Labyrinth Seals

Labyrinth seals with teeth on either the rotor or the stator are frequently used, because the teeth help to minimize the leakage through the seals. However, the teeth also have rotordynamic consequences which have been explored by Wachter and Benckert (1980), Childs and Scharrer (1986), and others. Childs and Scharrer measured the stiffness and damping coefficients for some labyrinth seals, and reached the following conclusions. First, in all cases, the rotordynamic forces were independent of the rotational speed, Ω, and dependent on the axial pressure drop, Δp. The appropriate nondimensionalizing velocity is therefore the typical axial velocity caused by the axial pressure drop, $(2\Delta p/\rho)^{\frac{1}{2}}$. Childs and Scharrer suggest that the reason for this behavior is that the mean fluid motions are dominated by throughflow over and between the teeth, and that the shear caused by the rotation of the rotor has relatively little effect on the flow at the high Reynolds numbers involved.

Table 1: Rotordynamic characteristics of labyrinth seals with zero inlet swirl (data from Childs and Scharrer 1986).

	Teeth on Rotor			Teeth on Stator		
	Mean	Min.	Max.	Mean	Min.	Max.
$K^*/2\pi\Delta pL$	-1.17	-1.03	-1.25	-0.62	-0.45	-0.74
$k^*/2\pi\Delta pL$	1.15	0.79	1.68	0.86	0.67	1.07
$C^*/\pi RL(2\rho\Delta p)^{\frac{1}{2}}$	0.0225	0.0168	0.0279	0.0219	0.0182	0.0244

Typical dimensionless values of the rotordynamic coefficients K, k, and C are presented in table 1, where we may observe that the cross-coupled stiffness, k, is smaller for the teeth-on-stator configuration. This means that, since the damping, C, is similar for the two cases, the teeth-on-stator configuration is more stable rotordynamically.

However, Childs and Scharrer also found that the coefficients were very sensitive to the inlet swirl velocity upstream of the seal. In particular, the cross-coupled stiffness increased markedly with increased swirl in the same direction as shaft rotation. On the other hand, imposed swirl in a direction opposite to shaft rotation causes a reversal in the sign of the cross-coupled stiffness, and thus has a rotordynamically stabilizing effect.