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GAS LABYRINTH SEALS: ON THE EFFECT OF GEOMETRY AND OPERATING CONDITIONS ON FLOW FRICTION FACTORS – A CFD INVESTIGATION

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Bulk-flow predictive models, though simple and fast, often fail to accurately predict the performance of gas labyrinth seals (LSs). Presently, a CFD analysis quantifies the effects of labyrint LS tip clearance (C_r) and operating conditions on the friction factors (f_r, f_s) at the rotor and stator surfaces, along the circumferential direction. The analysis aims to improve the prediction of LS dynamic force coefficients, in particular the evolution of the circumferential flow velocity and the seal cross-coupled stiffness. A fourteen teeth on stator LS seal (L/D=0.29) with clearance C_r=1/733 D is selected for analysis. The seal operates at nominal supply and discharge pressures equal to 73 bar and 51 bar, respectively, and at a rotor speed of 12 krpm (surface speed=138 m/s.).

The analysis models the seal with a fine mesh of a few million nodes and a commercial CFD code calculates the flow field for the nominal operating conditions, as well as for changes in clearance, 20% above and below C_r, shaft speed from 5 krpm to 15 krpm (58 m/s ~173 m/s), inlet pre-swirl velocity varying from 42% to 72% of rotor surface speed, a gas supply pressure ranging from 60 bar to 100 bar, and along with various discharge pressures producing a pressure ratio (*PR*) ranging from 0.40 to 0.85. The numerous predictions output the wall shear stresses as well as the bulk-flow velocity and frictions factors. The rotor surface friction factor f_r is independent of the (modest) changes in clearance (C_r) or the inlet presiwrl ratio; whereas an increase in rotor speed or pressure ratio (*PR*) decreases f_r. On the other hand, an increase in rotor speed, pressure ratio and inlet preswirl ratio decreases f_s, the stator friction factor. Besides, f_s increases with an increase in radial clearance. Further, f_r and f_s are only sensitive to the pressure ratio, but not to the magnitude of the supply pressure or discharge pressure.

Lastly, The CFD predictions produce new coeffients for the classical Blasius friction factor model, $f=n\,Re^m$, with *Re* as a bulk-flow Reynolds number relative to a wall. Later, integration of the found *f*'s into a BFM code will improve its accuracy to predict the evolution of the circumerential flow velocity and the seal rotordynamic force coefficients.