Optimization design of axial- and radial-flow turbomachines operating with non conventional fluids

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1 Introduction

In the last years we have seeing a fast increase of the exploitation of non conventional energy sources. For example: renewable energy sources (geothermal, biomass, solar) and heat recovery from waste heat at different temperature levels.

The optimization of the system requires in many instances the use of thermodynamic cycles, Rankine or Joule-Brayton, with non conventional fluids. Very frequently the useful power available from these sources is rather small and the traditional steam Rankine cycles results too much expensive and with too low conversion efficiency. Sometimes, for technological reasons, the working gaseous fluid in Joule-Brayton cycles might not be air, but a different ideal gas (helium, argon, a well determinate ideal gas mixture ...) or could reveal intense real gas effects (as carbon dioxide, in power cycles proposed for nuclear reactor plants, and potentially employable with some advantages in solar thermodynamic plants too).

The nature of the operating fluid and the power size affect directly all the system components and, particularly, the design and the efficiency of the turbomachines.

In the search of the optimum solution, the possibility to have a relatively simple and convenient method to value the main characteristics of turbomachines (stages number, rotor diameter and blade height, the rounds per minute ...) and to estimate the efficiency ought to be very useful.

Generalized diagrams based on the usually similarity parameters, as those described in [1, 2], are certainly helpful for a first rough evaluation, but they do not consider the peculiar characteristics of non-conventional operating fluids.

It is then desirable to implement a specific numerical tool for the optimization of any turbomachine stage (axial or radial) and operating with any fluid.

2 Objectives

The aim of the work is

- the implementation of an application program for the one-dimensional preliminary optimization of the stage efficiency of a turbomachine, axial
The optimization of the efficiency have to be carried out by means of a robust algorithm which can use and satisfy many geometrical non linear constraints. The main losses are going to be predicted using literature correlations.

The program has to give the efficiency, the velocities triangles and the main geometrical dimensions of the stage.

The volumetric and thermodynamic properties of the working fluid are going to be evaluated by means of a suitable equation of state.

Many Authors already were dealing with the preliminary design of turbomachines (see, for example [3, 4]) but often with reference to ideal fluids. On the other hand, complete numerical evaluation, as that reported in [5], are definitely necessary but a one-dimensional realistic and practical one-dimensional analysis is the basis for a good three-dimensional design.

It is essential for the execution of the work

- an in-depth search of correlation of losses in turbomachines, in supersonic conditions as well

- to select appropriate equations of state for the evaluation of the volumetric and of the thermodynamic properties of fluids. The equations of state ought to be accurate enough but, at the same time, as much as possible simple and they ought to enable the use of any working fluid

The application routine has to be written in an high level programming language, as C++. 
References


