Aerodynamic Validation for Compressor Blades Structural Morphing Concepts

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Abstract:

In order to reduce an aircraft's polluting emissions and to comply with international environmental goals for a sustainable and eco-friendly aviation, it is necessary to re-design aircraft, focusing on a high performance during all flight phases. To achieve this, it is necessary to move from a single design point development process towards an adaptive and multidisciplinary design process. In order to guarantee an optimal performance at different flight phases, aircraft need to be adaptable. Since the engine's performance and therefore the compressor performance is crucial for an aircraft's overall efficiency, one can increase performance by designing compressor blades capable of adapting themselves to different flying conditions.

Within the frame of the Sustainable and Energy Efficient Aviation Excellence Cluster, the use of structurally integrated actuators on the blades' suction and pressure sides is investigated, the goal being to increase aerodynamic performance by structurally morphing the blade shape. By expanding or contracting, the integrated actuators are capable of achieving the desired aerodynamic shapes for off-design operating conditions by modifying spanwise turning and stagger.

Once the desired design and morphed shapes are defined, it is necessary to study the aerodynamic sensitivity of the deformed rotor geometries in 3D. To achieve this, the focus of this research lays on the aerodynamic validation of different piezoceramic actuation configurations and the comparison of the resulting structural morphed shapes with the aerodynamic pre-design / expectations. With the results of this comparison, it is then possible to analyze the aero-structural discrepancies and perform the necessary adaptions in the aerodynamic pre-design. For the structural analysis FEM simulations allowing to calculate the morphed shapes are performed. The results are then transferred to the aerodynamics and further analyzed with the help of stationary 3D RANS CFX simulations also focusing on the suitability of different turbulence models.

Short Abstract:

For increasing an aircraft's engine efficiency and reducing emissions, the use of adaptive blades capable of guaranteeing an optimal performance at different flight phases is researched. An aerodynamic design point blade shape and morphed shapes for different conditions are determined. A structural design process develops structurally actuated morphing blades aiming to reach these aerodynamic goals. Finally, the aerodynamic sensitivity of the structurally achieved deformed geometries is studied.