INVESTIGATION OF AERO-DESIGN OPTIMIZATION TECHNIQUES FOR REDUCED STATOR-ROTOR INTERACTION IN HIGH-PRESSURE TURBINES

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During the past decades, investigations of aerodynamics in modern aircraft engines enabled to exceed 90% of turbine efficiency. Nowadays, new challenges arise with the development of lighter and more compact engines for improved fuel consumption. As a result, the high pressure turbine component might be designed as a single-stage operating in the transonic regime.

Experimental and numerical investigations have been extensively and continuously carried out to fully understand the steady and unsteady phenomena occurring in turbomachinery. In a transonic turbine stage, the rotor has to ingest non-uniformities generated within the stator. In order to limit the forcing on the rotor, the stator could be designed to have a downstream flow field as uniform as possible.

The purpose of the present project is the investigation of aero-design optimization techniques aiming at a stator design for reduced stator/rotor interaction in high-pressure turbines. Statement of work is shared in two main activities; first, the improvement of the optimization techniques; secondly, their application to the case of transonic turbine stage.

The effectiveness of optimization techniques is shown to be strongly dependent on the parametrization, the size of the design space, the robustness of the mesh and the handling of constraints. To fasten the process, a metamodel can be used as an approximation of the Navier-Stokes computation. It is shown that a proper calibration could lead to a fast and efficient training. Optimization techniques are then applied and compared to complete the design of a turbine stator for reduced stator/rotor interaction. Improvements of 2D sections with optimized contraction channel at hub and tip enables a reduction of more than 45% of the downstream 3D transverse static pressure oscillations. Complementary optimization of the stacking line with lean is also studied and enables reduction up to 65%.

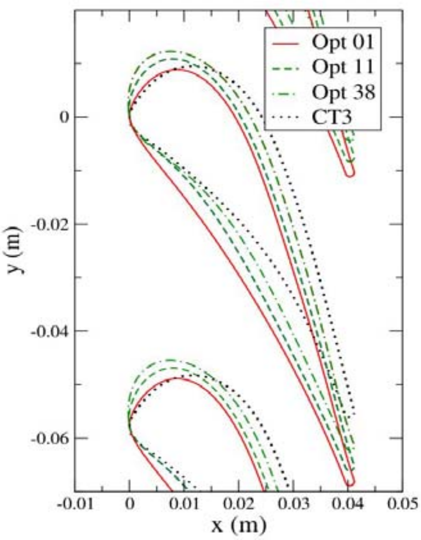

Figure 1: Series of optimized profile geometries

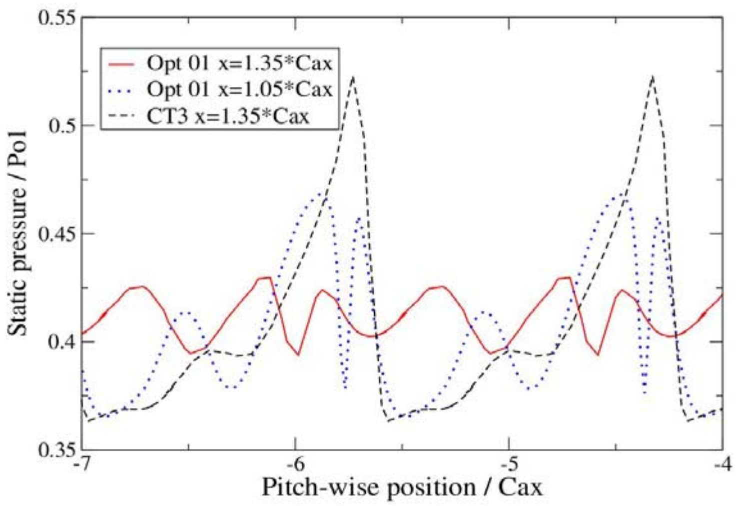

Figure 2: Pitch-wise distribution of the static pressure downstream of the transonic vane