IMPEDANCE TUBE METHODS FOR CHARACTERIZING COMPOSITE/HYBRID MATERIALS

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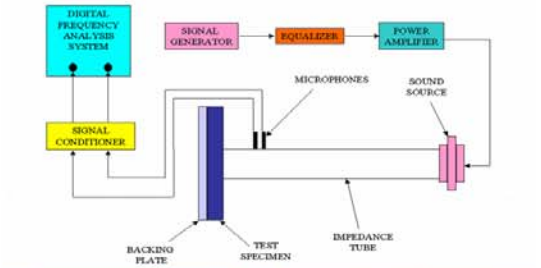
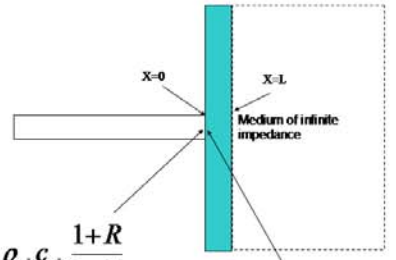
OBJECTIVES

- Ability to acoustically characterize composite/hybrid materials for a broad range of frequencies.
  - Beyond 2 kHz.
  - Especially around 10 kHz.
- ...all materials used for making composite/hybrid panels, especially in these frequency ranges.
- ...layers of materials that make composite/hybrid panels, especially in these frequency ranges.
- ...the effects of damage to composite/hybrid materials, specifically differences in the attenuation properties between the undamaged and damaged composites.
- One of the primary purposes of this acoustical characterization is for providing needed parameters, such as absorption coefficients, propagation constants, and specific impedances, for ballistic shock modeling.

APPARATUS



THEORY



$$Z = \rho_{air} c_{air} \frac{1+R}{1-R}$$

$$Z = Z_C \coth(\Gamma l)$$

THEORY

Must Be Equal

$$Z = Z_C \coth(\Gamma L)$$

Impedance at the surface of material from the material side

$$Z = \rho_{air} c_{air} \frac{1+R}{1-R}$$

Impedance at the surface of material from the air side

where:

- Z – Normal Acoustic Impedance
- Z_C – Characteristic Impedance
- Γ – Propagation Constant
- l – Thickness of the Sample
- R – Complex Reflection Coefficient

PARAMETERS

Certain physical parameters of the tube must be observed

$$f_u < \frac{Kc}{d} \qquad f_u << \frac{c}{2s}$$

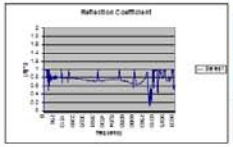
where:

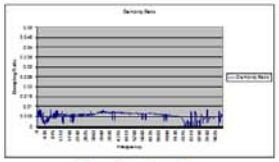
- f_u – upper frequency limit
- c – speed of sound in the tube
- d – diameter of the tube
- K – 0.586
- s – microphone spacing

Actual Values

- c = 344 m/s
- d = 0.027 m
- s = 0.0175 m
- l = 0.04 m
- f_u = 7466 Hz

RESULTS





Quarter-inch Polymeric Foam

FUTURE WORK

- Basic idea and methodology are good, but excitation medium has too small *characteristic impedance*.
  - Must use a medium with characteristic impedance closer to characteristic impedance of sample – WATER.

$$Z_C = \rho_{water} c_{water} \sim 1000 kg/m^3 \times 1500 m/s = 1.5 \times 10^6 kg/m^2 \cdot s$$

- Reflection Coefficient moduli would be in the range of 0.45 – 0.75
  - New microphones will certainly be able to measure changes in Reflection Coefficient moduli in first decimal place

ACKNOWLEDGEMENTS

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