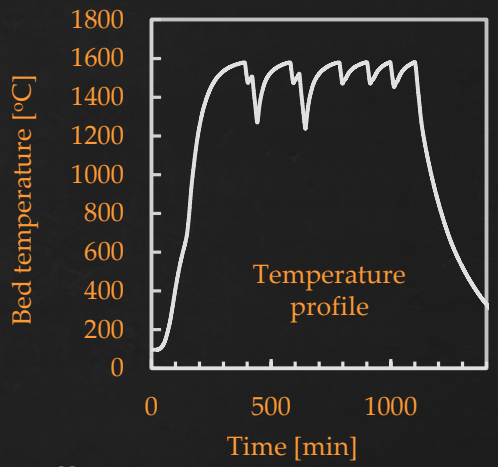
Efficiency

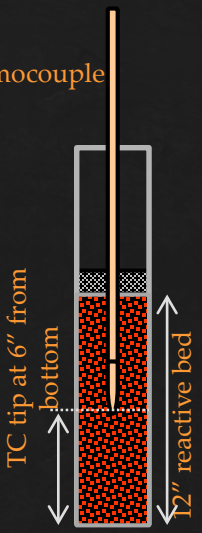
- Cycle 1: 7.4%
- Cycle 2: 6.6%
- Cycle 3: 6.1%
- Cycle 4: 5.2%
- Cycle 5: 4.9%
- Cycle 6: 5.1%

Test run for H_2O splitting on 3 tubes









Efficiency

- Cycle 1: 5.1%
- Cycle 2: 5.6%
- Cycle 3: 5.7%

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