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A study of sound propagation in tubes with a moving boundary

JIANWU DANG[1,*], **QINGZHI HOU**[2], **FUTANG WANG**[2]

[1] *Japan Advanced Institute of Science and Technology (JAIST), Nomi, Ishikawa, 923-1292, Japan*
[2] *Tianjin Key Lab. of Cognitive Computing and Application, Tianjin University, Tianjin, China.*
*e-mail: jdang@jaist.ac.jp

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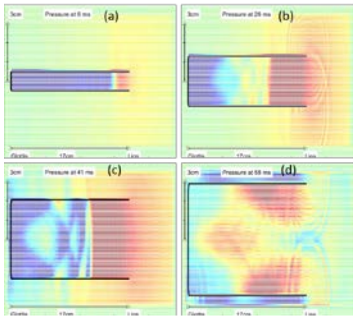

Figure 1. Sound pressure distribution at different time levels with increasing tube's radius from 0.5 cm to 3.0 cm.

Duct acoustics usually deals with the tubes with a hard-wall or soft-wall. When a tube has a moving wall such as the vocal tract whose configuration changes with time, how will the acoustic characteristics of sound propagation be affected by the moving boundary of the tube? In this study, we combine the finite-difference time-domain (FDTD) with the immersed boundary method (IBM) to investigate the sound propagation in the tubes with a moving boundary. To replicate the property of a free space by a finite computational field, eight perfect matching layers (PML) were set around the computational field (CF) to absorb the outgoing waves. While FDTD of the hybrid method discretizes the whole CF by a Cartesian grid (Eulerian points) that keeps the duct entirely immersed, IBM uses a series of discrete control points (Lagrangian points) with added forcing to replicate the geometrical wall. When the wall moves, the Lagrangian points will travel in the CF. Numerical experiments were carried out on uniform, convergent and divergent tubes, and the computed sound pressure distributions demonstrate the physical properties of the tubes. The resonant frequencies show reasonable accuracy with a maximum error of 10% comparing with the theoretical ones.

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