Design of a cascade vapor tunnel and testing of ORC turbine blade rows

Supervisors: TUD: A.J. Head

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Starting date: ASAP

Location: Faculty of Aerospace, TU Delft

Project Overview

In 30 years from now, there will be 2 billion more people living in the so-called sun belt region. Agriculture will have to double food production to sustain the global population, with fewer resources and reduced environmental impact. No technology exists to achieve this target. SOLHO was founded to bridge this gap: we developed an innovative system called SPRHOUT (Solar-PoweRed Horticultural Off-grid UniT). The SPRHOUT uses the sun and available water sources (e.g., sea or sewage) to generate all the streams required by a greenhouse facility: electricity, heating/cooling, fresh water, and CO2. See right for the proof of concept.

The SPRHOUT enables:

- 75% reduction in CO2 emission,
- Off-grid, no need for electricity grid or gas network,
- 24/7 operation thanks to unique storage capabilities, and
- 90% operational savings compared to current solutions.

However, our technology relies on immature hardware, i.e. the performance can be increased, and software codes which require validation against experimental data. We use Organic Rankine Cycle (ORC) Power Systems since they are of paramount importance to exploit waste heat and renewable energy sources. The design of the turbine of ORC systems is the most challenging task. Standard design rules and empirical models are mostly available for steam/gas machines but are not directly suitable for ORC turbine design. This is mainly due to the thermodynamic behavior of the working fluids, which expand in the so-called dense vapor region.

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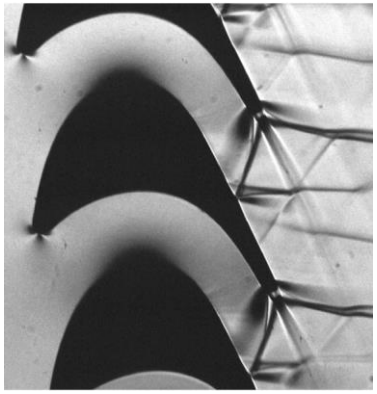
Project Details

A new vapor tunnel facility called the ORCHID has recently been commissioned in the PP Lab, see below, and is being used to generate the data required for validation of an open-source CFD code which will then be used for turbine design.

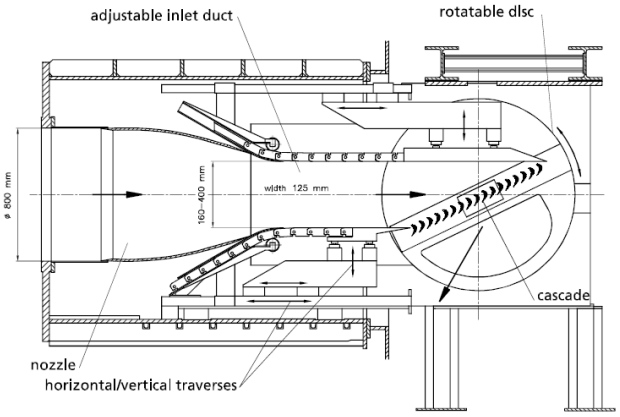


A simplistic representation of a turbine which maintains the flow physics is a linear blade cascade, one of the future test sections of the ORCHID, see right. The experiments needed to validate the thermodynamic model of the CFD code consist of generating complex flow patterns in the nozzle diverging part such as Mach and shock waves, see the figure above showing a schlieren image of the flow field. There is an uncertainty attributed with the thermodynamic properties (critical point and transport values) which lead to uncertain shock angles.

The student will focus on the detailed design and realization of a cascade vapor tunnel and a linear blade cascade. Turbine designs from SOLHO will then be used in the tunnel to study the performance over a series of operating conditions.

Deliverables

1. Literature study on cascade wind tunnels and the adaptations required for organic vapors. (1 month);
2. Detailed CAD and CFD analysis to assess the feasibility (1 month); and,
3. Make a list of specifications, bill of materials, sensor selection and procurement. (2 weeks)
4. Communicate with DEMO and other manufacturers to help realise the test section. (2 weeks)



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Internship assignment