First-Order Equations

(*a*) Axial-Momentum Equation

$$\frac{-C^2}{\mu U}\frac{\partial p_1}{\partial z}=\frac{2Ch_1}{\mu U}\frac{\partial p_0}{\partial z}$$

$$+\frac{n_0}{2}R_{C0}{}^{1+m_0}A_1[(1+m_0)h_1U_{z0}+U_{z1}]$$

$$+\frac{n_0}{2}R_{C0}{}^{1+m_0}U_{z0}(1+m_0)A_2$$

$$+CR_{C0}\left(\frac{1}{U}\frac{\partial U_{z1}}{\partial t}+\frac{U_{\theta 0}}{R}\frac{\partial U_{z1}}{\partial \theta}+U_{z0}\frac{\partial U_{z1}}{\partial z}\right)$$

$$A_2=(U_{\theta 0}^2+U_{z0}^2)^{\frac{m_0-1}{2}}(U_{\theta 0}U_{\theta 1}+U_{z0}U_{z1})$$

$$+[(U_{\theta 0}-1)^2+U_{z0}^2]^{\frac{m_0-1}{2}}[(U_{\theta 0}-1)U_{\theta 1}$$

$$+U_{z0}U_{z1}] \qquad \text{(B.3)}$$

(*b*) Circumferential-Momentum Equation

$$\frac{-C^2}{\mu U}\frac{1}{R}\frac{\partial p_1}{\partial \theta}=\frac{n_0}{2}R_{C0}{}^{1+m_0}U_{\theta 1}A_1+\frac{n_0}{2}R_{C0}{}^{1+m_0}(1+m_0)A_3$$

$$+\frac{n_0}{2}R_{C0}{}^{1+m_0}(1+m_0)A_4h_1$$

$$+CR_{C0}\left(\frac{1}{U}\frac{\partial U_{\theta 1}}{\partial t}+\frac{U_{\theta 0}}{R}\frac{\partial U_{\theta 1}}{\partial \theta}+U_{z0}\frac{\partial U_{\theta 1}}{\partial z}\right.$$

$$\left.+2h_1U_{z0}\frac{\partial U_{\theta 0}}{\partial z}+U_{z1}\frac{\partial U_{\theta 0}}{\partial z}\right)$$

$$A_3=U_{\theta 0}(U_{\theta 0}^2+U_{z0}^2)^{\frac{m_0-1}{2}}(U_{\theta 1}U_{\theta 0}+U_{z1}U_{z0})$$

$$+(U_{\theta 0-1})[(U_{\theta 0-1})^2$$

$$+U_{z0}^2]^{\frac{m_0-1}{2}}[U_{\theta 1}(U_{\theta 0}-1)+U_{z1}U_{z0}]$$

$$A_4=U_{\theta 0}(U_{\theta 0}^2+U_{z0}^2)^{\frac{1+m_0}{2}}$$

$$+(U_{\theta 0}-1)[(U_{\theta 0}-1)^2+U_{z0}^2]^{\frac{1+m_0}{2}} \qquad \text{(B.4)}$$

(*c*) Continuity Equation

$$\frac{\partial U_{z1}}{\partial z}+\frac{U_{\theta 0}}{R}\frac{\partial h_1}{\partial \theta}+\frac{1}{R}\frac{\partial U_{\theta 1}}{\partial \theta}+\frac{1}{U}\frac{\partial h_1}{\partial t}=0 \qquad \text{(B.5)}$$

DISCUSSION

Wei-Tang Lai[2]

Forces exerted by high pressure annular seal are important in the rotordynamic stability analysis. The author improved the model for calculating dynamic seal coefficients by considering the influence of fluid inertia terms and inlet swirl based on Hirs' bulk flow thoery. The results showed a remarked difference in cross coupled stiffness and direct damping terms. The inlet swirl was found to decrease the cross coupled stiffness and damping coefficients.

Since the fluid friction loss for the rotating concentric cylinders depends on the radial clearance, the discussor wonders what would be the effect of eccentricity on dynamic coefficients through the perturbation of friction loss term?

Author's Closure

The present analysis accounts for a circumferential variation in friction factor due to a perturbation from the centered position. This perturbation in position yields a circumferential variation in clearance and a consequent change in the Reynolds numbers. The factor β in the equations accounts for this change, and was introduced by Black and Jenssen in [4].

Concerning the influence of finite changes in eccentricity, the work of Allaire et al. [7, 10] predicts that the seal coefficients remain relatively constant out to static eccentricities on the order of 0.5 ~ 0.6.

[2] Crane Packing Company, Morton Grove, Ill.