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Design and Testing of Externally Finned Tube Cavity Receiver for Brayton Cycle Preheating Purposes

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Overview

The experimental research process undertaken

- Background of research
- Methodology employed
- Results and observations
- Conclusions

Air as HTF for CSP cycles

Why air?

- Freely available
- Safe, stability at high temperatures
- Absence of phase change
- No risk of freezing
- Brayton cycle integration

SUNDISC cycle

Stellenbosch University Direct Storage Charging Dual-Pressure Air Receiver

- Co-generation power cycle
- Aimed at bypassing the Bottleneck of GT

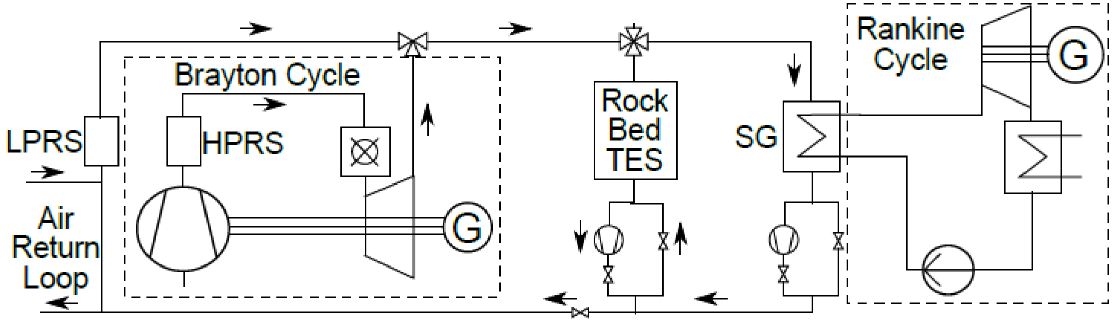


Figure 1: Schematic of the SUNDISC cycle (Heller,2016)

The modified HPAR

Hybrid Pressurised Air Receiver

- Tubular volumetric cavity design
- Pressurised internal air
- Induced flow into the cavity
- Macro and micro cavity effects

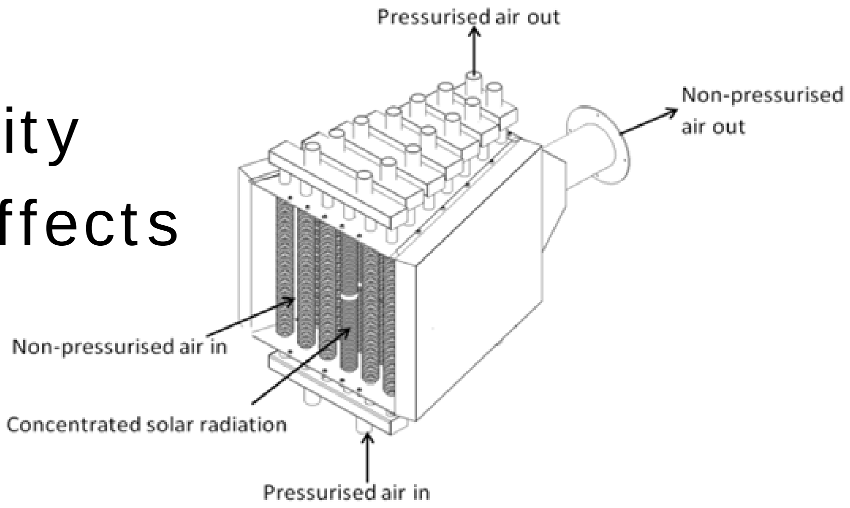


Figure 2: Schematic of the HPAR

Receiver design

Process overview

- Literature
- Simulation

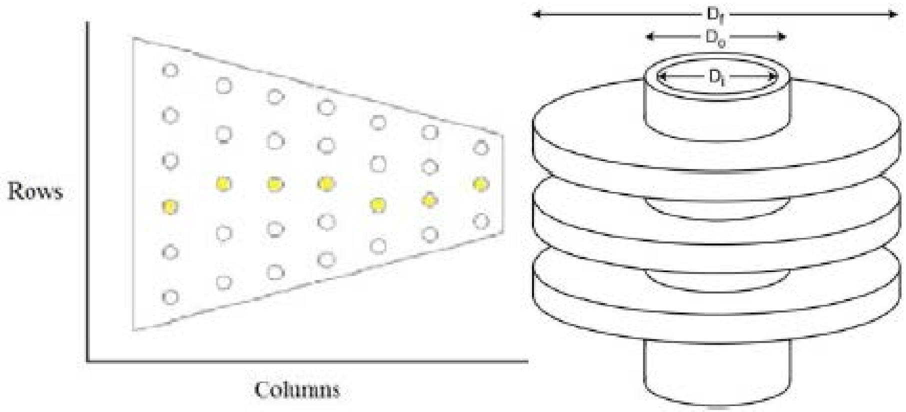


Figure 3: Cavity and tube layout

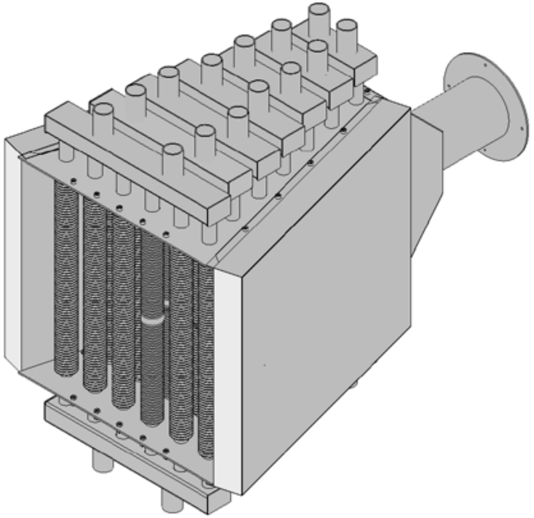


Figure 4: Final test receiver

Construction and installation

Process undertaken

Figure 5: Machining of the fins

Figure 6: Instrumenting the receiver

Figure 7: Installed on the tower

Experimental testing overview

34:45 hours of testing

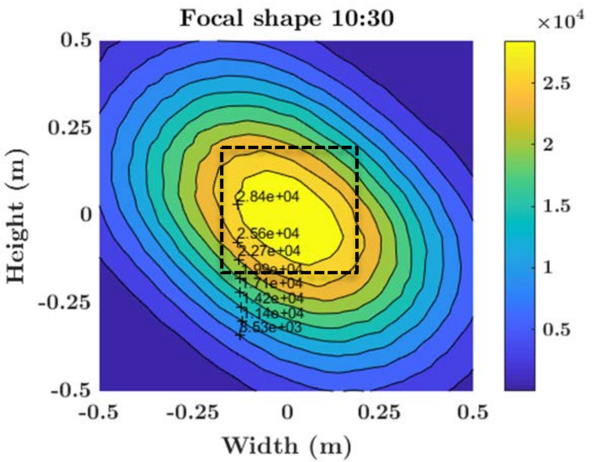
- Half and full heliostat field
- Windless and windy days
- Isolated both the internal and external fluid
- Variation in both the internal and external fluid mass flowrate

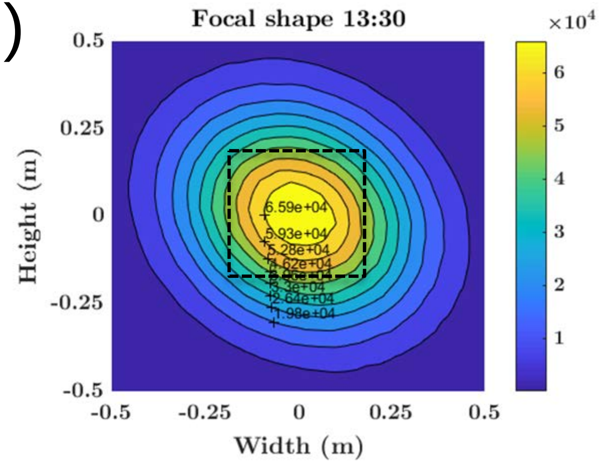

Figure 8: Heliostat field and test tower

Field Characterisation

Capability and limitations

- No data on field performance
- No means of measuring
- Large cosine losses (Eastern field)
- Limited window of opportunity





Results

Overall receiver thermal behaviour

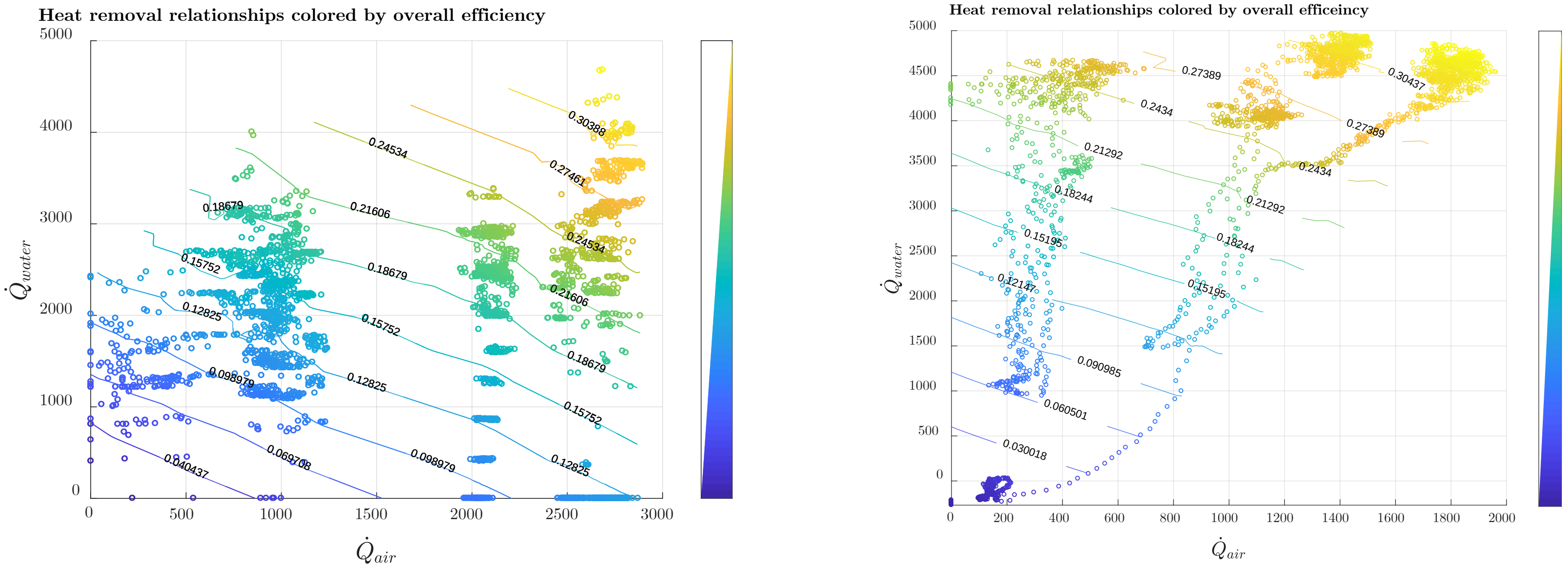


Figure 9: Overall field efficiency comparison for two tests

Results

Circumferential temperature distribution

- Fast ramp up after interruptions
- Control the thermal difference
- Location specific

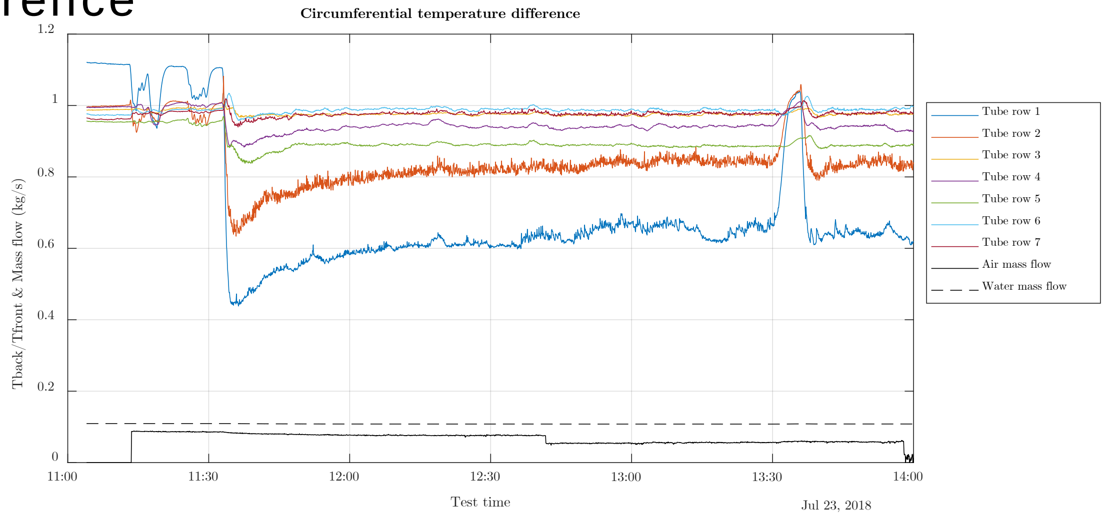


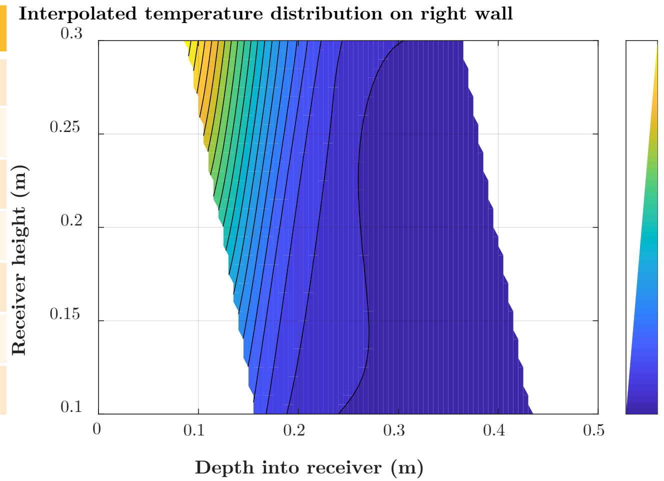
Figure 10: Sample response

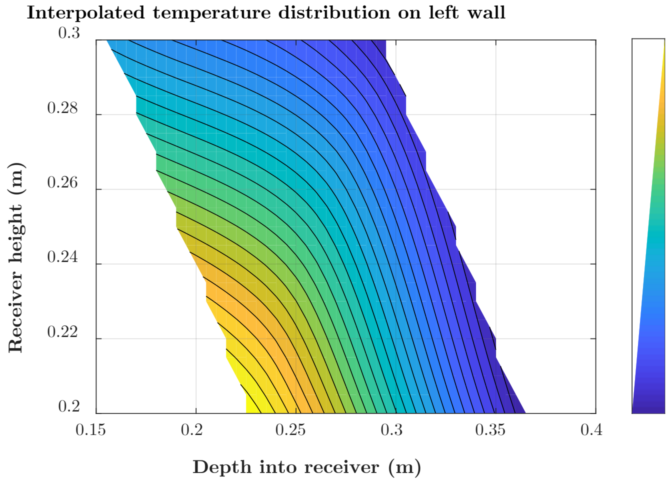
Cavity temperature distribution

Interpolated steady-state distribution

Table 1: Conditions at steady state

Variable	Value
DNI	855 W/m^2
T_{amb}	19.69°C
T_{water}	38.83°C
V_{wind}	0.69 m/s
$\dot{m}_{air}$	0.0713 kg/s
$\dot{m}_{water}$	0.0238 kg/s
V_{air} in	0.414 m/s





Sensitivities

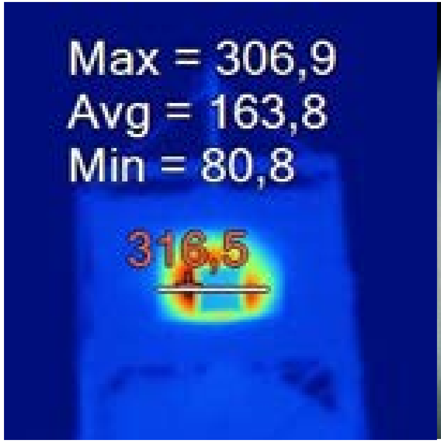
Receiver response to environmental influences

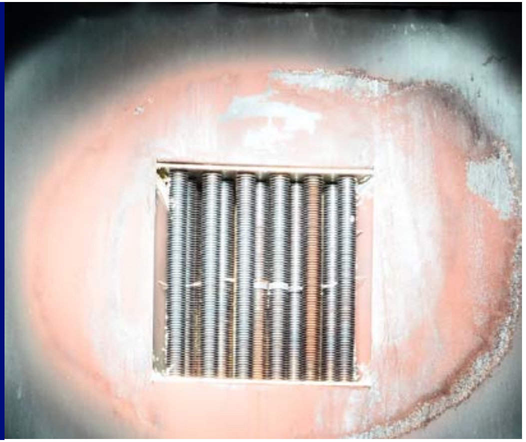
- Several variables influencing the tests
- Insensitive to ambient wind (max 7.3m/s in test with aperture inlet velocity of 0.5m/s)
- Mass flow rate relationship

Observations

Visual observations during the tests

- No volumetric effect
- No noticeable hot spot
- Spillage from field





Conclusion

The modified HPAR test demonstrated the following

- Ability to modulate the circumferential temperature gradient
- Ability to control the different energy absorption quantities
- Ability to capture/ repurpose convective losses

Thank you

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