Project Proposal

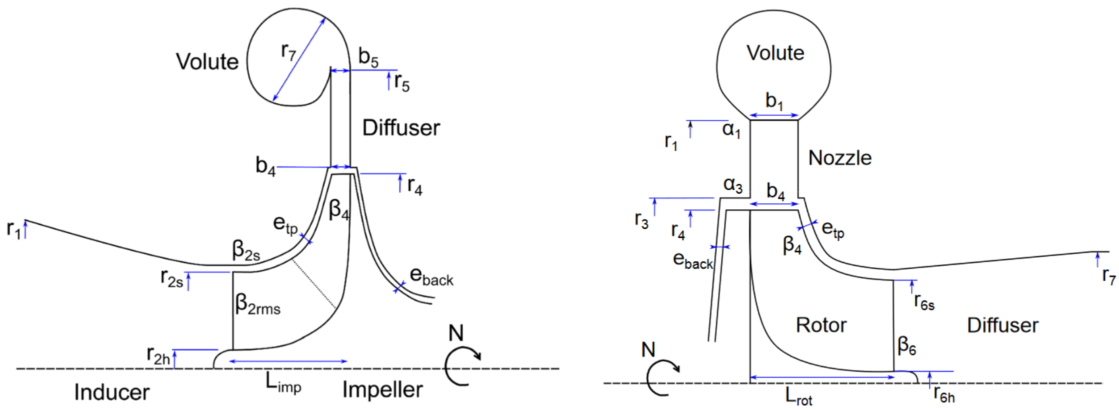
Radial Turbomachinery Blade Generator

General Information

Type:	Master Thesis (30 ECTS) or Semester Project (10 ECTS)
Laboratory:	Laboratory for Applied Mechanical Design (LAMD)
Supervisors:	G. Iovanna; I. Soukhmane; Prof. J. Schiffmann
Location:	Neuchâtel[1] (travel allowance offered)
Contact:	gabriele.iovanna@epfl.ch
Website:	`https://www.epfl.ch/labs/lamd/`

Background

The design process for a radial turbomachine, whether a radial inflow turbine or a centrifugal compressor, typically involves three phases. The first phase, termed *0D design*, is based on dimensional analysis and provides first estimates of the ideal tip diameter, the ideal rotational speed, and the isentropic efficiency. The subsequent step, termed *1D design*, entails the application of a *mean-line flow model* to identify the set of geometric parameters, named *1D geometry*, that maximize the isotropic efficiency of the turbomachine. The mean-line model incorporates velocity triangles, conservation laws, and empirically derived loss correlations to predict the performance of the turbomachine for a given operating condition and a given 1D geometry. An overview of the geometric parameters considered during the 1D design phase is given in Figure 1. The final design phase is the *3D design*. In this phase, the three-dimensional CAD model of the turbomachine is implemented in CFD simulations to analyze and optimize detailed flow patterns.



(a) Compressor (b) Turbine

Figure 1: 1D geometry

The geometric parameters obtained from the 1D design phase are limited to the inlet and outlet surfaces of the different components (inducer/nozzle, impeller, diffuser) of the turbomachine. To obtain a complete 3D geometry of the impeller, additional geometric parameters, such as the shroud and hub profiles and the blade angle distribution, are needed. The optimization of these additional parameters is done in the 3D design phase, which is the most accurate but also the most expensive in computational time. It is therefore essential to have a promising first estimation of the 3D geometry to reduce the required CFD iterations.

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

Objective

The objective of this project is to develop a strategy to identify a promising initial estimate of the geometric parameters required, in addition to those provided by the 1D geometry, to fully define the shape of the impeller blades. Furthermore, the goal is to integrate this strategy into a tool capable of directly generating a 3D model of the impeller, ready to be implemented in Ansys CFX to easily proceed with the CFD simulation.

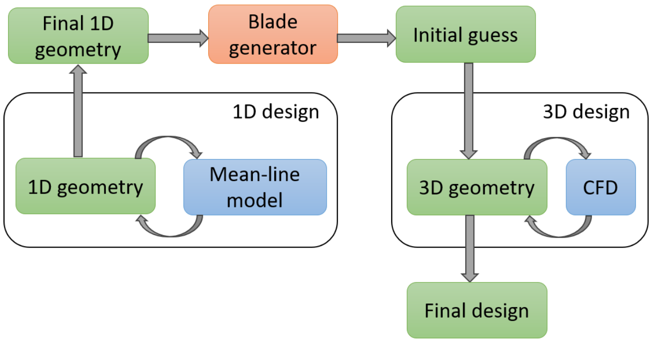


Figure 2: 1D and 3D design phases connected by the blade generator

Ideally, this toll needs to be developed for both radial inflow turbine and centrifugal compressor. However, the student is encouraged to focus on only one type of turbomachine at the beginning of the project, and to eventually extend to the other one if time allows.

Tasks

1. Familiarize yourself with the turbomachine design procedure.
2. Conduct a literature review on the design methods used for blades in radial turbomachines.
3. Formulate a strategy to identify a set of geometric parameters, supplementary to those provided by the 1D geometry, that fully characterize the shape of a promising impeller blade.[2]
4. Develop a blade generator capable of providing a 3D model of the impeller, ready to be use in CFD software.
5. Assess the blade generator's performance by scrutinizing the blade designs it proposes through CFD simulations.

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

Prerequisite knowledge

1. MATLAB / Python
2. Fluid dynamics and CFD
3. Thermodynamics
4. Analytic geometry

References

[1] W. Jansen and A. M. Kirschner. Impeller blade design method for centrifugal compressors. In *Pennsylvania State Univ. Fluid Mech., Acoustics, and Design of Turbomachinery, Pt. 2*, 1974.

[2] Ronald H. Aungier. *Turbine Aerodynamics: Axial-Flow and Radial-Flow Turbine Design and Analysis*. ASME Press, 2006.

[3] Chao Li, Zhiping Guo, Hao Guo, Xin Bao, and Le Zhou. Influences of main design parameters on the aerodynamic performance of a micro-radial inflow turbine. *AIP Advances*, 12(10):105012, 2022.

[2] Master thesis only