RPG Technical Bulletin

The Effect of Covering a Reflection Phase Grating with Fabric

The RPG diffuser was designed to diffuse rather than absorb sound, however phase gratings can provide some absorption below the design frequency due to high energy flows from wells in resonance to wells out of resonance and ¼ wave resonant absorption in the wells, especially if the wells are rather narrow. Consider a pure tone wave incident onto a series of divided wells of varying depth. For simplicity consider just two neighbouring wells. Furthermore, consider this to be a frequency where one well is in resonance, and the neighbouring well is not, as illustrated in Figure 1. The energy at the mouth of the resonating well will be

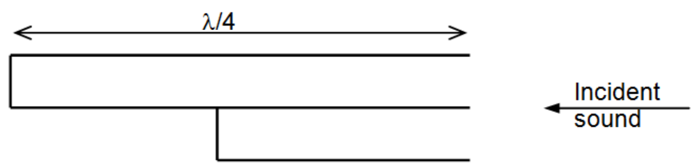

Figure 1. Two divided wells for an RPG diffusor

much greater than that of the non-resonating well. This means that there will be energy flow from the resonating well to the well that is not resonating. Consequently, around the entrances to the wells there is high particle velocity. Indeed, Fujiwara et al., Figure 2, showed that the particle velocity is up to 14 times greater at the mouth of the wells compared to the incident field. As sound moves around the front of the dividers, from one well to the next, excess absorption occurs. This is the source of the additional absorption in reflection phase grating diffusers and occurs even in properly constructed structures. Commins [D.E. Commins, N. Auletta and B. Suner, "Diffusion and absorption of quadratic residue diffusers", Proc. IoA (UK), 10(2), 223-32 (1988)] showed that by sloping the wells the bottom of the diffuser wells, the absorption could be reduced. However, in the first measurement of the absorption coefficient by D'Antonio in 1983, it was shown that the random incidence absorption coefficient of properly fabricated diffusors was roughly 0.2 and with the demonstrated inaccuracy and non-reproducibility of the absorption coefficient according to

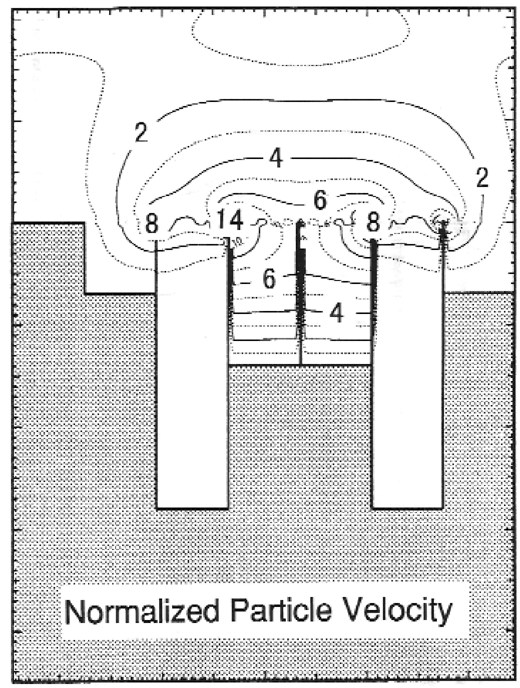

Figure 2. Normalized particle velocity distribution around the surface of a QRD with well arrangement [0,1,4,2,2,4,1] K. Fujiwara et al., Applice Acoustics 60, 225-235 (2000)

ISO 354, this absorption was not too much of a concern to warrant the effort of using sloping wells. Also ramping the wells has a specular orientation effect on the scattered hemidisc for 1D QRDs, which may not always be desired.

While this absorption is small, placing a resistive element in front of the diffusor, such as fabric, wire mesh or any material with an appropriate acoustic resistance, can increase the absorption. Figure 3 shows the random incidence absorption coefficient for the 1D QRD 734 and 2D Omniffusor diffusors with and without a fabric covering.

Figure 3 shows how important it is not to cover reflection phase grating diffusers with cloth as this greatly increases the absorption. There is energy flow between wells of the absorber promoted by pressure gradients caused by wells being in resonance and having high energy adjacent to wells not being in resonance and

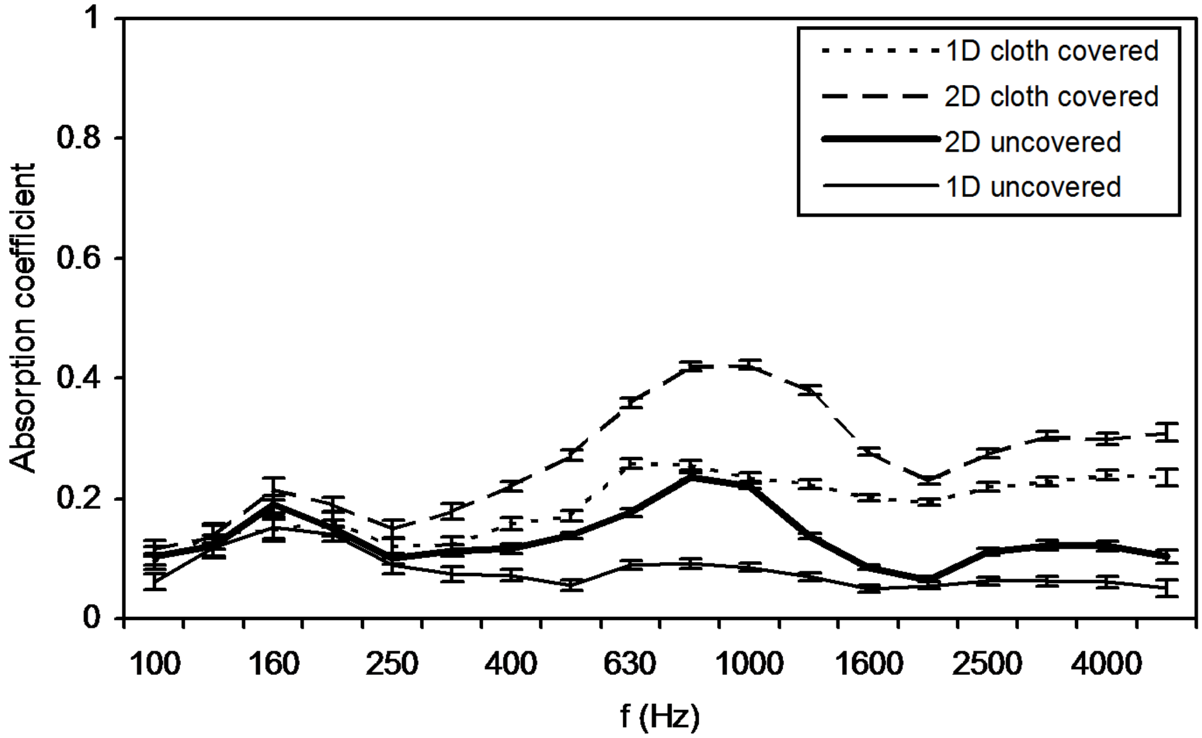

Figure 3. Random incidence absorption coefficients measured for 1D and 1D Schroeder diffusers based on N = 7 with and without cloth covering.

having low energy. Consequently, there is high particle velocity around the front face of the diffuser, and any cloth covering will cause excess absorption as might be expected if resistive material is placed in a region of high particle energy flow. Any cloth covering should be placed at least a well width (preferably several well widths) away from the front face. The cloth should have the highest possible flow resistivity; indeed it is better if the cloth is not present at all.

Figure 3 also shows that 2D diffusers absorb more sound than 1D devices. It is assumed that this is due to the greater number of different well depths in the 2D device, leading to more energy flow between the wells as well as in addition to a greater density of 1/4 wave resonances. Furthermore, because there are more well walls present than in a 1D device, more losses due to viscous boundary layer effects can occur.

It is important that a reflection phase grating diffuser is constructed to a high precision. When these devices are included in architectural drawings to be constructed by millwork firms, there is a danger that small cracks in the bottom of the wells, between the well sides and bottoms, If any cracks open up to cavities behind, these can cause excess absorption as a Helmholtz absorber/resonator has been formed. Proper sealing with varnish or paint is vital. Construction materials are generally not that important unless rough surfaces are used.

While placing a resistive material directly on or close to the face of a QRD will provde some absorption, there is little change in the diffusion coefficient, as seen in Figure 4.

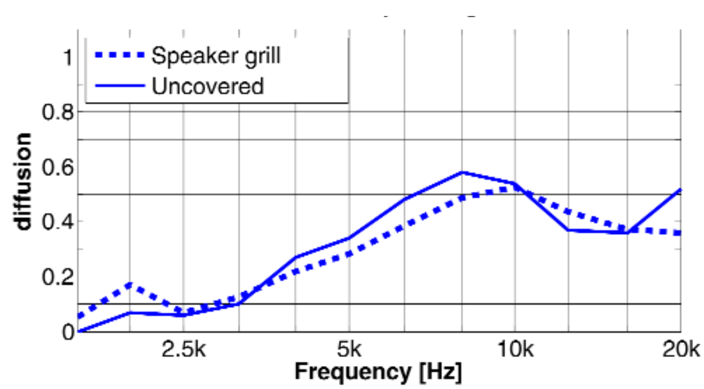

Figure 4. Comparison of the diffusion coefficient for FlutterFree Uncovered and with a Speaker grill cloth on the face