The Topic of the Report

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Abstract:

- **What is studied in this report?**
- **Methodologies?**
- **Results (in figures and tables, etc.) and analysis?**
- **Conclusion?**

I. Introduction

First explain the research topic and the contribution of this report. An example is given below.

"Acoustic liner remains to be the most effective strategy to reduce noise emission from aeroengine [1, 2]. To meet increasingly stringent environmental regulations, research interest on optimizing the lining technology is continuously renewed, which calls for the development of the related numerical methods. High-order computational aeroacoustic methods have been developed for decades to simulate near-field noise generation and propagation and far-field radiation from a lined duct acoustic system [1–7]. The grazing incidence tube (GIT) experiments conducted by the NASA Langley research center [8, 9] were usually used in those numerical simulations to verify and to validate the proposed numerical methods. Despite the high fidelity of the GIT experimental datasets, the experiments [10] were performed for a representative but limited range of test parameters. To provide a better understanding of the related physics, here we develop a theoretical model with a geometrical setup similar to the GIT tests. This theoretical model could provide quick predictions covering various parametric ranges, which shall benefit more exhaustive parametric studies and constitute the benchmark problem for further numerical developments."

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Second, literature review of the topic, such as:

"A typical impedance boundary condition used in numerical methods for flow duct acoustics is Ingard-Myers boundary condition [11, 12]. However, the Ingard-Myers impedance boundary condition assumes an infinitely thin boundary layer from the lining surface that is to some extent against physical intuition. Some recent experiments by laser Doppler velocimetry [13, 14] have suggested that the interaction between background flows and sound waves is possible to give rise to instability waves. Theoretical speaking, the Ingard-Myers condition appears ill-posed [15] that shall trigger numerical instabilities especially at high frequency ranges [16, 17]. To address this issue, boundary layers with a finite thickness δ have been considered in developing new impedance boundary conditions. For example, Rienstra and Darau [18] derived the small value of δ by neglecting compressibility, and Brambley proposed an impedance boundary condition by using matched asymptotic expansions [19]. The two impedance boundary conditions are mathematically well-posed in time domain and could provide improved numerical stability in time-domain simulations [20]. More detailed comparisons between these modified impedance boundary conditions could refer to the reference [21]."

II. Methodologies

The studied problem is described and the methods to study the problem are explained here. An example is given below.

A. Statement of the problem

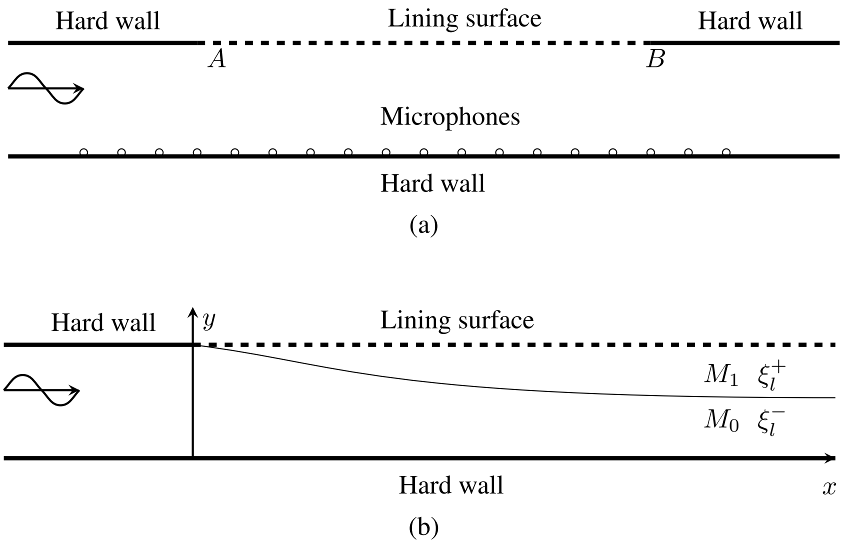

Figure 1. Case setups for (a) the GIT experiments [10] and (b) our theoretical model. The two labels, A and B in (a), denote the two hard-soft interfaces between the lining surface and hard walls. A vortex sheet is presumably developed from the hard-soft interface. The thickness of the vortex sheet is infinitely thin, i.e. the kinetic displacement of the vortex sheet infinitely approaches the upper wall ($\xi_l(x) \approx 1$ for all $x \geqslant 0$).

"Figure 1(a) shows the case setup of the GIT experiments. A liner (represented by the dashed line) was flush mounted on the central surface of the upper wall. The dimensional length and height of the test section is 838.2 mm and 50.8 mm, respectively [22], and the length of the lining surface is 387.35 mm. An incident plane wave propagates insider the flow pipe from the left to right. The frequency of the wave was varied between 0.5 kHz and 3 kHz. Surface pressure measurements were recorded by using microphones that were flush mounted to the surface of the lower wall. The dataset of surface pressure measurements was then heavily used in many previous works to validate the proposed numerical methods. In this work, we will also use the GIT datasets of the surface pressure measurements to verify and validate our theoretical model.

The lined duct contains a uniform mean flow outside the thin vortex sheet. Then, the acoustic velocity potential ψ satisfies the following convected wave equations:

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} - \left(-i\omega + M_0 \frac{\partial}{\partial x}\right)^2 \psi = 0, \quad y < \xi_l^-(x) e^{-i\omega t}, \tag{1}$$

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} - \left(-i\omega + M_1 \frac{\partial}{\partial x}\right)^2 \psi = 0, \quad y > \xi_l^-(x) e^{-i\omega t}. \tag{2}$$

All variables are nondimensionalized by using appropriate reference scales (e.g. the width of the pipe as the length scale).

Here we assume that the tube contains a uniform mean flow with a Mach number M_0 in the region with $-\infty < x < +\infty$ and $y < \xi_l^-$, and the uniform mean flow close to lining surface has a Mach number $M_1 = 0$ for the region with $x > 0$ and $y > \xi_l^+$. The superscripts $(\cdot)^\pm$ represent the corresponding variables at the upper and lower sides of the vortex sheet, respectively. "

III. Results and Discussion

Results and discussion are given here, along with figures and tables.

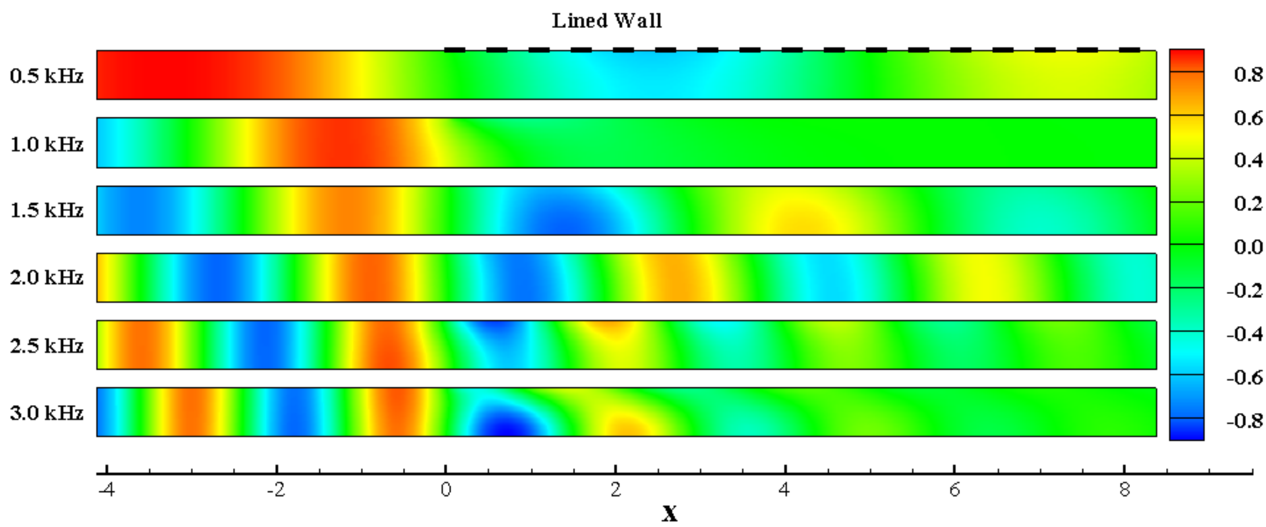

Figure 2. Instantaneous sound pressure field at the frequencies between $f = 0.5$ kHz and 3.0 kHz with $M_0 = 0.079$. The normalized pressure contour is shown between ± 0.9 to make the largely attenuated waves in the lined region at $x \geqslant 0$ still visible. The lining surface at $x \geqslant 0$ is represented by the bold, dashed line, and for simplicity, which is only shown here in the top panel.

Table 1. Representative values of specific resistance and reactance from previous works [8, 9, 22].

Frequency (kHz)	0.5	1.0	1.5	2.0	2.5	3.0
Re(Z)	0.41	0.46	1.08	4.99	1.26	0.69
Im(Z)	-1.56	0.03	1.38	0.25	-1.53	-0.24

"To verify and validate our theoretical model, we first carried out numerical simulations by using a commercial finite/infinite element software, ACTRAN®. Figure 3 shows the corresponding numerical setup, where the incident wave and acoustical nonreflection are implemented by setting appropriate boundary conditions. The background mean flow is uniform with the Mach number M_0. The whole computational domain consists of 2000×100 gridpoints to ensure appropriate points per wavelength especially around the hard-soft interface. In addition, the computational domain is stretched near the both computational domain ends in the x-direction to diminish possible numerical reflections.

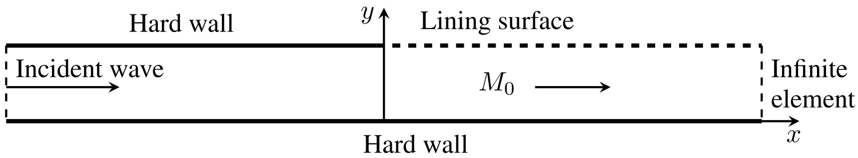

Figure 3. Sketch of the numerical simulation setup (not to scale).

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IV. Conclusion

Conclusion or summary is given in this section.

Acknowledgement

If there is anyone you own thanks to...

Appendix

If an appendix is necessary...

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