71·63

BRITISH ACOUSTICAL SOCIETY: Meeting on
"ABSORPTION OF SOUND" 17th September, 1971
at the Univers ty of Salford.

# Mechanical and Acoustical Properties of Porous Foam Materials

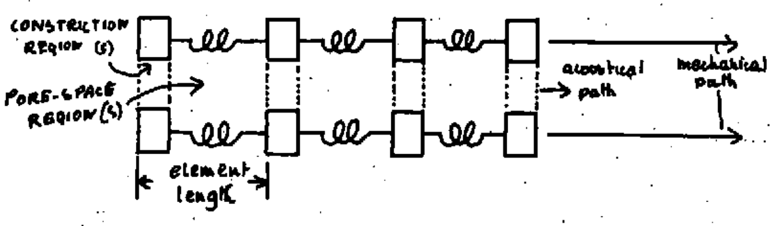
Professor P.E. Doak and M.R. King
Institute of Sound & Vibration Research, University of Southampton.

The aim of the work outlined here is to develop a method for the analysis of the acoustic behaviour of flexible porous materials, in particular those of the polyurethane expanded foam type. It was intended that the model and method should enable a link to be established between the physical parameters of a particular foam material and its acoustical properties in a given situation.

Those parameters of the material which are expected to effect its acoustic behaviour are:-

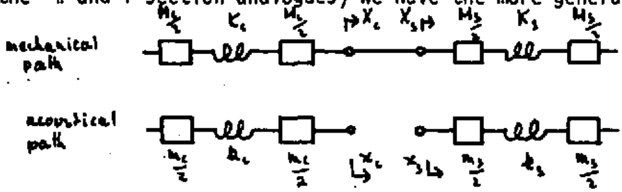
1. the mechanical spring stiffness of the structure of the material (i.e complex modulus) - in general this will be frequency dependant;
2. the mass of the mechanical structure;
3. the flow resistivity of air through the foam; and
4. the geometry of the structure.

In the model, the wave propagation is considered as occurring in the pore-space air (measurement of typical foams shows them to be of the "open-cell" type) and through the mechanical structure. There will be a linking of the waves due to viscous forces and pressure forces. The model suggested is (for one dimension)




The periodically concentrated masses, m, are to represent the nodules of solid in the foam structure occurring at the apices of each pore within the material - in reality the structure is of a dodecahedral and not cubic nature; and the complex stiffness, K, represents the stiffness of the struts of the edges of the cells.

By further subdivision of the elements of regions c and s of the elements in figure 1 into three elements (from equivalence to the $\pi$ and T section analogues) we have the more general model

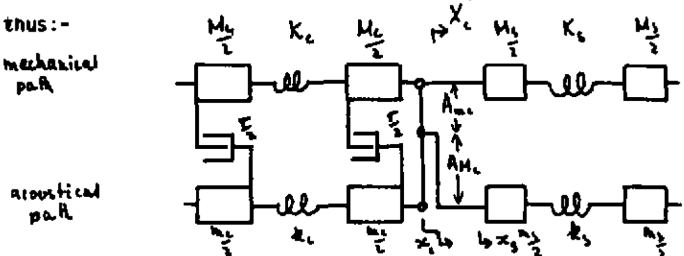



(u.c. = mechanical path; l.c. = acoustical path; subscript c for constriction and s for pore-space region.)

From a consideration of continuity at the interface between constriction and pore-space regions (the A's representing the area ratios of the two parts of the path), then

$$x_s = A_{Mc}.X_c + A_{mc}.x_c,$$

because for practical purposes $A_{Ms} \to 0$ and $A_{ms} \to 1$. In the model this is satisfied by the lever-type linkage between the acoustical and mechanical paths at the interface and of the acoustic path across the interface and of the acoustic path across the interface, thus:-




Dashpots, $\frac{r}{2}$, are included to account for the flow resistivity of air through the foam, this constituting the second coupling effect between the acoustic and mechanical systems.

Expressions for the $Z_i$ and $z_i$ as functions of $Z_t$ and $z_t$ and the other material parameters have been derived.

## Experimental

Values for propagation constant and characteristic impedance are derived from a two-thickness test of samples in a standard Bruel & Kjoer standing wave tube.

Estimates of $A_{Mc}$ are made from direct microscopic or microphotographic observation of the material's structure. Values for r, $M_c$, $m_c$, and $k_s$ are derived from measurements of flow resistivity, density, and porosity.

The complex modulus, $K_s$, of the material structure is obtained by means of a dynamic test of a small sample in vacuo. With a specimen loaded by a mass, m (the accelerometer) and by measurement of the phase lag, θ, and amplitude loss, ΔdB, of the acceleration across the sample, the complex stiffness is given as

$$\overline{K_s} = \frac{m^2}{\left(1 - \exp\left(\frac{dB}{20 \log_{10} e} + i\theta\right)\right)}$$