Simulation of a Concentric-Tube Resonator
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Objective: Accurate modeling and fast simulation of silencers is important for the purpose of their design aiming at reducing engine exhaust noise.

Applications: Manufacturing of exhaust systems, tube-resonators, mufflers.

A four cylinder engine model with silencer.

Modeling: At higher excitation frequencies we use a modification of the St. Venant equation for the mass flow rate through the holes of the silencer:

$$\dot{m} = c_d p_0 \sqrt{\frac{2}{RT_0} \left[ \frac{\kappa}{\kappa - 1} \left( \frac{p}{p_0} \right)^{\frac{\kappa}{\kappa - 1}} - \left( \frac{p}{p_0} \right)^{\frac{\kappa+1}{\kappa-1}} \right] - \left( \frac{p}{p_0} \right)^{\frac{\kappa}{\kappa-1}} \frac{1}{RT_0} \frac{\partial w}{\partial t}}$$

(1)

Used to determine the source terms of the Euler Equations of Gas Dynamics for the flow in the silencer:

$$\frac{\partial}{\partial t} \left( \begin{array}{c} \rho \\ \rho u \\ e \end{array} \right) + \frac{\partial}{\partial x} \left( \begin{array}{c} \rho u \\ \rho u^2 + p \\ u(e+p) \end{array} \right) = -\frac{1}{S} \frac{dS}{dx} \left( \begin{array}{c} \rho u \\ \rho u^2 \\ u(e+p) \end{array} \right) - \frac{1}{S} \frac{Q_m}{Q_e},$$

(2)

A result: The influence of the perforation on the pressure curve

Pressure at the inlet of the perforated section versus time, expressed in degree crank angle.