Numerical Study on Passive Morphing Control Adapted to a Large Axial Fan

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ABSTRACT

Industrial and tunnel ventilation fans can work in environments that can entail unsteady and distorted inflow conditions. These installation effects lead the fan to work with an inlet condition that is different from the one supposed in the design phase, producing unsteadiness in loads and aerodynamic field. With new materials and more complex three-dimensional designs, to control these unsteadiness becomes very important in the virtual prototyping phase.

The concept of morphing geometry finds interesting applications in load reduction and performance increasing for aircraft wings and rotor blades in off-design conditions. We applied this control logic to a large axial fan blade in the form of an elastic surface applied to the trailing edge.

The work has divided in two parts, a study at the section level about the effect that the morphing geometry has on the local section aerodynamic coefficients, and then the application to the three-dimensional blade to verify the system including three-dimensional effects.

All the simulations imply the solution of the fluid-structure interaction between the incompressible, turbulent flow and the elastic structure. This solution is obtained using a finite element based, strongly coupled solver, applied to the periodic three-dimensional domain of the blade vain.

The FSI solver computes the solution of the systems of equations of fluid and structure, using a quasi-direct coupling algorithm. The Petrov-Galerkin stabilized formulation for the solution of the ALE-URANS (Arbitrary Lagrange Euler formulation of Unsteady Reynolds Averaged Navier Stokes) equations is implemented for the aerodynamic portion of the global system, while a structural solver based on the linear elasticity equations is implemented to model the structural part. The low-Reynolds k-ϵ turbulence model is used to close the turbulence problem.

The mesh motion problem is treated as a static elastic problem by solving the elasticity equations for the displacement of the mesh nodes. The algorithm is implemented into an in-house code, already used and tested by the authors for the simulation of turbulent flows in turbomachinery applications.

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