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AEROELASTIC ANALYSIS AND OPTIMAL DESIGN OF AXIAL MULTISTAGE FANS AND COMPRESSORS

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ABSTRACT

The continuous increase in aeroengine performances and efficiency has lead to very high blade loadings. High efficiency and high design specific performances enable the designer to match the prescribed performances at reduced rpm. This is a quite effective way of reducing the fan noise [1] and of designing compact gasturbines. The higher efficiency is obtained by increasing the blade circulation along the dominant part of span, by using a non-free-vortex design. This results in sharper flow gradients and in an increased sensitivity to off-design conditions as well as to variations of the mass flow distribution [2].

A better flow behaviour over the blades can be obtained by optimizing the blade planform in order to have smoother flowfields, to increase the tolerance to off-design conditions and to decrease aerodynamic losses. For this purpose, the blade sweep/lean seems to be a key design parameter. Numerical and experimental investigations have shown a strong influence of sweep/lean on the flowfield in the blade channel. The use of sweep and leaned blades allows for ducted fans that are more tolerant to incidence variations at the tip region, and a reduction of the tip leakages is also observed [3]. The blade sweep/lean can have a strong influence on the aeroelastic behaviour of the system as well, and the related effects should be accounted during the optimization process by the designer.

The work here proposed focuses on the accounting of aeroelastic effects in the global process of the optimal aerodynamic design. By focusing our efforts on axial turbomachines, in particular on fan and compressors, an unsteady through-flow model is developed in formulating both a direct analysis problem as well as a design problem, which is solved by an inverse procedure. In *direct mode* the aeroelastic and aerodynamic effects of an external perturbation or of an imposed blade motion can be analyzed. In *design mode* the aeroelastic characteristics of the system are solved as a part of the constrained inverse problem. After the description of the method and some numerical experiments, the benefits deriving by the coupling with adjoint and MOGA optimization procedures, available on previous tools [4][5] is discussed.

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