Project Proposal

Design of Supercritical Diffusers

General Information

Type:	Master Thesis (30 ECTS) or Semester Project (10 ECTS)
Laboratory:	Laboratory for Applied Mechanical Design (LAMD)
Supervisors:	K. Jacoby; Prof. J. Schiffmann
Location:	Neuchâtel[1] (travel allowance offered)
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Background

Supercritical power cycles will play a key role in the energy transition towards renewable energies benefiting from higher efficiencies and higher energy density.
Supercritical fluids are fluids at higher pressures and temperatures where the ideal gas law does not apply. Supercritical fluids are subject to real gas effects, and non-linear thermo-physical proprieties. The compressibility factor Z is given as, $Z = \frac{v}{v_{ideal}}$, where $v_{ideal} = \frac{RT}{p}$. At the critical point, the compressibility factor is at a minimum. Low compressibility leads to a reduction in compression work resulting in an increase in efficiency. Going away from the critical point, the compressibility increases rapidly allowing for more aggressive expansions within a diffuser.

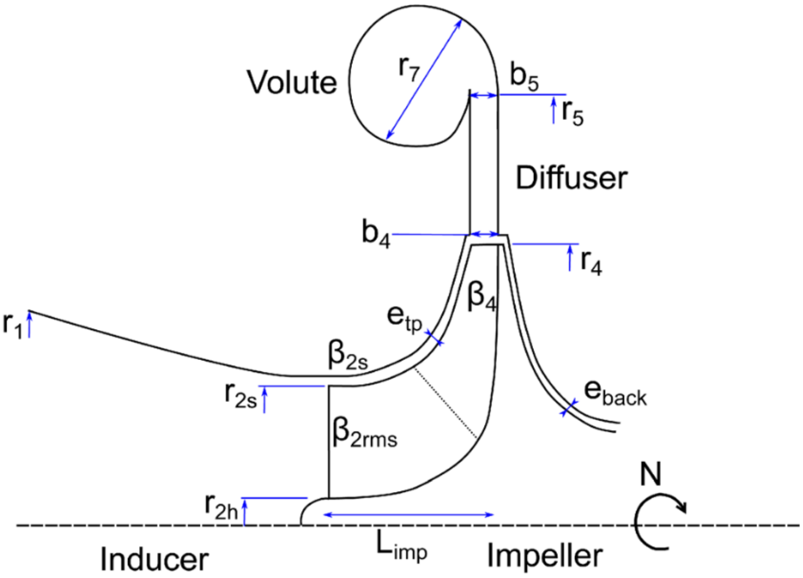

Figure 1: Compressor

Figure 2: Radial Compressor Geometry

Supercritical power cycles consist in an compression, heat addition, expansion and heat rejection with a supercritical working fluid. The compressor consists of an inducer, impeller and diffuser. Supercritical flow expansion within a diffuser has not been studied. Understanding the design limitations of diffusers operating with supercritical fluids will allow for a reduction in diffuser size and losses.

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[1] The possibility to work from the EPFL main campus in Lausanne can be discussed (semester project only)

Objective

Identification of thermo-physical properties of interest and real gas effects to provide design guidelines for supercritical diffusers.

Tasks

1. Identification of real gas effects within an expansion flow.
2. Identification of loss mechanisms within a diffuser.
3. Defining the design space for diffusers operating in the supercritical phase.
4. Study the impact of thermo-physical properties on diffuser performance.
5. Implementation of an optimization scheme to find the optimal diffuser geometry for a given set of operating parameters (massflow, Reynolds number, etc.) and thermo-physical properties (ANSYS OptiSLang or genetic algorithms).[2]
6. CFD to validate results.[2]

NB: adjustments may be required according to progress, results, and project duration.

Prerequisite knowledge

1. MATLAB
2. Fluid dynamics and CFD
3. Thermodynamics

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[2] Master thesis only