SELECTED TOPICS
In Aerospace Engineering

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SURGE AND ROTATING STALL

7.1 Stability of compression systems

A stability analysis can be performed based on the eigenvalues of the linearized, second order Greitzer lumped parameter model. At this point, we introduce the characteristic equation (Greitzer, 1981):

$$s^2 + \left[\frac{1}{B\frac{d\,\Psi_t}{d\Phi_t}} - B\,\frac{d\,\Psi_c}{d\Phi_c}\right] s + \left[1 - \frac{\frac{d\,\Psi_c}{d\Phi_c}}{\frac{d\,\Psi_t}{d\Phi_t}}\right] = 0 \qquad (7.1)$$

where is $\frac{d\,\Psi_t}{d\Phi_t}$ the slope of the dimensionless throttle characteristic and $\frac{d\,\Psi_c}{d\Phi_c}$ is the slope of the dimensionless compressor characteristic. Thus, the linearized compression system is equivalent to a damped linear oscillator:

$$s^2 + 2\,\varsigma\,\omega_0\,s + \omega_0^2 = 0 \qquad (7.2)$$

Application of the Routh-Hurwitz criterion gives that the system is strictly Hurwitz, *i.e.*, all the roots have negative real parts, if and only if,

$$\varsigma\,\omega_0 > 0 \quad and \quad \omega_0^2 > 0 \qquad (7.3)$$

Comparison of the previous two equations learns that both stability conditions for the compression system depend on the slopes of the dimensionless compressor and throttle characteristics,

$$\frac{d\,\Psi_c}{d\Phi_c} < \frac{d\,\Psi_t}{d\Phi_t} \quad and \quad \frac{d\,\Psi_c}{d\Phi_c} < \frac{1}{B^2\frac{d\,\Psi_t}{d\Phi_t}} \qquad (7.4)$$