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Numerical Method for Wet-Steam Flows in Turbine Cascades

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ABSTRACT

A numerical method for the simulation of wet-steam flows with a polydispersed spectrum for the liquid droplet size is presented. The so-called moment method [1-6] is used to represent the liquid droplets evolution, since it guarantees at the same time a low computational cost and a well-suited modeling. This approach consists of a partial modeling of the droplet size distribution, through the resolution of transport equations for the lowest-order moments of the droplet spectrum. This allows evaluating the wetness fraction and the mean radius of the droplets without a full representation of the size spectrum.

If viscous effects are neglected, the motion of the two-phase mixture is governed by the Euler equations, completed by suitable thermodynamic models for the gas and liquid behavior. Several equations of state are considered to model the thermodynamic behavior of the vapour phase, namely, the equation for perfect polytropic gases, a Z-factor equation of state, and the van der Waals equation. The main system of governing equations for the two-phase mixture are coupled with four additional equations for the moments of the droplet radius distribution. Precisely, equations for the zeroth- to the third-order moment are considered. The equations are discretized by means of a finite-volume scheme on multiblock structured meshes [7]. The scheme uses a third-order accurate centred space discretization, with corrections that take into account mesh deformations and ensure high-order accuracy even on irregular grids. The discretization method has been successfully validated, in previous works, for the computation of flows of dry vapours close to saturation conditions past airfoils [8], wings [9], and through two-dimensional turbine cascades [10].

In the final presentation details of the physical model and of the numerical method will be presented, along with validation results for well-documented test cases concerning wet-steam flows through turbine cascades.

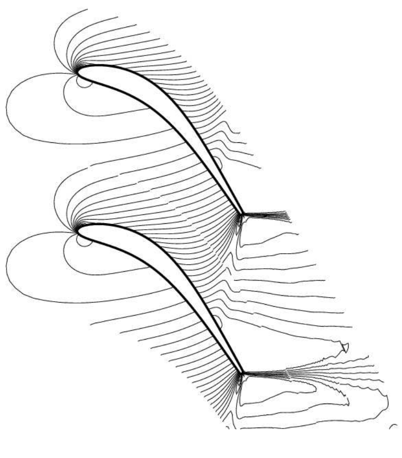

Figure 1: *Mach iso-lines for a dry steam flow through a turbine cascade with inlet thermodynamic conditions (normalized with critical-point values)* $p_1/p_c = 0.9$, $\rho_1/\rho_c = 0.6$, *inlet angle* 15.2^0, *and inlet-to-outlet pressure ratio equal to 1.64.*

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