

Abstract- Draft

SHAPE OPTIMIZATION OF TYPICAL HEAVY-DUTY GAS TURBINE COMPRESSOR AIRFOIL USING METAMODEL BASED ALGORITHM

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Abstract

Engineering optimization algorithms are used extensively nowadays to optimize complex real life engineering applications. Shape and topology optimization of complex mechanical systems represents one of the challenges that require efficient and robust optimization algorithms. In this paper, shape optimization methodology for a typical heavy-duty gas turbine (GT) compressor rotor blade sections is presented and modified. The approach presented here combines a Non-Uniform Rational B-Spline (NURBS) driven parametric geometry description, a two-dimensional flow analysis, and a meta-model optimization algorithm known as approximated promising region identifier (APRI), which is a modified version of space exploration of unimodal region elimination (SEUMRE), developed specifically for this purpose.

Since the use of evolution-based techniques in combination with CFD analysis tools for solving optimization problems in turbomachinery aerodynamics is limited by the massive computational effort, applying surrogate assisted algorithms seems to be a useful alternative. The genetic algorithms, for example, need too many CFD evaluations for convergence, which is not acceptable especially for expensive objective functions evaluation in aerodynamic shape optimization. Hence because of most of the computational time is spent in the evaluation of the objective function, a faster solution approach would be more appropriate.

APRI mentioned previously works by exploring the whole design space by sending agents (sampling points) to explore the design space and report some information on it. Based on the information obtained from all agents, the algorithm focuses the search in the most promising region and explores it more by deploying more agents (generating more sample points). Latin Hypercube Design (LHD), which is a well-known sampling technique, is used as a sampling technique to generate sample points. Once a promising region is identified, this region is refined

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by more sample points. A surrogate model or metamodel is then constructed to mimic the expensive objective function and help in searching for optimum solutions. With the objective of minimizing the total pressure losses for the design condition as well as maximizing the airfoils operating range, design optimization is carried out by coupling an established MATLAB code for the geometry parameterization of the airfoils' shape, a blade-to-blade flow analysis in CFD module of COMSOL Multiphysics, and a developed APRI in MATLAB script as the optimization algorithm. Using the combination of these adaptive tools and methods, the preliminary results are considerably promising in terms of computation time, number of function evaluations and ability to extend the methodology for three-dimensional and multidisciplinary problems, and last but not least is the airfoils' shape performance enhancement from efficiency and pressure rise point of view. The obtained results will be compared with other well-known and widely used optimization algorithms such as Genetic Algorithm (GA) for performance comparison and to highlight the advantages of using meta-model based optimization algorithms for real life and complex engineering problems such as aerodynamic shape optimization problems in the turbo-machinery field.