Special Program in Applied Mathematics and Applied Mechanics

Acoustic Impedance and the Control of Sound Waves

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308, Mathematics Research Center Building (ori. New Math. Bldg.)

Acoustic impedance is one of the most important parameters for fluid media and it signifies also the \'energy cost\' to make fresh waves. It is determined by the elastic modulus of fluid, which is often fixed, and the dynamic mass which can differ from its static values. This talk explores various methods to alter the acoustic impedance and the implication for the control of sound waves. First, we consider the alteration of dynamic mass. Perforated panel is considered as the most common method of adding dynamic mass while its associated resistance increase is only significant at sub-millimeter scale for sound waves in air. An example is given to demonstrate the reduction of speed of sound through a macro-scale, lossless waving channel and its possible use in creating low-frequency resonance. When this is coupled with frictional loss, a broadband sound attenuation at low frequencies becomes attractive in some applications. On the other hand, the decrease of dynamic mass is much trickier to achieve and an example of using helium gas is discussed. In the second part of the talk, we explore the alteration of system elastic modulus, which is often manifested through cavity air stiffness, by electro-magnetic forces. Reduction of equivalent air stiffness is the key to a lot of noise control problems and we demonstrate a device based on a common moving-coil diaphragm with a shunt circuit. Electrical capacitor is found to play a crucial role in bringing down the mechanical stiffness of the coupled system. The device is found to be effective in controlling thermoacoustic instability in a classical test rig called \'Rijke tube\' over a wide range of working conditions. However, we caution that the reduction of the system stiffness has unusual spectral characteristics, and that

the correct spectral characterization is essential in overcoming our metal \'impedance\' to a proper understanding of physics.