Preliminary Meanline Design for Gas Turbines Using Multi–objective Optimization.

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***Abstract*—Designing gas turbines is a very complex task. It is not a linear procedure but an iterative one, composed by several phases. In the initial phase, the general geometric characteristics and estimate efficiency of the turbine are determined. This phase is known as the meanline design, and it is very important because it determines the starting point for more complex analysis. In this work we use a multi–objective evolutionary algorithm to calculate the meanline design. We consider two conflicting objectives: the number of stages of the turbine, and the efficiency of the stages.**

***Keywords*-Multiobjective; turbines; evolutionary; design;**

I. Introduction

Gas turbines are devices that extract energy from a fluid and transform this energy into useful work. As the name suggest, gas turbines use gas a the working fluid. Other kinds of turbines use other fluids to generate work. Turbines work with a continuously flowing fluid that interacts with a rotating blades in order to generate work. Gas turbines are classified in axial turbines and radial turbines. In axial turbines, the fluid flows mainly in an axial direction through the length of the turbine. In radial turbines, the fluid enters to the turbine in a plane perpendicular to the turbine axis, then the fluid is turned and leaves the turbine following the axial direction. In this work we focus on axial turbines for power generation. In Figure 1, an outline of a turbine is presented.

Two of the most important components of a turbine are the rotor and the stator. The stator is a fixed ring of blades or airfoils, that receives the fluid with an angle α_1. Then, the stator accelerates the flow so it arrives to the rotor with an angle α_2. The rotor is a circular array of blades, that turns as the fluid passes through it. The movement of the rotor turns a shaft, and this shaft transmit power that is transformed into movement or electricity. The fluid enters to the rotor with an angle α_2, and leaves the rotor with an angle α_3. The change in the flow of the fluid $(\alpha_3 - \alpha_2)$ is very important, because it is related with quantity of work that is performed by the rotor.

The combination of a rotor with its corresponding stator is called a stage. In order to extract as much energy as possible from a fluid, several stages may be necessary. There exist a trade off between the number of stages and the efficiency

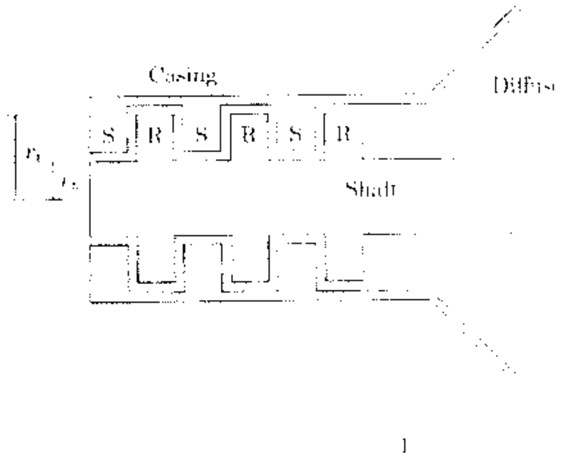

Figure 1. An axial of a turbine, S= stator, R=rotor.

of a turbine. The amount of energy extracted from a fluid in a stage is directly proportional to the losses due to friction. Incrementing the number of stages in a turbine increases its initial cost. But, it is possible to improve the efficiency of a turbine using several stages. Small increments in efficiency may result in huges saves in combustible in the long term.

The losses due to friction and the quantity of work done by an stage depends highly on the angles α_1, α_2 and α_3. The designer have infinite number of options with respect to what set of angles must be used. It is common to use a set of angles that fulfil the requirements of the turbine, but this set of angles not necessarily are the optimum with respect to efficiency.

In this work we use a multi–objective evolutionary algorithm to optimize the incidence angles α, so that the number of stages and the losses due to friction are minimized. The rest of the article is divided as follows: in Section II we give and introduction to multi–objective evolutionary optimization. In Section III we explain briefly the preliminary meanline design procedure for a gas turbine. In Section IV, we state the multi–objective problem to solve. In Section V, we present some experiments to evaluate the feasibility of our approach. Finally, in Section VI we state our conclusions.

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