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SOLAR THERMAL ENERGY RESEARCH GROUP

Performance Characteristics of the Spiky Central Receiver Air Pre-heater (SCRAP)

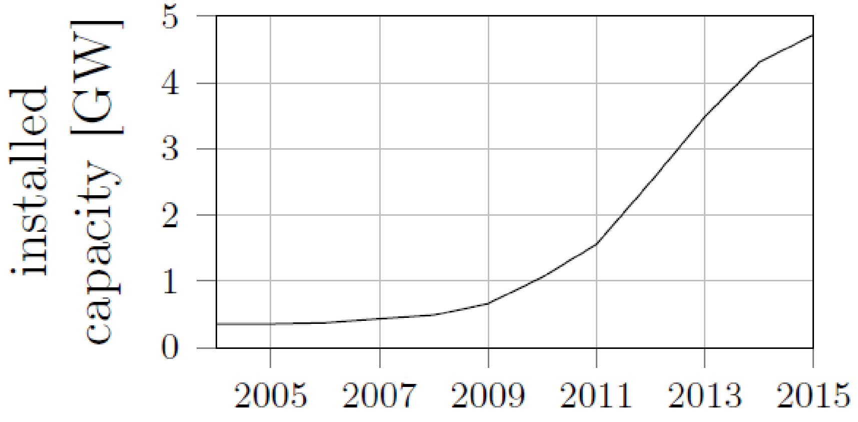
M Lubkoll, TM Harms, TW von Backström

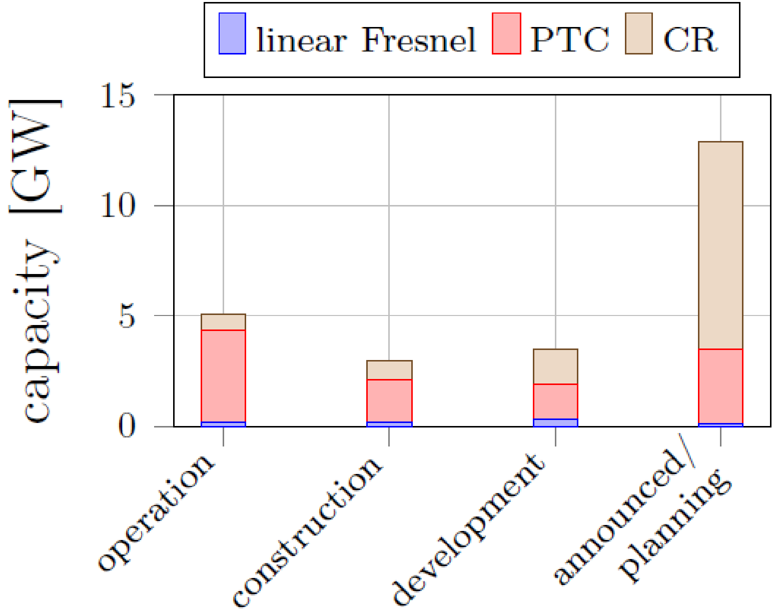
Solar Thermal Energy Research Group (STERG)

Department of Mechanical and Mechatronic Engineering, Stellenbosch University

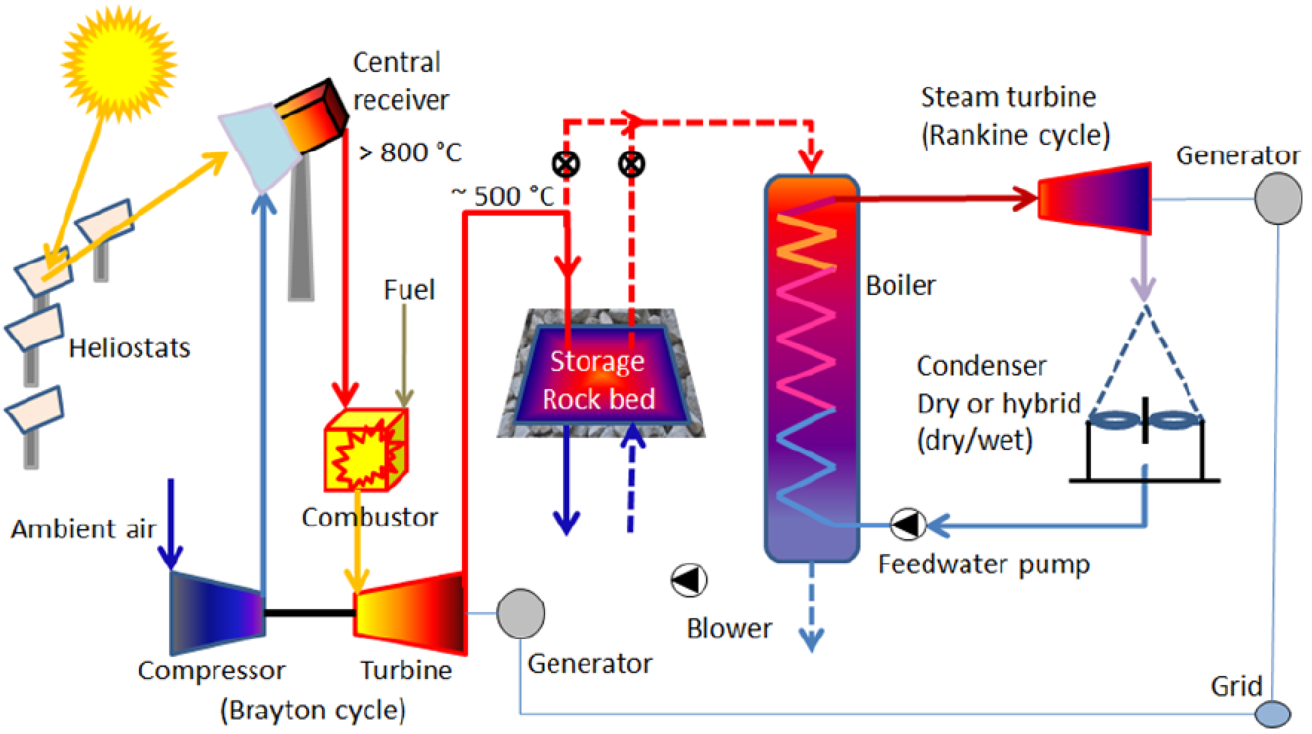
matti@sun.ac.za

1. Introduction



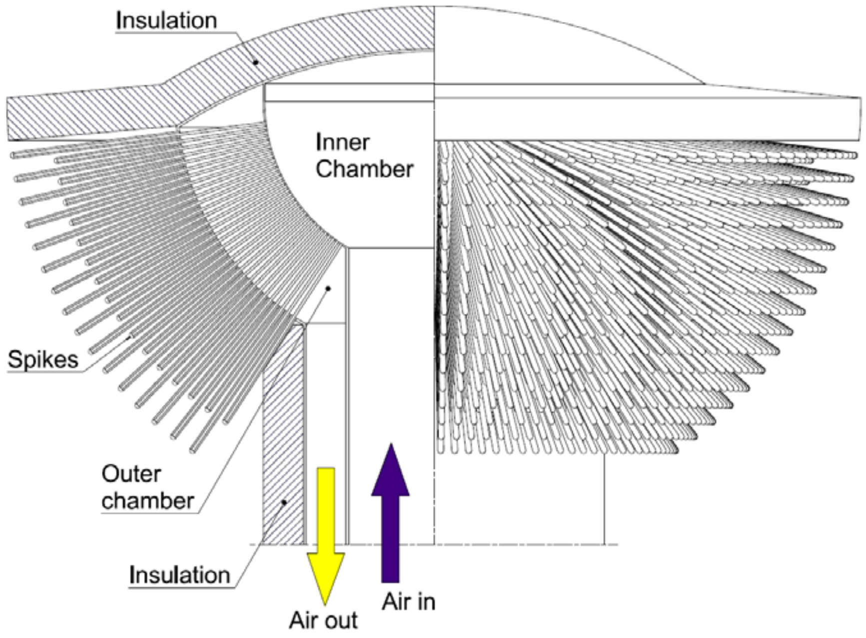


1. Introduction



Source: Kröger, 2012

2. The SCRAP receiver



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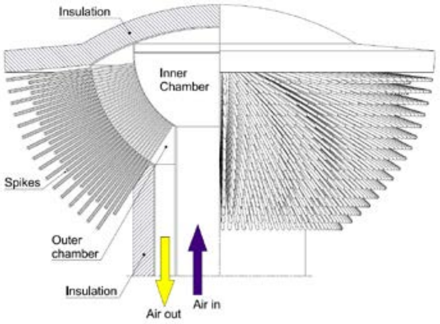

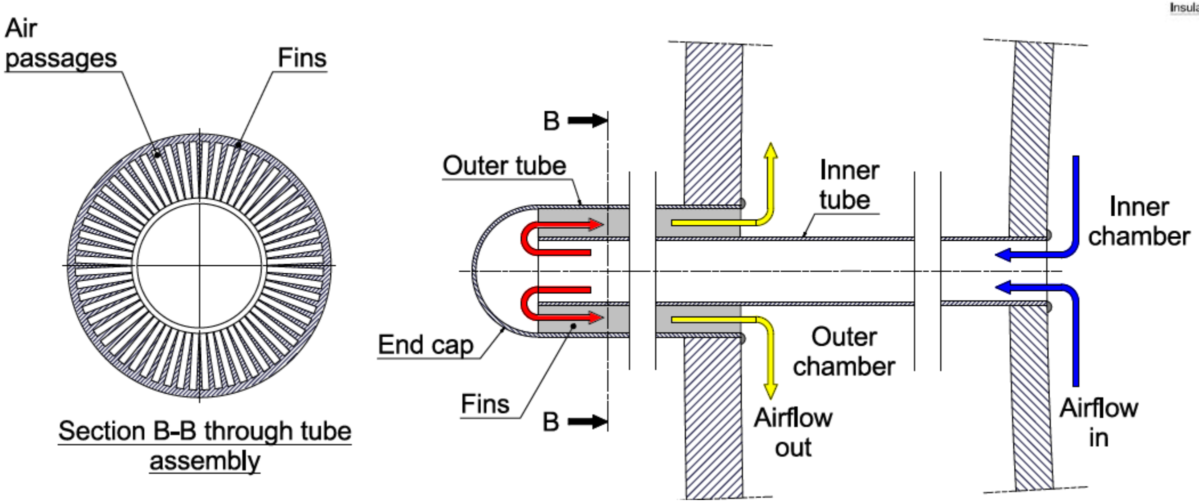

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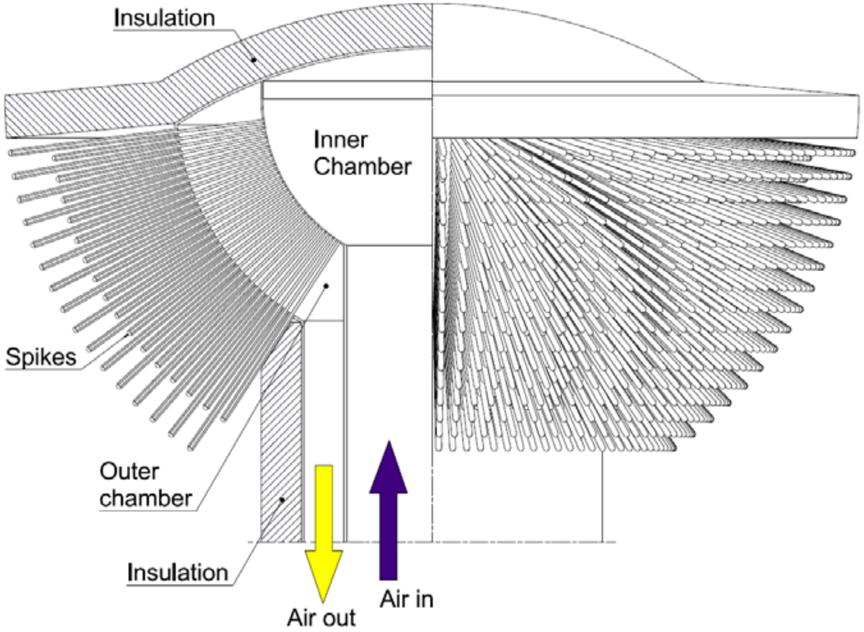
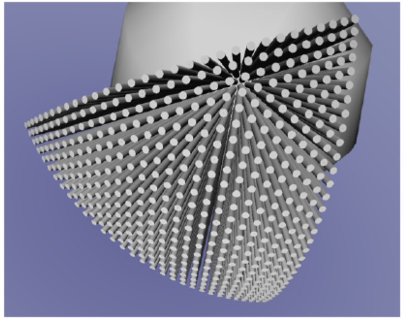
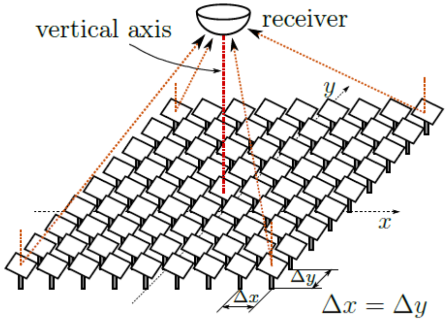


Source: Kröger, 2008

4. Modeling – ray-tracing



(a)



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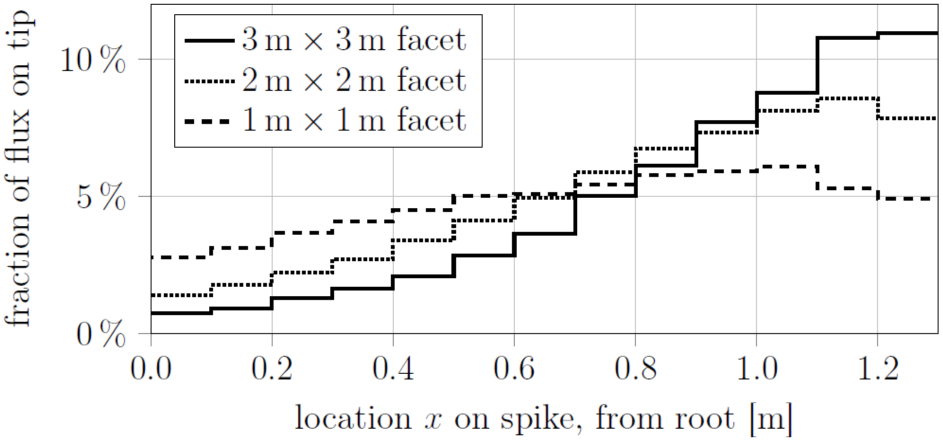
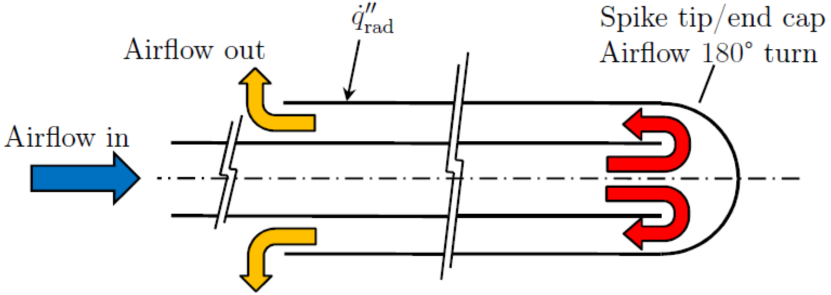
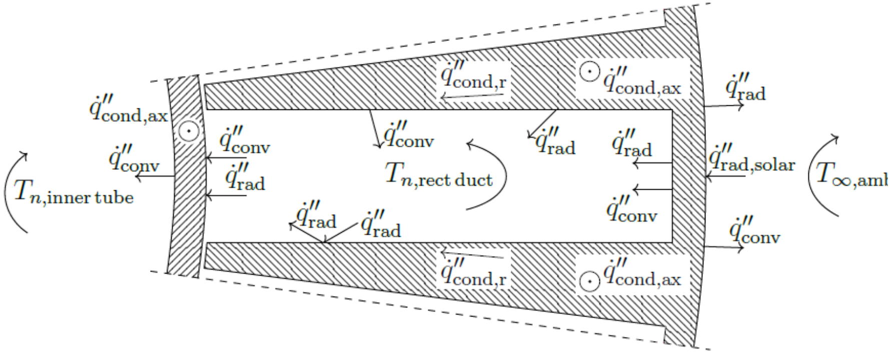


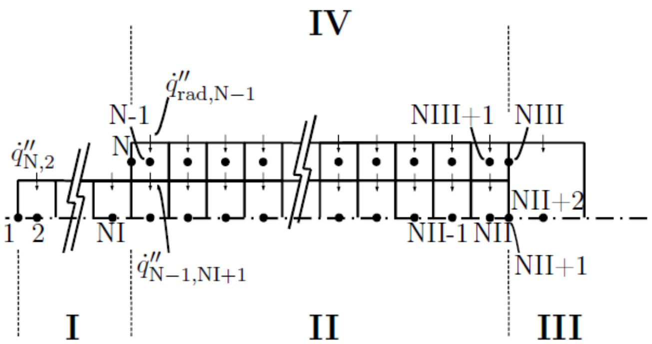
4. Modeling – internal heat transfer

Implicit solver that satisfies:

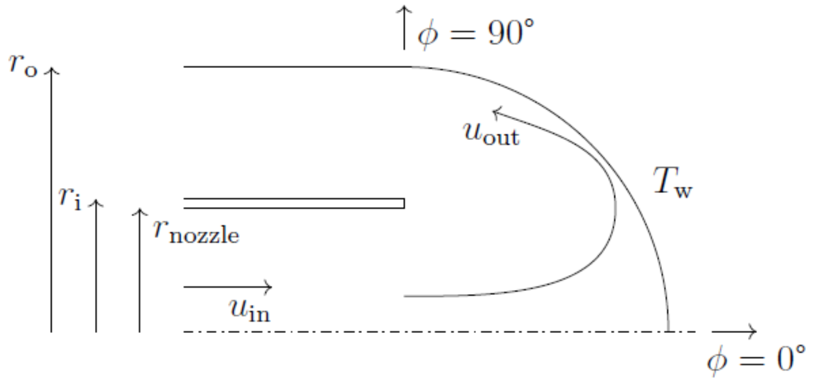
- conservation of mass
- conservation of momentum
- conservation of energy

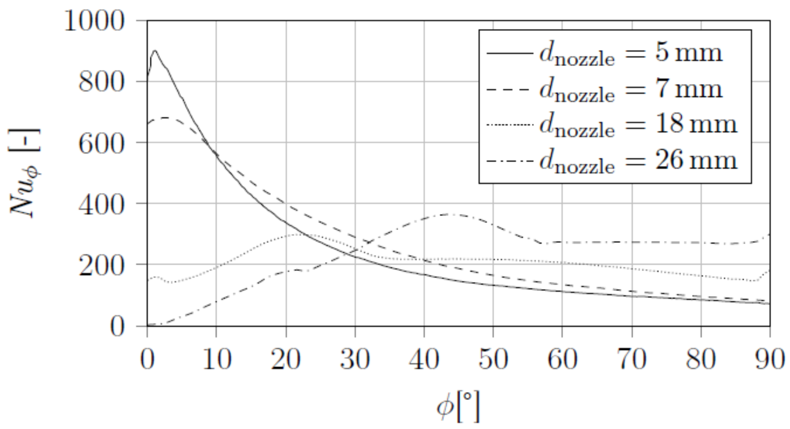


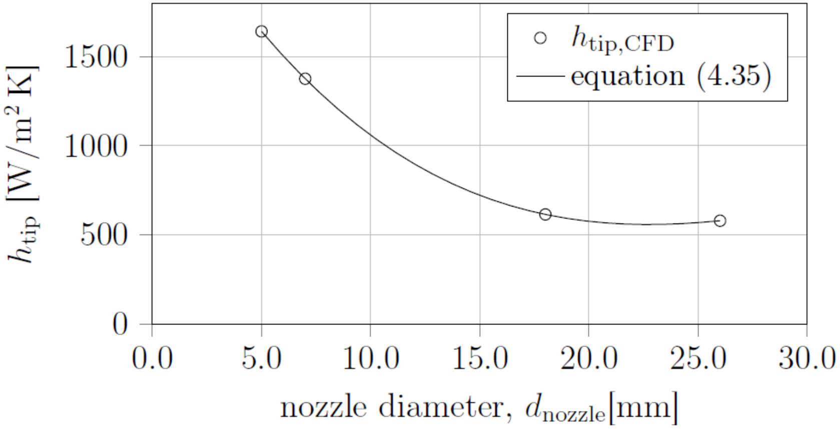




4. Modeling – spike tip

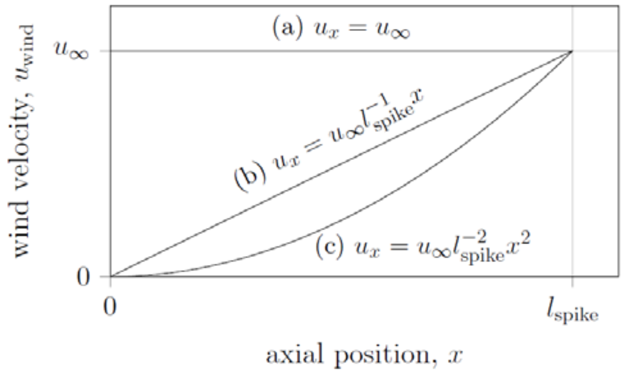


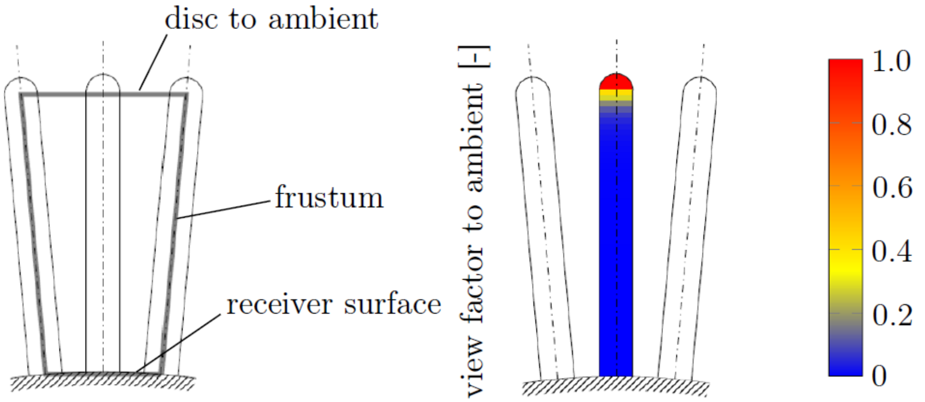




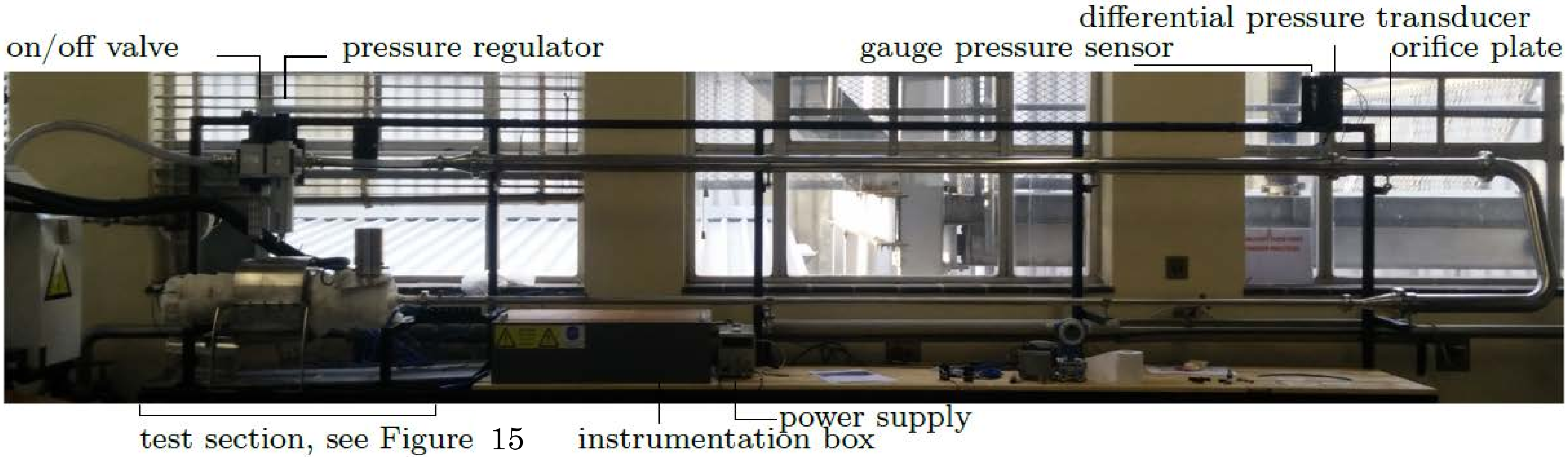
4. Modeling – thermal losses

$$h_{\text{combined}} = \left(h^n_{\text{forced}} + h^n_{\text{natural}}\right)^{1/n}$$





5 . Experimental apparatus



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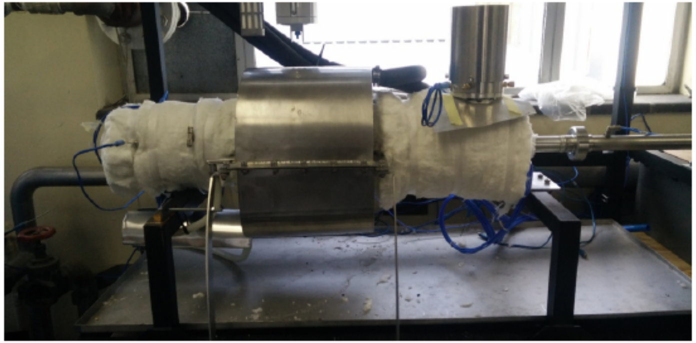
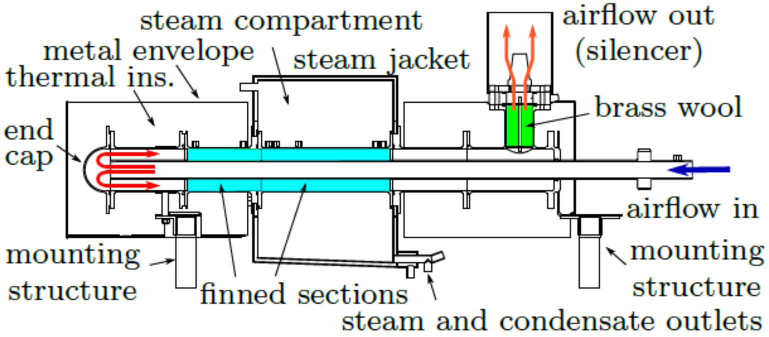
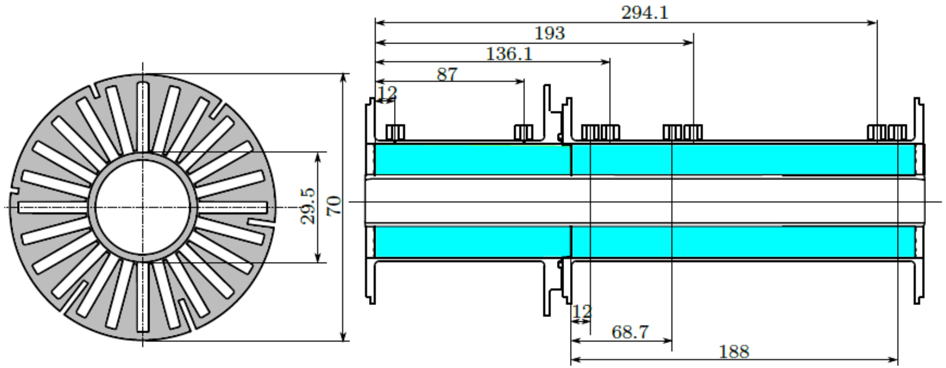
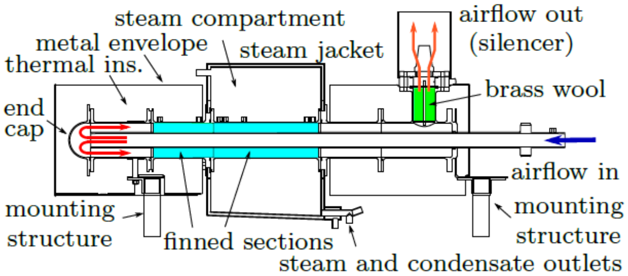


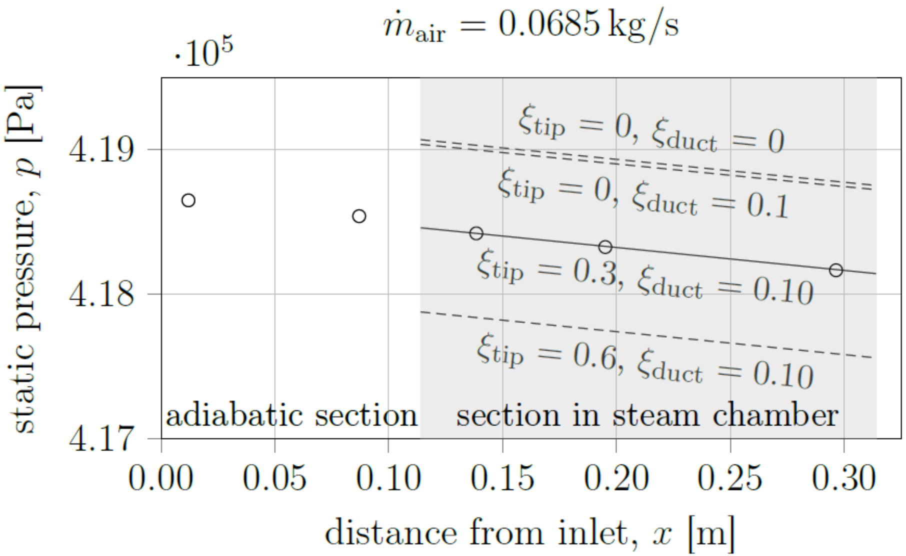


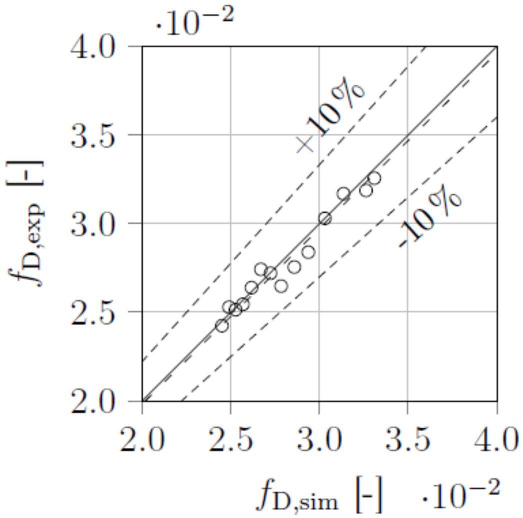


5. Experiment - results

Under adiabatic conditions:

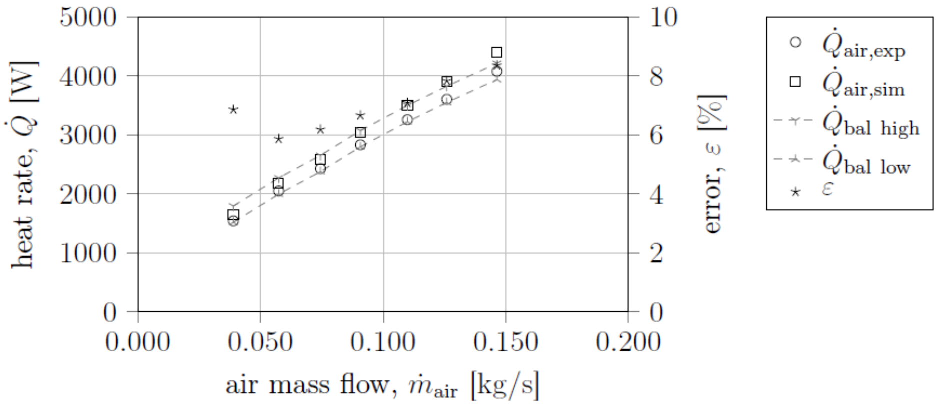


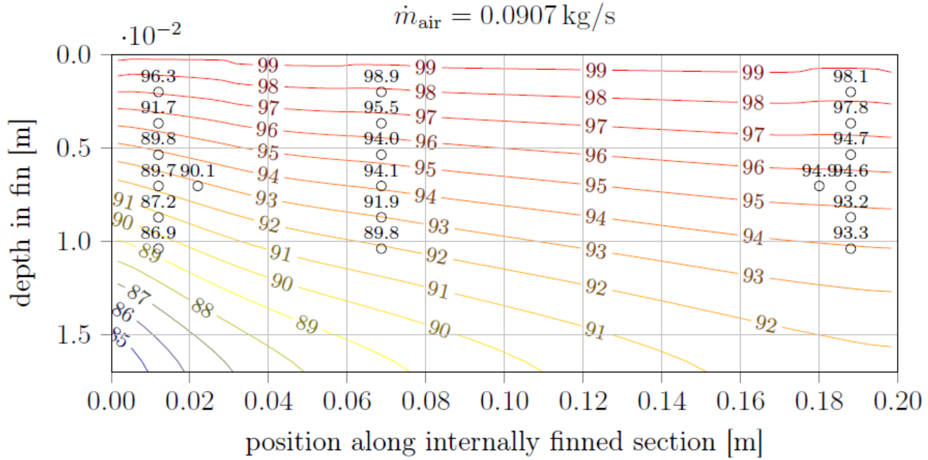




5. Experiment - results

Under heating (~100 °C):

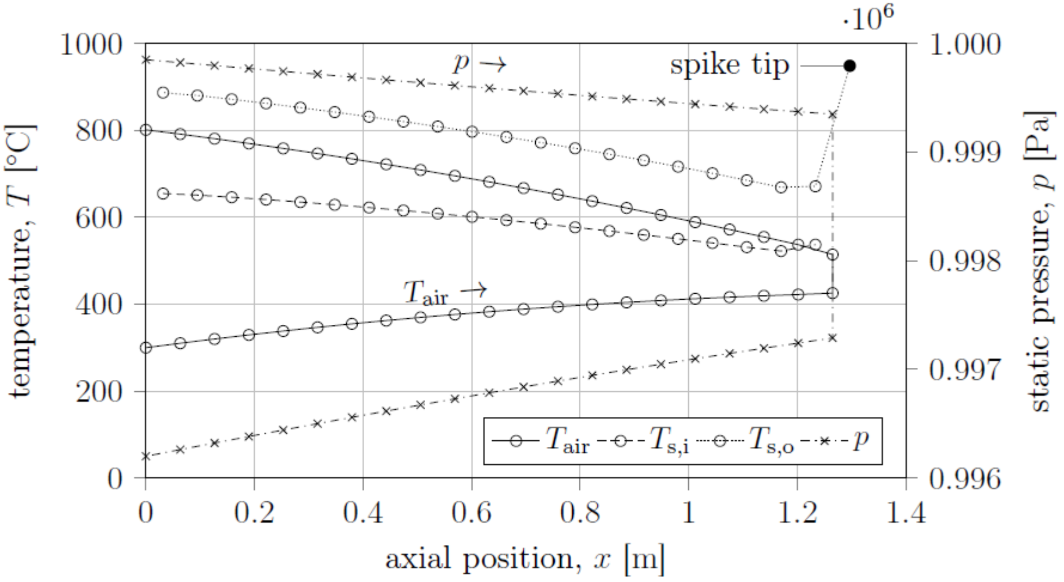




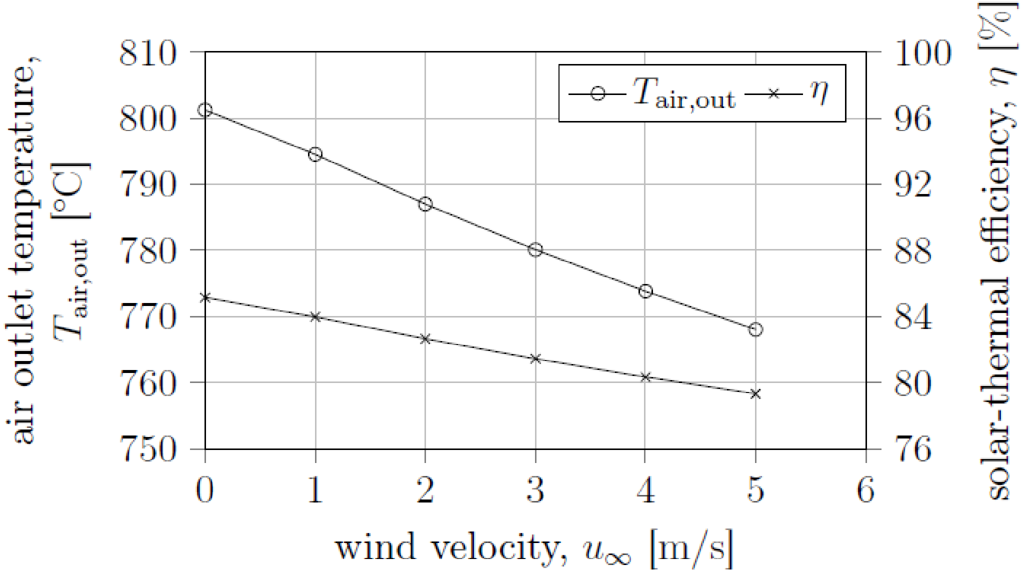
6. Performance prediction

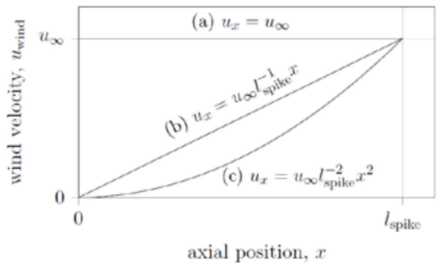
Performance prediction for reference geometry:

	reference geometry	improved geometry
$T_{\text{air,out}}$	801 °C	800 °C
Δp	38 mbar	126 mbar
$\eta_{\text{solar-thermal}}$	85.2 % (9.5 % + 5.3 %)	86.7 % (9.1 % + 4.2 %)
$\Delta T_{\text{air-wall}}$	86 K – 136 K	65 K – 92 K
T_{tip}	949 °C	874 °C
T_{root}	887 °C	864 °C



6. Performance prediction – sensitivity to wind





7. Conclusion

- SCRAP receiver technology appears a viable technology for pressurized air applications
- Spike tip capable of coping with high flux
- Performance prediction values appear promising
- Pressure drop over a spike / receiver system is moderate
- Exploitation of volumetric effect appears somewhat successful (low radiative heat loss at cost of vulnerability to convective heat loss)

7. Further work

- Testing of a spike cluster exposed to radiation
- Improve model to represent circumferentially varying conditions
- Investigate helically swirled fins
- External CFD model of receiver to investigate wind and convection effects
- Detailed CFD modeling of spike tip and development of improved spike tip geometry
- Material and manufacturing considerations

Thank you.

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STERG

CONTACT DETAILS:

Matti Lubkoll, P.hD.
Solar Thermal Energy Research Group (STERG)
Stellenbosch University
South Africa

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