

Acoustic foam characterization using a four microphone measurement technique combined with a minimization procedure

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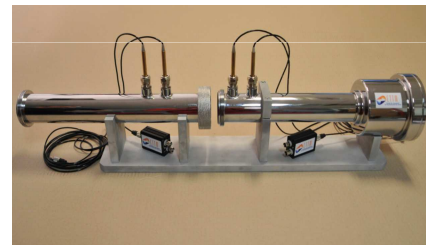
Context

While the measurement of the usual Champoux-Allard-Johnson parameters (porosity ϕ , tortuosity α_∞ , flow resistivity σ and viscous Λ and thermal Λ' lengths) can be determined using your favorite method the recovery of the thermal resistivity σ' is still challenging.

In our method based on the four microphone technique the recovery of the six parameters of the Champoux-Allard-Johnson model is proposed.

Measurement set-up

A 44 mm diameter impedance tube, with a partially anechoic end is employed with a four microphones set up.



Recovery procedure

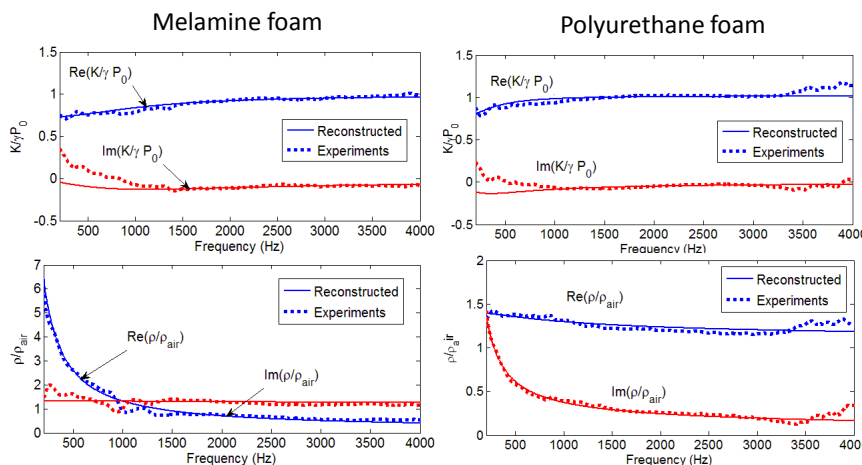
The recovery procedure is performed in two steps:

- from the state vector $\langle p, V \rangle$ on both sides of the sample (related to p_+ and p_-), the equivalent wavenumber and impedance of the materials are recovered. This last recovery is not performed through the element of the scattering matrix, but through Nicolson-Mead-Wear procedure. The equivalent complex and frequency dependant density ρ_{meas} and bulk modulus K_{meas} are reconstructed over the frequency range [200 Hz, 4000 Hz].
- from the equivalent density and bulk modulus, the 6 parameters are reconstructed through a constrained minimization of the following cost function:

$$F(\Phi, \alpha_\infty, \Lambda, \Lambda', \sigma, \sigma') = \sum_{\omega_{min}}^{\omega_{max}} \left(\frac{\|\rho_{meas} - \rho\|}{N\omega} + \frac{\|K_{meas} - K\|}{N\omega} \right), N\omega \text{ being the number of discrete frequency}$$

Instead of minimizing for ϕ , α_∞ , Λ , Λ' , σ , and σ' , we prefer to minimize for ϕ , α_∞ , Λ^2 , Λ'^2 , c , and c' where c and c' are geometrical parameters [1] respectively related to Λ and Λ' through $\Lambda = c\sqrt{8\eta\alpha_\infty} / \sigma\Phi$ and $\Lambda' = c'\sqrt{8\eta\alpha_\infty} / \sigma'\Phi$. The theoretical equivalent density ρ and bulk modulus K then only depend respectively on ϕ , α_∞ , Λ^2 , and c and of ϕ , Λ'^2 , and c' , which greatly increases the sensitivity.

Results and comments



	ϕ	α_∞	Λ (μm)	Λ' (μm)	σ (N.m.s^{-4})	σ' (N.m.s^{-4})
Melamine foam						
Present procedure	0.99	1	111	339	9693	4697
Classical procedure	0.97	1	166	3A	8640	
Polyurethane foam						
Present procedure	0.96	1	239	632	1945	1629
Classical procedure	0.97	1.05	272	3A	1955	

The recovered parameters are in accordance with those derived from classical procedure. The main advantages of the present method is that it enables to recover these 6 parameters, including the thermal resistivity, through a single procedure and measurement, without assuming a relation between the viscous and thermal lengths.

[1] Y. Champoux and J.-F. Allard, Dynamic tortuosity and bulk modulus in air saturated porous media, J. Appl. Phys., 70, 1975-1979, 1991.