DEICON
Dynamics & Controls

Active Helmholtz Resonator

An effective way to add damping to a standing wave (mode) or absorb energy at an undesirable disturbance frequency in an acoustic medium is the use a Helmholtz resonator (HR). HRs are commonly used for tuning of acoustic systems such as industrial processes, engine intake and exhaust, mufflers in ducts and pipes, listening and recording rooms and more.

A Helmholtz resonator is comprised of a cavity connected to the acoustic system of interest, e.g., a duct, via one or a few narrow tubes through which the fluid travels back and forth between the cavity and the external medium; see Figure 1. The complex acoustic impedance of the HR relates the pressure P of the acoustic medium to the fluid velocity v flowing through the neck.

Despite their simplicity, HRs have the following unattractive attributes:

1. To be effective as a dynamic absorber and achieve significant noise/disturbance abatement, a HR must be tuned precisely over a relatively narrow frequency range. Changes in the disturbance frequency and environmental conditions detune these devices.
2. When used as tuned dampers, for adding damping to an acoustic mode, a fair amount of energy dissipation should occur in a HR. There is not enough friction to the flow of fluid in the neck of a typical HR for it to be used effectively as a tuned damper.
3. The size of HRs become objectionably large when they are tuned to low frequencies.

Tunable (smart) HRs have been developed which by online modification of their boundary conditions, such as changing the cavity volume or neck dimensions, can be easily retuned. This tunability addresses the first concern listed above, but does not address the other two concerns.

DEICON's patent-pending active HR uses, depending on the application, either a long throw bass speaker or a piston manipulated by a linear actuator, *in place of a traditional HR*. Figure 2 shows the device installed on an enclosure. Through proper actuation of the speaker/piston via a feedback controller, the device is made to disturb the fluid, the same way as a HR would have, had it been installed at the same location. Due to the full controllability of the speaker/piston, this synthetic HR can be made to behave either as a dynamic absorber or a tuned damper. Due to the absence of the neck and cavity, the size of DEICON's active HR is very small, practically the size of the driver.

Figure 3 shows the frequency response functions of an acoustic enclosure, measured at two different locations, with and without an active HR. The active HR which is tuned to add damping to the first acoustic mode of the enclosure, is performing effectively. A considerable amount of damping is added to that mode. Figure 4 depicts the simulation frequency response functions of a stock-line (a pipe carrying pulp) in a paper mill without (dashed/blue) and with (solid/red) the active HR. In this Figure 3 Frequency response functions of an enclosure, measured at two different locations, with and without DEICON's active HR application, the active HR which is a piston actuated by a pneumatic cylinder acts as a dynamic absorber reducing the undesirable effects of a 0.1 Hz pressure pulsation produced by the motion of an upstream screen. A passive HR tuned to such a low frequency would have been unacceptably large.

In addition to being tunable, DEICON's active Helmholtz resonators are highly reliable, cost-effective and *small in size. The compensators controlling these Helmholtz resonators are built in small, low-cost, op-amp electronic circuits.*

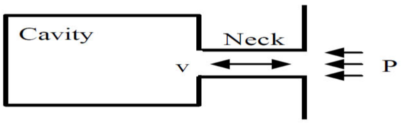

Figure 1. A Helmholtz resonator

Figure 2. Active Helmholtz resonator installed on an enclosure

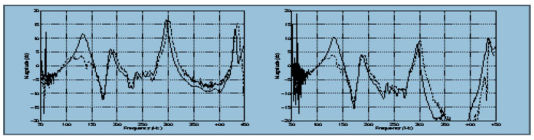

Figure 3. Frequency response functions of an enclosure, measured at two different locations, with and without DEICON's active HR

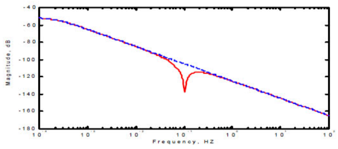

Figure 4. Frequency response functions of a pipeline without (blue) and with (red) the active HR