jh190031-NAJ

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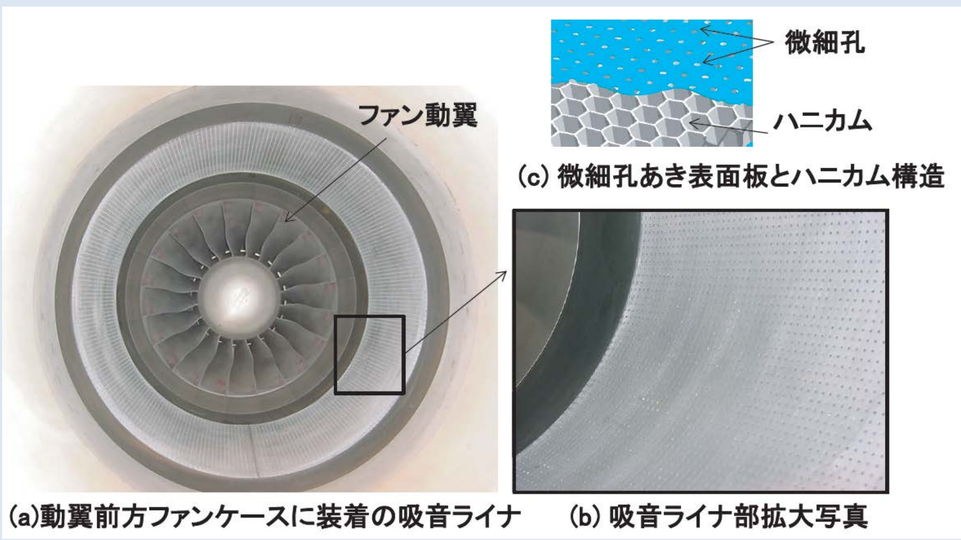
Investigation of Sound-Flow Interaction of Acoustic Liner using CFD/CAA Hybrid Approach

Background and Objective

Background

- Fan is one of major noise sources and further noise reduction for the future aircraft development is required
  - Ultra High Bypass (UHB) turbofan for higher efficiency
  - Acoustic liner is equipped to reduce fan noise
  - Structural and weight limitation for acoustic liner

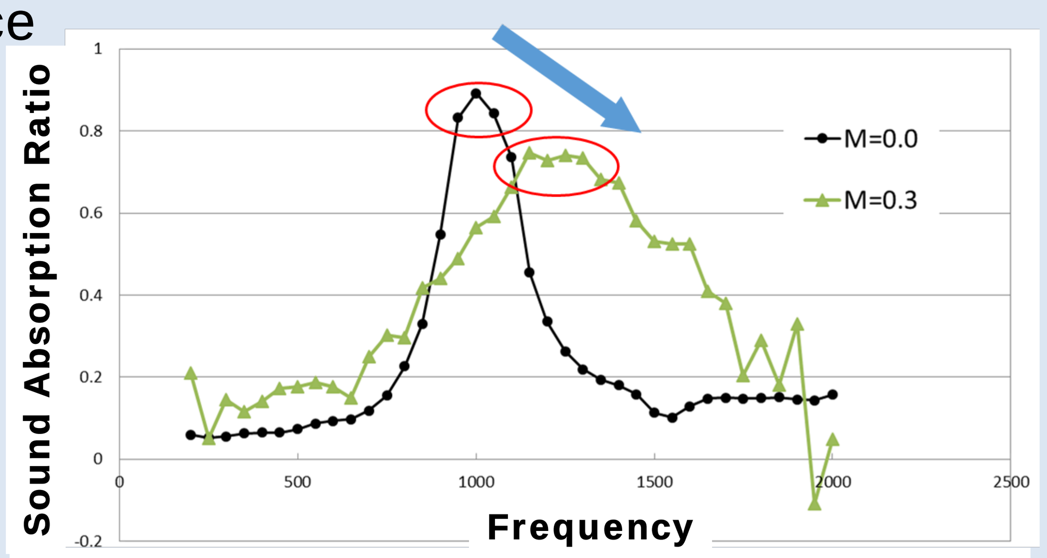
Acoustic liner plays more important role in high sound absorption for wide frequency range



【1】 大石勉, 「航空機騒音源の低減対策について」, 日本音響学会誌, 73巻, 11号, 2017年

Acoustic liner attached at intake [1]

- The characteristics of acoustic liners:
  - Sound absorption performance is changed due to the existence of grazing flow



JAXA experimental result of acoustic liner model

  - Non-linear effect appears at high incident sound level and high Mach number grazing flow
  - Interaction of sound and flow needs to be investigated for the understanding and design of a new liner

Time-domain direct CFD analysis of acoustic liner model is useful

Research Institutes and Members

CFD/CAA Algorithm Development and Applications

- Kanazawa Institute of Technology (D. Sasaki)

3D Extension of Solver

- Cyberscience Center, Tohoku University (R. Egawa, K. Komatsu)

Acoustic Liner Expertise (Analysis of Application Results)

- Institute of Sound and Vibration Research, University of Southampton (R. Sugimoto, P. Murray)

Planned computational resources at Tohoku university

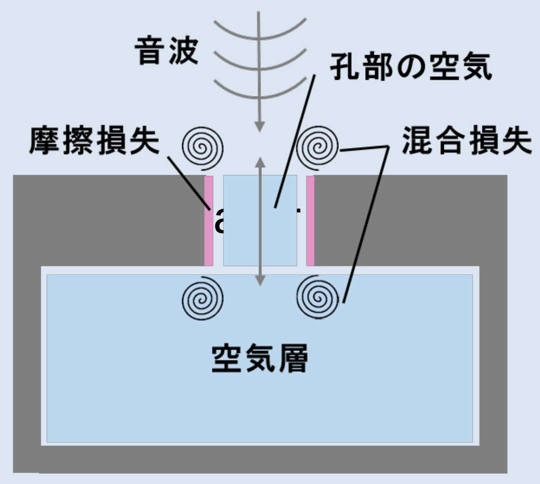
- Vector supercomputer (SX-ACE)
- Scalar parallel computer (LX406Re2)
- 3D Visualization

Project Representative: dsasaki@neptune.kanazawa-it.ac.jp

Fundamental of Helmholtz Resonator

Sound absorption principle (without grazing flow)

- The air in the neck and the air in the cavity works as a mass-spring system (resonant frequency)
- Energy loss caused by a resonator results in sound absorption
  - Loss occurs in viscous boundary layer at walls of resonator neck
  - Acoustical energy dissipation at edge of resonator



Principle of Helmholtz resonator

Objectives

Objectives

- CFD/CAA algorithm development and validation based on Cartesian mesh for acoustic liner model
- Application of direct CFD/CAA solver to investigate the influence of multiple resonators to sound and flows
- 3D extension of solver for more realistic geometry (multiple orifices, various shapes, etc.)

Fundamental Model and Numerical Methods

Numerical Methods

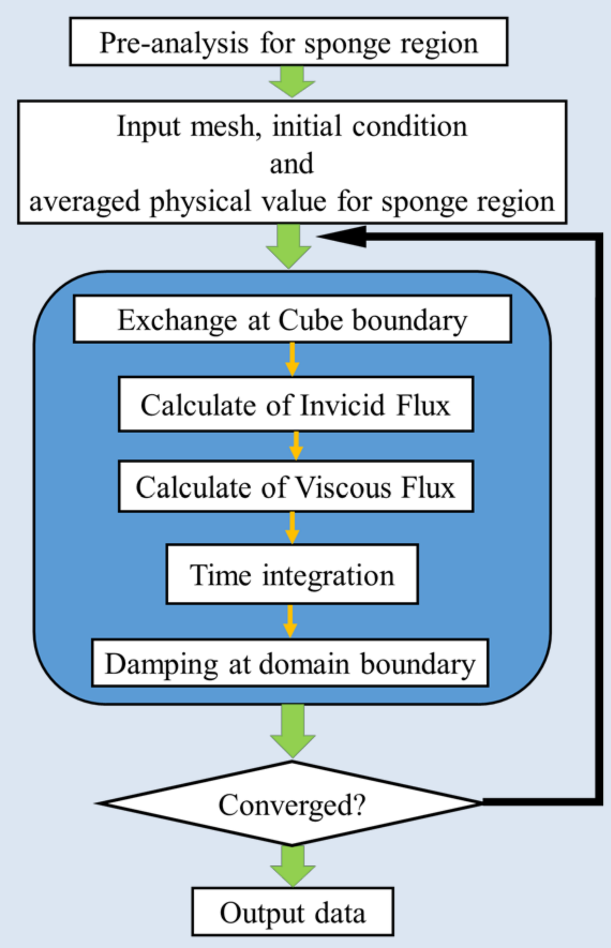
- 2D Compressible BCM (planned for 3D extension)
- Direct Numerical Simulation (DNS)
- 4th-order Runge-Kutta method (time-marching)
- 5th-order WENO scheme (space)

Inflow Boundary Condition

- Mach Number: 0 / 0.088 (Re13123 based on opening width)
- Laminar Boundary Layer (Blasius solution)
- Incident sound wave: plane sine wave (120 dB)
- Acoustic sponge region

Outflow Boundary Condition

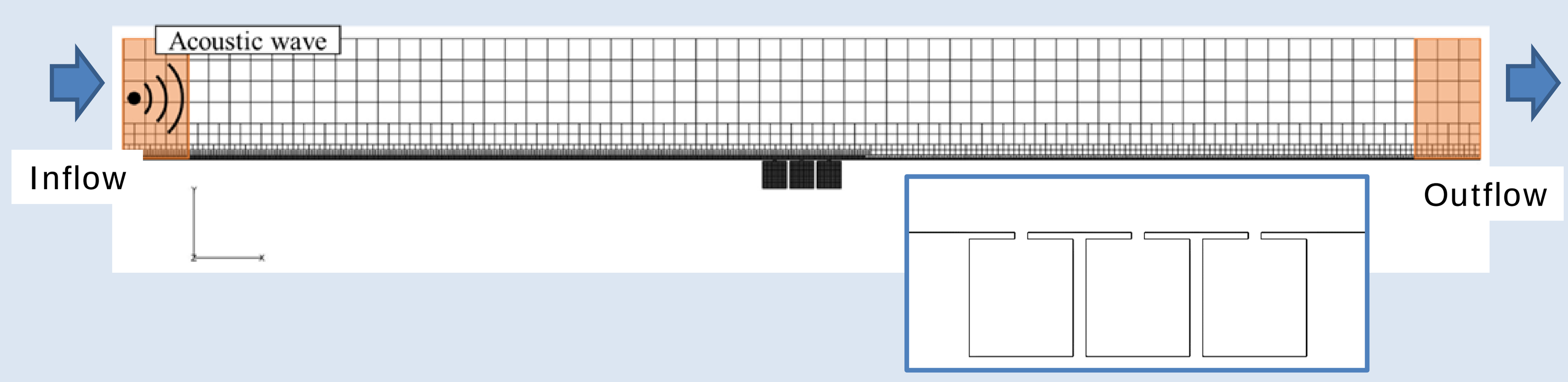
- Acoustic sponge region



Flowchart of BCM

Model Example

- Multiple-resonator case (3 resonators)
- 100 minimum-size cells for opening width



Computational model with Cube allocation (32^2 Cell in each Cube)