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Negative Pre-Swirl Brakes: Design and Numerical Modeling

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Experimental investigations have shown that negative pre-swirl at inlet in the seal beneficially affects the cross-coupled stiffness, and therefore the rotor stability. The pre-swirl brake used by Childs et al. (2014) [Childs, D.W., Mclean, J.E., Zhang, M., Arthur, S.P., June 2014. Rotordynamic performance of a reverse-swirl brake for a tooth-on-stator labyrinth seal. In: Proceedings of ASME Turbo Expo 2014: Turbine Technical Conference and Exposition GT2014. No. GT2014-25577. Dusseldorf, Germany] was our first attempt to design the brake using computational fluid dynamics. An improved version of the pre-swirl brake was obtained by redesigning the casing and optimizing the number of vanes (brakes) and their stagger angles, and the vane axial location. The negative pre-swirl was obtained by reducing flow separation over the vane. The numerical simulations of the brake flow, however, did not model the seal flow and only specified a static pressure at inlet in the seal. We propose herein to include the details of the seal flow in the simulation. In addition, we propose to assess the effects of using cambered vanes for the brake. Furthermore, we propose to also explore the benefit of using splitters, that is, half-chord vanes, similar to those used in some centrifugal compressors, to better control the flow in the brake. In addition to the investigation of these flow features, we propose to add grid adaptation to the flow solver to reduce the computational cost generated by the more complex geometries we plan to simulate.

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