Enhancement of the low frequency performance of thin, film-faced layers of foam by surface segmentation

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Objectives: Understand the absorption of film-faced foam with circumferential air gap

Main results:
- New peak, at low frequency with viscous dissipation due to Diaphragm-Helmholtz resonator effect [1]
- Very low motion of the membrane around 400 Hz
- Membrane increases the structural dissipation
- Gap enhances also the absorption at higher frequencies when compared with airtight membrane
- Independently tunable membrane and air gap effects

Melamine foam: \( E = 50 (1 - 0.076i) \) kPa, \( \nu = 0.4, \sigma = 9000 \text{Nm}^{-1}, \phi = 0.995, \alpha_{\infty} = 1.01, \Lambda = 64 \mu m, \Lambda' = 143 \mu m. \) Sample: radius \( r = 50 \text{mm}, \) height \( h = 25 \text{mm}, \) air gap \( b = 1 \text{mm}. \) Measurement B&K impedance tube

Simplified airtight membrane model

**Assumptions:**
- Membrane of surface mass \( \lambda_m \) with no stiffness
- No air leak
- 1D Biot model

An approximation of the mass-spring resonance frequency, can be obtained with Ritz method

\[
f_{mb} \approx \frac{1}{2\pi} \sqrt{\frac{K_{eff}}{(\rho_1 + \rho_2)h/3 + \lambda_m}}
\]

where the effective compressibility of the material \( K_{eff} = E + K_c \) is the sum of the stiffness of the fluid phase \( K_c \) and the stiffness of the solid phase \( E. \)

Here, we get \( f_{mb} = 930 \text{Hz}. \)

Numerical simulations

**Assumptions:**
- FEM simulations with Quadratic elements [3]
- Dissipated energy computed with [4]
- Clamped boundary condition, DtN map for radiation

Effect of the air gap, ranging from 0.5, 1, 2, 5, 10 mm and radius \( r = 50 \text{mm} \)

Periodic patch and oblique incidence effect: \( L_x = 50 \text{mm}, \ L_y = 50 \text{mm}, b = 1 \text{mm}, h = 25 \text{mm} \)

Prospects:
- Combination with double porosity material [5]
- Combination with Cuboid [6]

References