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SOLAR THERMAL ENERGY RESEARCH GROUP

Initial analysis on the novel Spiky Central Receiver Air Pre-heater (SCRAP) pressurized air receiver

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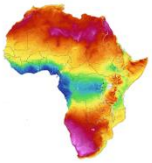

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The Pressurized Air Receiver

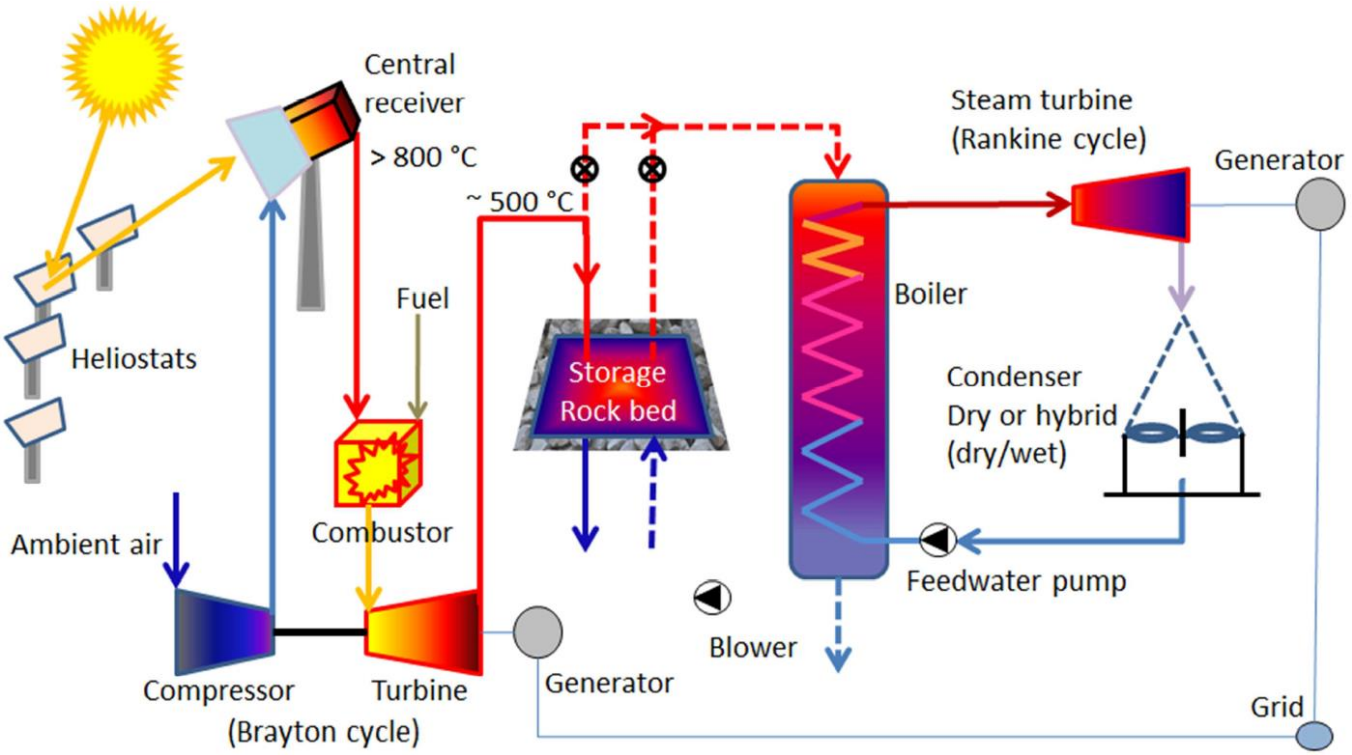

Figure 1: The SUNSPOT cycle [1]

Motivation

A recent review [7] of the systems demonstrated to date has indicated a need for a technology that:

- Provides effective heat transfer from the concentrated solar radiation to a pressurized air stream
- Does not require secondary concentrators
- Can operate with a 360°/surrounding heliostat field
- Is a robust and practical technology
- Demands a low pressure drop

The SCRAP receiver concept

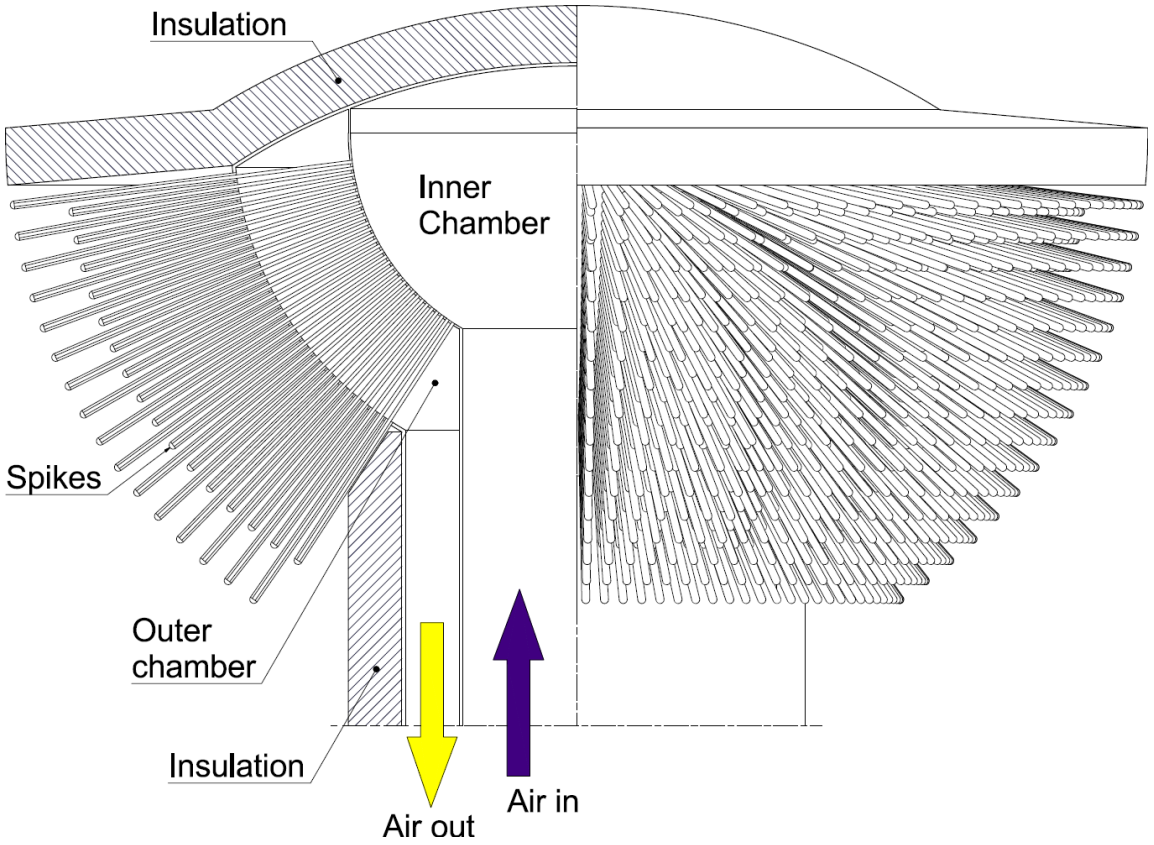

Figure 2: **S**piky **C**entral **R**eceiver **A**ir **P**re-heater (**SCRAP**) Concentric spherical surface chamber (left half in section) [2]

An introduction to the **S**tellenbosch **UN**iversity **S**olar **PO**wer **T**hermodynamic (SUNSPOT) cycle

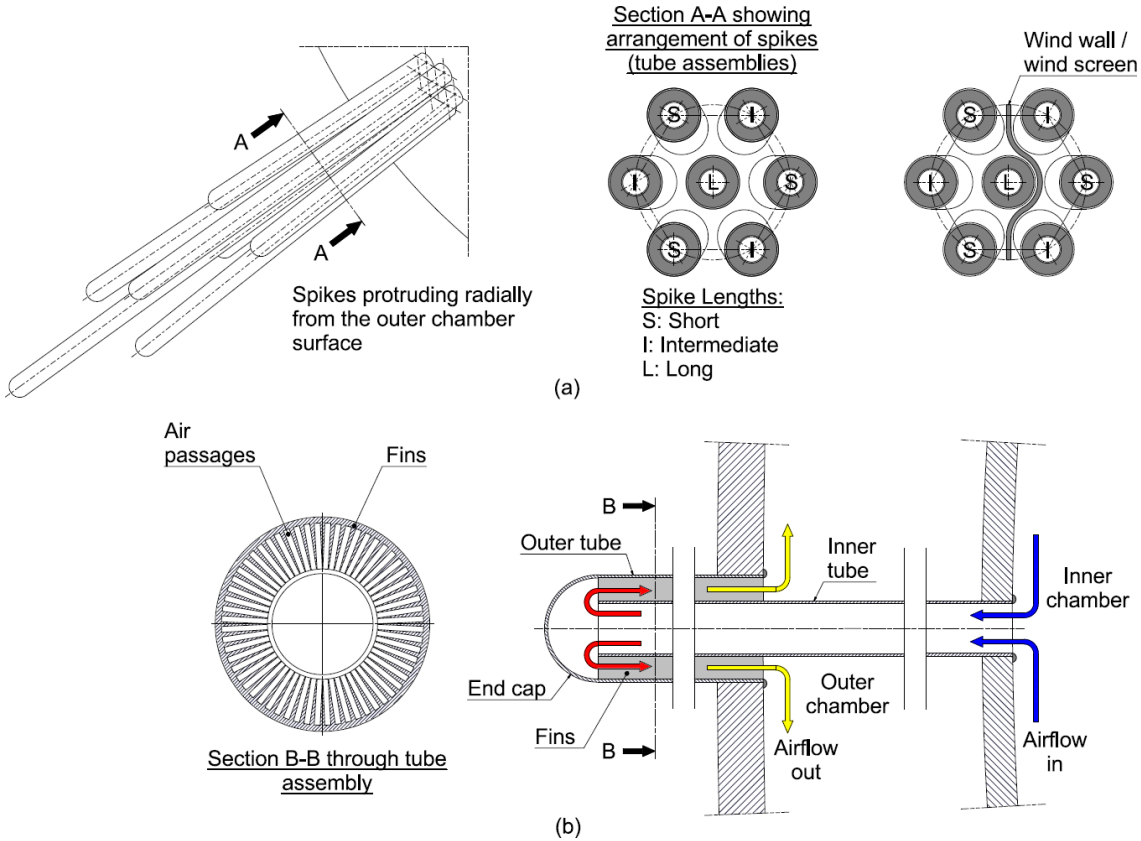

Figure 3: SCRAP tube assembly (spike) details: (a) tube arrangement, (b) tube geometry

Preliminary ray-tracing study

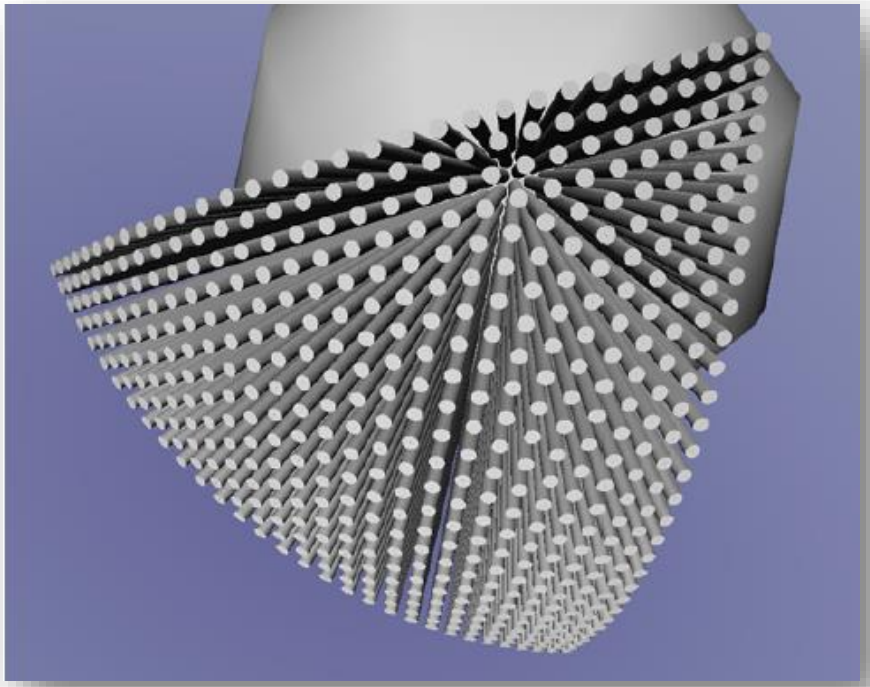

Figure 4: A screen shot of a SCRAP receiver with equal spike length

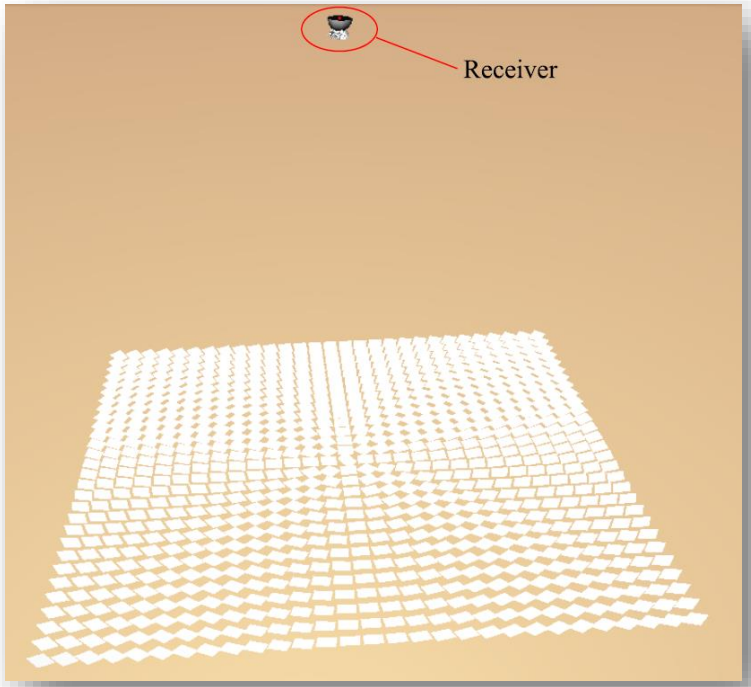

Figure 5: Terminology describing a spike

Sensitivity of flux distribution to heliostat size

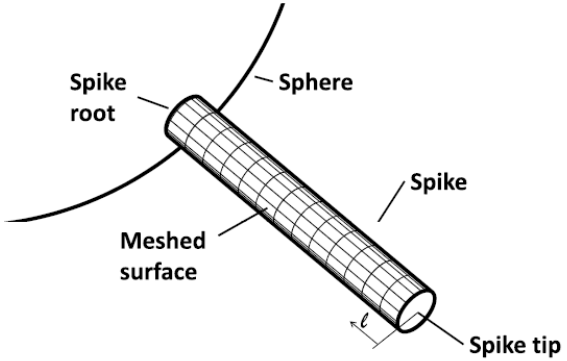

Figure 6: Terminology describing a spike

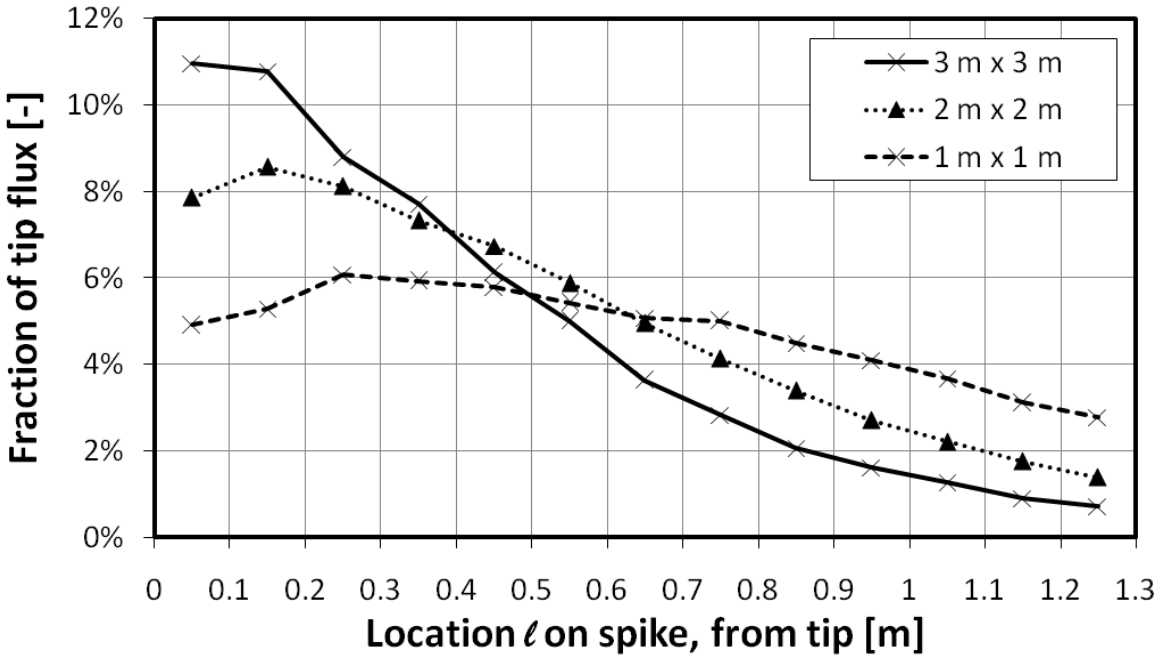

Figure 7: Flux along a spike for identical heliostat field density of 50 %

One-dimensional heat transfer model

- aid understanding of heat transfer mechanisms taking place,
- aid understanding of sensitivities of heat transfer to parameters,
- have a tool that allows for rapid change of parameters and viewing of their effect and
- have a tool that allows for easily programmable improvement of geometries.

One-dimensional heat transfer model

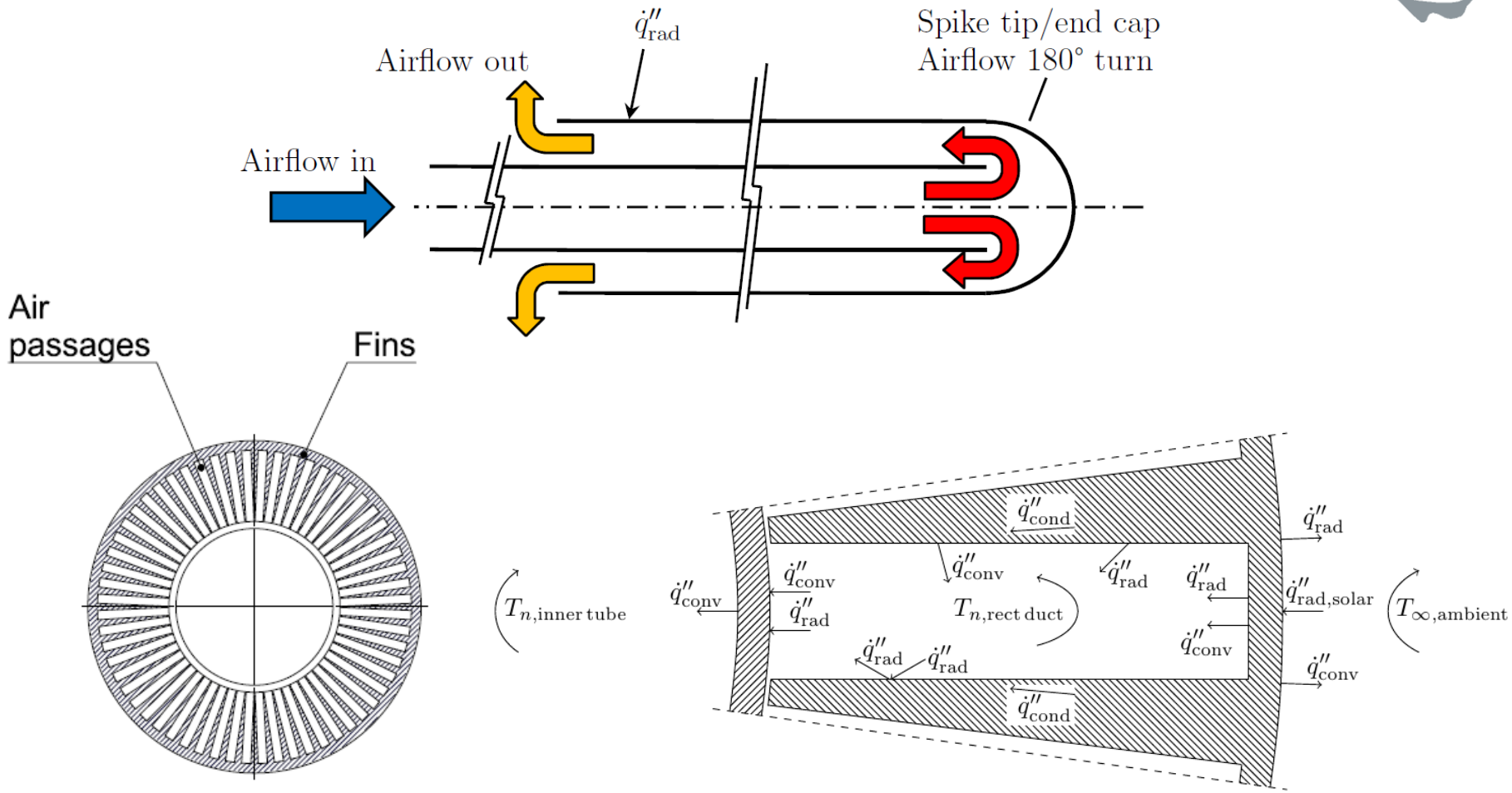

Figure 8: Visualization of heat transfer mechanisms within a rectangular duct

One-dimensional heat transfer model

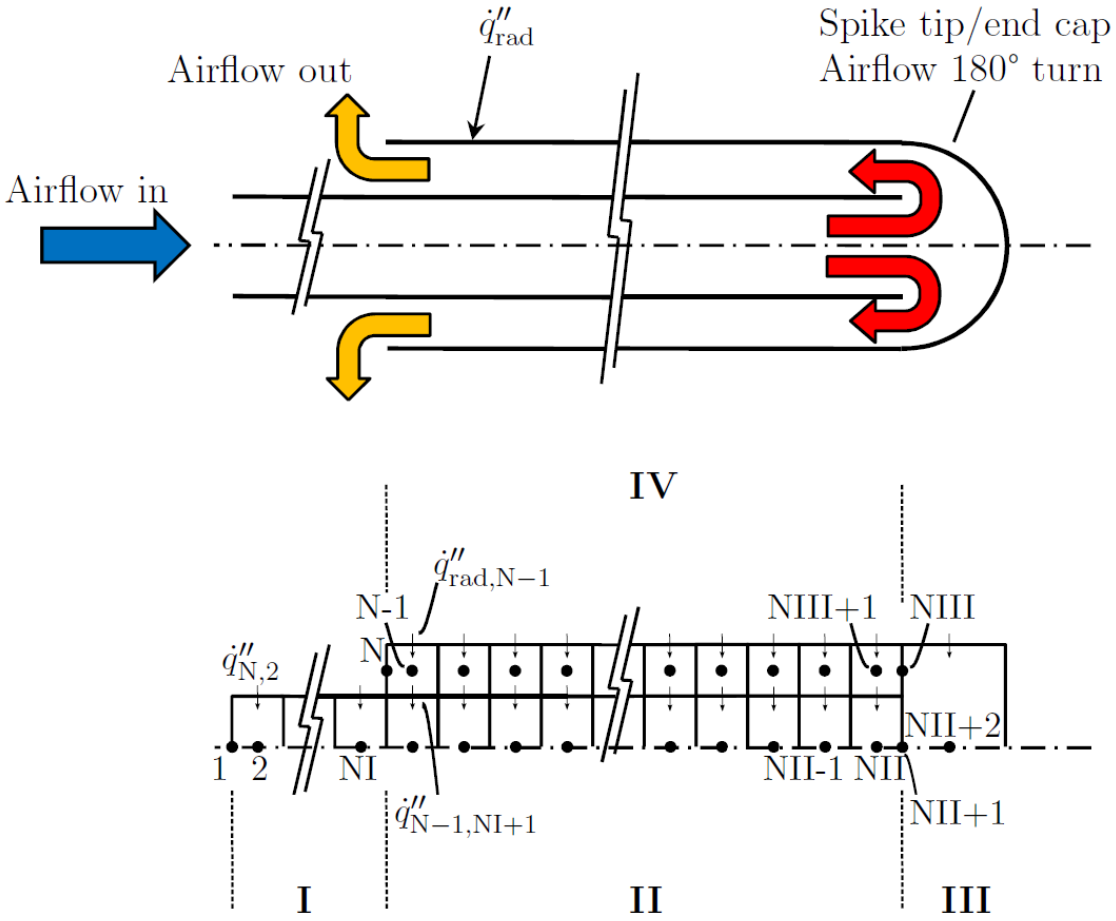

Figure 9: Topography of a spike

Some results

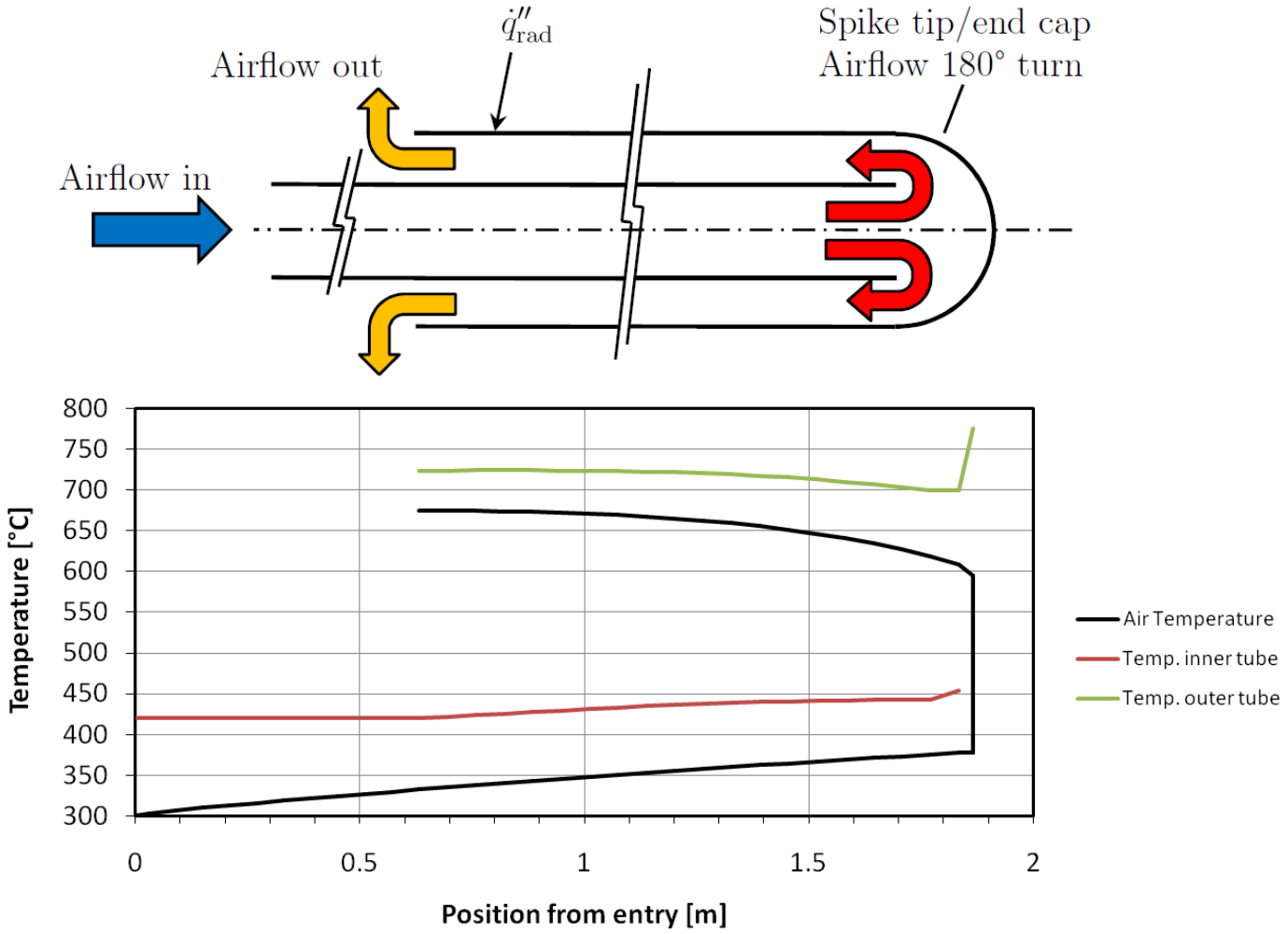

Figure 10: First results of temperatures in a spike

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STERG

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Development Approach

1. Begin with default design
2. Preliminary ray-tracing investigation
3. Development of one-dimensional code to simulate flow and heat transfer
4. Verification of (3.) in laboratory test
5. Development of a spike model in commercial CFD software
    a. Verify in (2.) and (3.)
    b. Develop details e.g. for tip cooling, spiraled ducts
6. Ray-tracing of receiver for design case
7. Optimization of spike geometries, using (3.)
8. Simulation of a spike cluster in commercial CFD software
9. Interpretation of results (η_{th}, Δp, $T_{metal,max}$, T_{air})
10. Development of receiver test model
11. Material considerations
12. In depth ray-tracing study
13. Aiming strategies

References

[1] Kröger, D. G. (2012). SUNSPOT - The Stellenbosch UNiversity Solar POwer Thermodynamic cycle. Technical report, Stellenbosch University, Stellenbosch.

[2] Kröger, D. G. (2008). Spiky Central Receiver Air Pre-heater (SCRAP). Technical report, Stellenbosch University, Stellenbosch.