Closure to "Discussion of 'The Lomakin Effect in Annular Gas Seals Under Choked Flow Conditions'" (2007, ASME J. Eng. Gas Turbines Power, 129, p. 1143)

Mihai Arghir
Université de Poitiers, France
e-mail: mihai.arghir@lms.univ-poitiers.fr

The authors are grateful for this experimental validation of the negative direct static stiffness of choked annular seals. For performing our own calculations, the mentioned conditions were supplemented by some additional assumptions that are somewhat usual for straight annular seals, namely, an imposed inlet pressure drop coefficient ζ_{inlet} and an exit recovery coefficient $\zeta_{exit}=1$ (complete pressure recovery). The rotation speed was $\omega=0$, and the flow regime was considered as being nonisothermal with adiabatic walls and $T_{inlet}=20°C$. Moody's friction factor was used with the possibility of bridging transition between laminar and turbulent flow. The employed grid had 16 equally spaced cells in the axial direction and 32 in the circumferential one (Fig. 1).

The first set of results was obtained for $\zeta_{inlet}=0.1$ and zero roughness. Results show a good prediction of the negative direct static stiffness at a pressure drop DP=18.3 bar and calculations could be performed for values of >20 bar. Nevertheless, the flow in the seal becomes choked at much lower pressure differences than the 10 bar announced by experiments. It was further recognized that ξ_{inlet} generally varies with the axial Reynolds number (triggered by the pressure difference); thus, a variable inlet pressure drop was used in a second set of calculations, $\xi_{inlet}=\sqrt{5.3/\log(\mathrm{Re})-1}$. The results show a larger negative value for the direct static stiffness at DP=18.3 bar but no modification of the predictions at lower pressure differences.

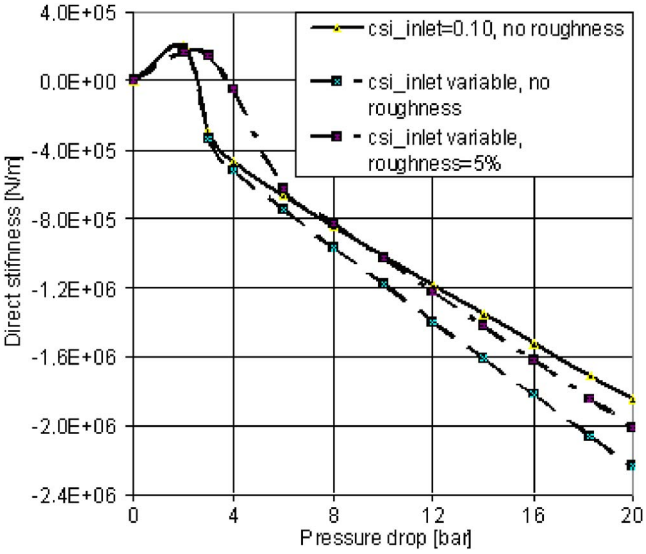

Fig. 1

A third set of results was obtained by considering the variable ξ_{inlet} and a 5% roughness of the rotor and stator surfaces. The prediction for DP=18.3 bar is very close to $K=-1.93$ MN/m, and the values of the static stiffness obtained for low-pressure drops corresponding to nonchoked flows show a tendency toward an improvement. Nevertheless, larger values of the roughness cannot be predicted by Moody's law.

Again, the authors are grateful for this discussion that evidenced that a choked exit flow of gas annular seals can lead to negative values of the static stiffness.

Submitted to ASME for publication in the JOURNAL OF ENGINEERING FOR GAS TURBINES AND POWER. Manuscript received January 3, 2007; final manuscript received January 4, 2007. Review conducted by Dilip R. Ballal.

