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DISCRETE ADJOINT MIXING-PLANE FORMULATION FOR MULTI-STAGE TURBOMACHINERY DESIGN

Simão Rodrigues, simao.rodrigues@tecnico.ulisboa.pt
CCTAE, IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Portugal

André Marta, andre.marta@tecnico.ulisboa.pt
CCTAE, IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Portugal

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The use of computational fluid dynamics (CFD) tools in turbomachinery has seen an increase as a result of the exponential growth of computational power, as well as of improvements of the accuracy of numerical simulations. These tools are often used in optimization environments, where gradient-based optimization algorithms are the most common due to its efficiency.

The optimization may contain a large number of design variables (typically in the order of thousands), such in cases of shape optimization. In these cases, the adjoint approach for calculating the gradients is beneficial, as it provides a way of obtaining function sensitivities with a computational cost that is independent of the number of design variables, as opposed to what happens with the well known finite-difference approach.

The interaction between adjacent blade rows has an important impact on the whole performance of a multi-stage turbomachine. The most commonly used method to address these effects in the simulation of multiple rows is the mixing-plane treatment, that has become a standard industrial tool in the design environment.

In this paper, improvements on the adjoint solver of a proprietary CFD solver for multistage turbomachinery applications are presented, namely the adjoint counterpart of the mixing-plane formulation used in the direct solver.

The solver is developed using the discrete ADjoint approach, where the partial derivatives required for the assembly of the adjoint system of equations are obtained using automatic differentiation tools.