Question 18

Murata Software

Q: How to perform the analysis with resistance of air or water taken into account?

A: By setting an acoustic impedance, which represents the resistance of air and water, to the boundary in contact with air and water, their resistance can be taken into account. The acoustic impedance indicates how much each material prevents sound waves from passing.

Additional Information

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By setting an acoustic impedance, which represents the resistance of air and water, to the boundary in contact with air and water, their resistance can be taken into account. The acoustic impedance, Z, indicates how much each material prevents sound waves from passing. It is defined as pressure, P, divided by volume speed, Sv.

$$Z = P/Sv\left[\frac{Pa}{m2 \cdot \frac{m}{s}}\right] = P/Sv[\frac{Pa \cdot s}{m3}] \quad (1)$$

If acoustic impedance is set to a boundary condition, it is given as a value per unit area. It is shown below.

$$Z = P/v\left[\frac{Pa}{\frac{m}{s}}\right] = P/v[\frac{Pa \cdot s}{m}] \quad (2)$$

Pressure, P, is related to particle velocity, v, through the equation of motion.

ρ is density and c is the sound speed of a medium. Harmonic sound waves have the relationship below.

$$Z = \rho c\left[\frac{kg}{m3} \cdot \frac{m}{s}\right] = \rho c\left[\frac{kg}{m2 \cdot s}\right] = \rho c\left[\frac{N \cdot s2}{m} \cdot \frac{1}{m2 \cdot s}\right] = \rho c[\frac{Pa \cdot s}{m}] \quad (3)$$

Equations (2) and (3) coincide in their unit. It indicates that equation (2) is expressed as equation (3). For your information, the acoustic impedances of air and water are shown below.

（Example）Acoustic impedance of air

Z = 1.205 [kg/m3]*340 [m/s]=409.7 [kg/(m2・s)]=409.7 [N・s/m3]

*In the SI unit system, 1.0 [N]=1.0 [kg・m/s2]. This conversion is used in Equation (3).

（Example） Acoustic impedance of water

Z = 997 [kg/m3]*1500 [m/s]=1.496e6 [kg/(m2・s)]=1.4596e6 [N・s/m3]