Master thesis and internship[BR]- Master's thesis : Front blade optimisation of a critical tandem stator[BR]- Integration internship

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Abstract

In the context of improving axial compressor efficiency in turbojet engines, the Outlet Guide Vane (OGV), located at the end of the low-pressure compressor, plays a crucial role in reorienting the flow axially to ensure optimal conditions for the downstream high-pressure compressor. However, during off-design operations, the inlet flow angle can vary significantly, which may cause flow separation, increase the pressure losses, and decrease the performance. The goal of this thesis is therefore to find an optimised variable tandem OGV geometry by adjusting the rotation strategy and the position of the front blade.

To achieve this goal, a tandem blades system with a variable stator vane (VSV) on the front blade was considered to enlarge the range of acceptable incidences. Tandem blades allow flow deviation to be distributed across two blades, reducing Boundary Layer (BL) separation by starting a new BL on the rear blade, while the VSV allows adaptation of its stagger angle to the inlet flow angle. The study explores how the rotation of the front blade around different pivot points can significantly enhance the compressor stage's performance across a wide incidence range.

Using the optimisation software Minamo, an automated process was implemented to determine the total pressure losses and the static pressure gain, by optimally rotating the front blade to a large range of inlet flow angles, given the position of the front blade and the pivot point. The results were obtained through 2D RANS simulations, performed with SU2.

As a starting point, one static and two rotating configurations from M. Brach's thesis [1] were used: rotation around the trailing edge and around the mid-chord. The first one offers very good performance while the second one presents a more practical application to manufacture.

With the automated process, a large number (282) of simulations were performed varying the front blade initial position and the pivot point position. These simulations allow to create surrogate models to link the input parameters to the output responses. These models were trained to predict, as precisely as possible, the responses from the parameters in a continuous way, in order to target the configuration(s) with the best performance.

The optimisation led to consider several optimal configurations, which constituted a Pareto front between maximising the pressure gain and minimizing the losses. Considering these configurations, while the pressure ratio was increased by only 1% to 3%, a reduction of up to 20% of the losses could be observed, compared to the best base rotating configuration.

Additionally, configurations with the pivot point located inside the front blade, between the mid-chord and the trailing edge, show the advantage of migrating from the first to the second point, particularly at low incidence angles.

Despite its limitations, mostly due to the 2D simulation geometry and the stationnary RANS model used, this work demonstrates the potential improvements achievable with optimisation-driven designs in variable tandem blades OGV.