Interface Boundary Conditions for the Transfer of Flow Structures based on the Method of Characteristics

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Interfacing information between flow simulations is relevant for several applications, especially if the flow character differs, but the correct flow structure transfer is essential for the realism of the results. For example, the hot flow structures from the gas turbine combustor are essential for the cooling arrangement in the consecutive turbine stage. The unified simulation would demand handling flow compressibility and combustion over the entire numerical domain. Splitting the investigated problem is computationally more efficient, where simplifying assumptions apply in the subdomains.
Therefore, we present a boundary condition based on the method of characteristics, where the spatial and temporal description of the flow structures is represented via proper orthogonal modes. The leading proper orthogonal modes are considered to represent the coherent flow structures, while the higher-order modes can be used to obtain appropriate estimates for the transport variables of the turbulence model.
The application of this boundary condition is exemplified on the problem of indirect combustion noise generation in a gas turbine. The unsteady combustor gasses are entrained into the turbine and accelerated at different speeds depending on their temperature. The proper orthogonal modes of combustor simulations are used to represent the process of entropy noise production and propagated through a high-pressure turbine stage. Centrifugal forces and buoyancy alter the flow path of the cold and hot streaks passing through the vane and blade passages and redistribute the entropy structures. The pressure drop over the particular blade row and the speed of the rotor are essential factors.

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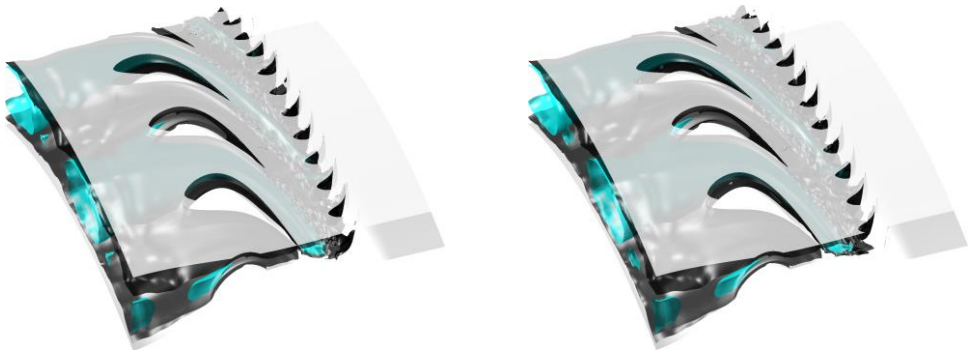

Figure 1. Two snapshots of the temperature iso-surfaces illustrate the propagation of hot streaks imposed at the inlet through the turbine stage, where the cyan and the black colours represent hot and cold temperatures, respectively.