Turbomachinery Laboratory
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Effect of Turbulence Model on Seal Flow Prediction

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The prediction the cross-coupled stiffness, *k*, and the direct damping, *C*, of annular gas seals is important for assessing rotor stability. An increase of direct damping improves stability, while an increase of cross-coupled stiffness decreases stability. Seal inlet fluid pre-rotation (or pre-swirl) opposite to the rotor rotation decreases cross-coupled stiffness, therefore increasing rotor stability. The effect of pre-swirl was also investigated for the development of a high-pressure fuel turbo pump of the Space Shuttle Main Engine (SSME) [Nielsen, K. K., Childs, D. W., Myllerup, C. M., April 2001. Experimental and theoretical comparison of two swirl brake designs. Journal of Turbomachinery]. This experimental investigation was supplemented by a numerical study of the effect of swirl brake on the seal inlet pre-swirl. According to our current understanding, the variation of the swirl ratio at the inlet in the brake should be similar to the variation of the cross-coupled stiffness. This was not, however, supported by the numerical results presented in Nielsen et al. (2001). Therefore, the work proposed herein was motivated by the need to understand how the numerical simulation of the brake flow must be improved to match experimental results. This project will assess the effect of the order of the discretization scheme vs. the turbulence model by comparing second-order $\kappa - \epsilon$ turbulence model vs. fourth-order $\kappa - \epsilon$, Shear Stress Transport and implicit large eddy simulation for several canonical cases, including backward-facing step, periodic hill, and cavity flow. In addition, it will compare the variation of numerically predicted seal inlet swirl ratio against the variation of experimentally measured cross-coupled stiffness for the SSME turbo pump.

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