CAD-based aerodynamic optimization of geometrically complex turbine components

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ABSTRACT

A CAD-centric approach is well suited to enable multi-disciplinary analysis and optimization, where the analysis models of the individual disciplines, i.e. aerodynamic, stress and thermal analyses, are all derived from the same "master" CAD model, which can also incorporate constraints ensuring manufacturability, see for example [1,2].

The prerequisites for CAD-based numerical optimization of geometrically complex turbine components are as follows: (1) an associative parameterized CAD model that regenerates robustly when parameters are changed, (2) automated and robust quality-mesh generation, (3) automated application of boundary conditions and solution, and (4) automated post processing to extract objective and constraint function values.

In this contribution we will focus on the aerodynamic analysis and optimization of high-pressure turbine rotor blades, one of the geometrically most complex parts of the engine. First, we will describe the CAD master model, the derived CAD model for aerodynamic analysis and detail our approach to its parameterization.

In the next part we will focus on the mesh generation step: For the aerodynamic discipline, the automated generation of meshes which are suitable for RANS solvers, especially the robust generation of high-quality viscous layers for complex geometries, poses significant challenges to the meshing software. In addition the robustness of the mesh generator against "dirty" CAD models is of utmost importance, since the automatic re-generation of parameterized CAD geometries might produce CAD models which contain fold-over surfaces or similar problematic features. Here the recent improvement of cartesian mesh generators such as HexPressHybrid, snappyHexMesh and Boxer [3,4] offer to address these issues.

Finally we will detail the solution and postprocessing steps and show results of a recent application involving the optimization of the tip geometry of a high pressure turbine rotor blade.

References

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