Efficiency Calculation and Experience from the Measurement Campaign of a Molten Salt Central Receiver

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Introduction

- Development and demonstration of a novel solar tower receiver operating with molten salt
- Increase of the upper temperature limit to 600°C for increased power block efficiency

Figure 1: View on the Solar Tower (left) and Multi-Focus Tower (right) in Jülich, Germany. The receiver is irradiated in the middle of the right tower.

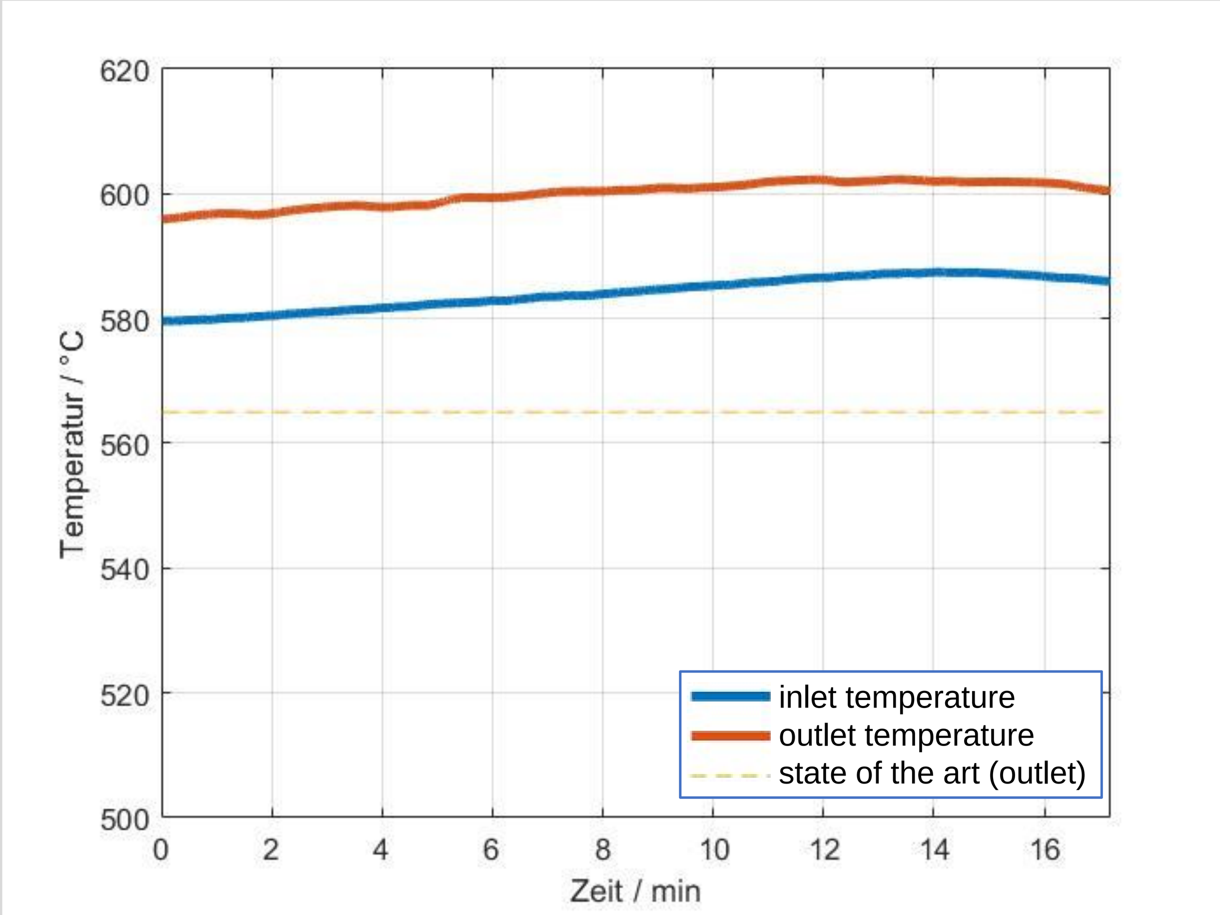

Figure 2: Demonstration of receiver outlet temperature at more than 600 °C

- Successful test of receiver panel to demonstrate increased working temperature of 600 °C
- Gathering data for efficiency measurement still ongoing
- Supporting technologies, such as camera based flux density and temperature measurement, successfully demonstrated

Thermal Loss Calculation Methods

Semi-analytical method:

- Based on physical principals of convection and radiation

Input parameters: temperature distribution over the receiver surface → measured via IR camera measurement (s. section right)

$$P_{loss,th} = \varepsilon\, \sigma\, A\, (T_s^4 - T_\infty^4) + h\, A\, (T_s - T_\infty)$$

Continuous Power-On method (CPOM):

- Based on Power-On method from Solar Two Project (comparison of receiver inlet power at constant temperature and different power levels)

Input parameters: various measurement points at stationary conditions with varying power levels

$$P_{loss,th} = \frac{\sum_{i=1}^{n} P_{MS,H_i} - \sum_{i=1}^{n} (P_{MS,L_i} \cdot R_i)}{(\sum_{i=1}^{n} R_i) - n}$$

IR Camera Measurement

- Temperature is calculated pixel-wise on the receiver aperture
- Movements of the camera due to wind are automatically corrected by the software developed
- Thermal emittance of the receiver aperture is calibrated by comparing the temperature measured with thermocouples at the back side of the receiver tubes with IR-camera values at high salt mass flow and no solar flux on absorber tubes
- Emissivity values differ too much between calibration and normal operation mode, investigation to clarify this issue still ongoing

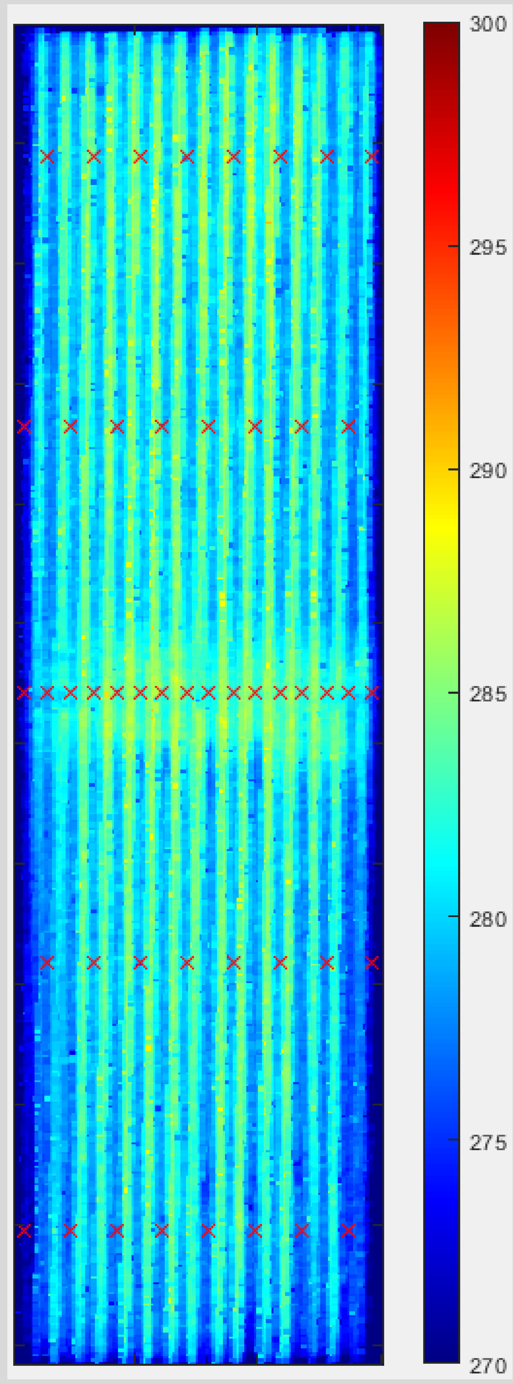

Figure 3: Measurement of receiver surface temperature via post-processing of IR camera images. Red crosses indicate the location of thermocouples.

High Uncertainty of IR Camera Measurement

Wide spread of emissivity values might be due to:

- Effect of reflection from concentrated solar radiation on receiver aperture
- Temperature-dependent properties of coating (Pyromark)
- Transmittance of air (e.g. due to humidity)

Further analysis to reduce uncertainty is planned, such as laboratory emissivity measurement at high temperatures and evaluation with different flux densities on the receiver.

Figure 4: Infrared camera looking at the irradiated receiver

Summary

- Maximum outlet temperature of 602 °C demonstrated
- Finalization of measurement campaign needed to determine efficiencies of receiver and cross validation of efficiency measurement methods
- Supporting methods for temperature measurement were developed successfully, but uncertainty is still too high
- Further tests are necessary to improve temperature values from IR camera

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