Validation of the open source **SU2 flow solver**

Supervisors: TUD: A.J. Head

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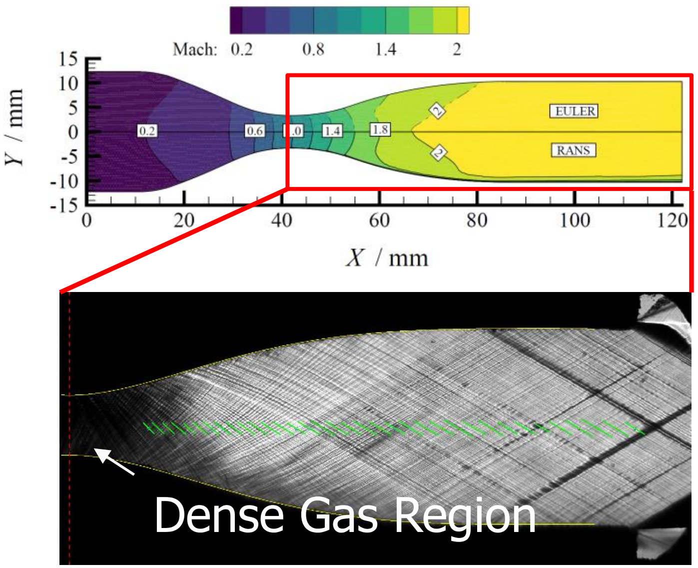
Starting date: ASAP

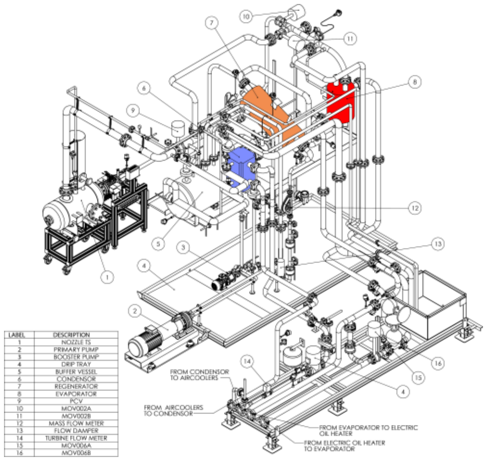
Location: Faculty of Aerospace, TU Delft

Project Overview

Nowadays Organic Rankine Cycle (ORC) Power Systems 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, see right.

There is an uncertainty attributed with the thermodynamic properties (critical point and transport values) which lead to uncertain shock angles, differences in strength and boundary layer thickness. A new vapor tunnel facility called the ORCHID, see below, has recently been commissioned 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.





FPP Master Thesis Assignment

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Project Details

A simplistic representation of a turbine which maintains the flow physics is a 2D de Laval nozzle, one of the test sections of the ORCHID. 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. A methodology has been developed to estimate the sensitivity of downstream fluid dynamic quantities to the uncertainty of thermodynamic model, however, it has yet to be validated with actual measurements together with the associated uncertainties.

In the framework of SU2 the student will focus on quantifying the different types of numerical errors, e.g., discretization errors in the context of the verification phase. Afterwards, in the validation phase, the student will assist with experimental campaigns whereby the Schlieren technique is adopted to study the flow patterns of a dense vapor expansion. Then, an automatic post-processing tool needs to be developed such that lines and angles can be automatically retrieved from the images.

Deliverables

1. Literature study on the various types of measurement techniques which could be adopted to study phenomena in a dense gas expansion. Review of relavent compressible flow phenomena, the use of CFD solvers and associated techniques. Review of 1D euler based real gas compressible solvers and Uncertainty analysis techniques. (2-3 months).
2. Assesment of the influence of the uncertainty of thermodynamic properties on calculated flow dynamic quantities. (1 month)
3. Verification assessment of SU2 for the ORCHID nozzle (1 month)
4. Validation assessment of SU2, e.g., UQ + Steady-state CFD flow simulations of the dense gas expansion. (1-2 months)
5. Development of a tool to automatically post process and extract lines and angles from Schlieren images (1 month)
6. Thesis write-up (1 month)