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Observation of acoustic streaming around a cylinder with a side hole for near-field acoustic levitation

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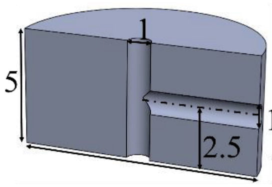
1. Introduction

The planar object is levitated on the vibrating surface due to the near-field acoustic levitation (NFAL) phenomenon[1)]. The jet flow is generated from a small through-hole of the object near the vibrating surface[2)]. Levitation and holding forces have been confirmed when the vibrating surface is approached above a cylinder with a center through-hole placed on a flat surface[3)]. When a side hole was added to the cylinder with a center through-hole, confirmed adsorption to the hole, rotation of the cylinder, and jet flow from the side hole, in addition to levitation[4)]. However, the acoustic stream around the cylinder with side holes has never been observed in the NFAL state.

The purpose of this study is to elucidate the acoustic stream around the cylinder with a side hole using microparticles.

2. Cylinder and vibration source

The cylinder has a small through-hole in the center and a small side hole. **Fig. 1(a)** and **1(b)** show a cross-sectional model of the cylinder and a photograph of a duralumin cylinder with small holes, respectively. **Fig. 2** shows the vibration source consisting of a duralumin horn with a 10mm diameter vibrating surface and a bolt-clamped Langevin transducer. The vibration surface vibrates longitudinally at a resonance frequency of 28 kHz. The sides of the vibrating surface and the cylinder were painted black to prevent the reflection of the laser used in the experiment.



(a) Cross-sectional model.

(b) Photo. of tested cylinder.

Fig. 1 Cylinder with central and side holes.

Fig. 2 Vibration source (Freq.: 28 kHz).

3. Recording method of jet flow

Fig. 3 shows the recording method of the jet flow. The cylinder with small holes was positioned between the linear jack and the vibration source in the acrylic box. The acrylic box was filled with tracer particles (a diameter of 0.2~0.3 µm). A sheet light was shone from the left side of the acrylic box into the side hole of the cylinder. The particle behavior around the cylinder was recorded by a high-speed camera (FASTCAM MiniUX50, Photron Ltd.) when the vibration source was excited at approximately 28 kHz, the height of the jack was adjusted, and the cylinder was levitated. **Fig. 4** shows the support method of the cylinder and the jack. The cylinder was supported by a wire fixed to the jack to prevent it from rotating due to the jet flow.

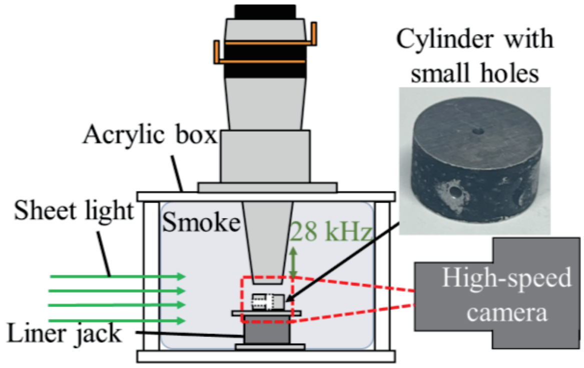


Fig. 3 Recording method.

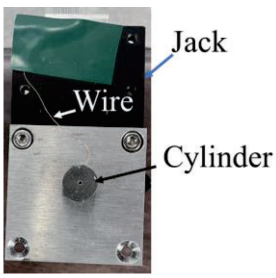


Fig. 4 Supporting method.

4. Record results

Fig. 5 shows the results of particle behavior around a cylinder with a side hole recorded at a continuous shooting speed of 5,000 fps. Area A confirmed that no air flowed between the vibrating surface and the cylinder. Acoustic streaming was observed around the side hole in Area B and between the cylinder and the planar surface in Area C. **Fig. 6** shows the particle behavior around the side hole taken at a continuous shooting speed of 10,000 fps. The jet flow was observed to absorb air around the side hole and release it on the axis of the side hole. **Fig. 7** shows the particle behavior around the cylinder when the cylinder is not levitated, recorded at a continuous shooting speed of 5,000 fps. The jet flow from the side hole was observed. However, no flow was confirmed in the area enclosed by the solid line, indicating that the cylinder was not levitated. It is thought that the liquefied particles accumulated under the cylinder, preventing it levitated. The jet flow from the side hole occurred regardless of whether the cylinder was levitated.

5. Conclusion

Particle behavior around a cylinder with a side hole was observed with a high-speed camera. No air flowed between the gaps, and the jet flow was generated by absorbing air around the side hole. Furthermore, the jet flow from the side hole was generated independently of the levitation of the cylinder.

Acknowledgment

This work was supported by KAKENHI Grant Number JP21H01268.

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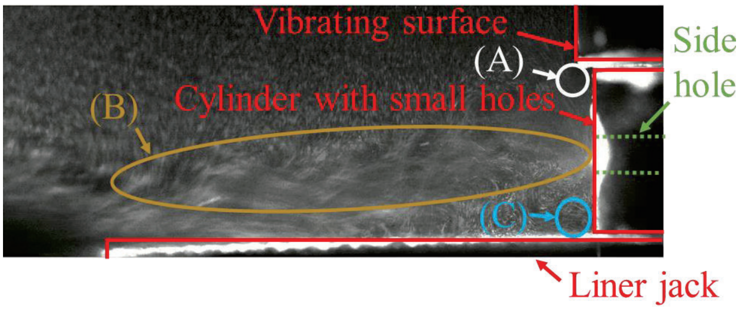

Fig. 5 Particle behavior around cylinder with small holes (5,000 fps).

Fig. 6 Particle behavior around the side hole (10,000 fps).

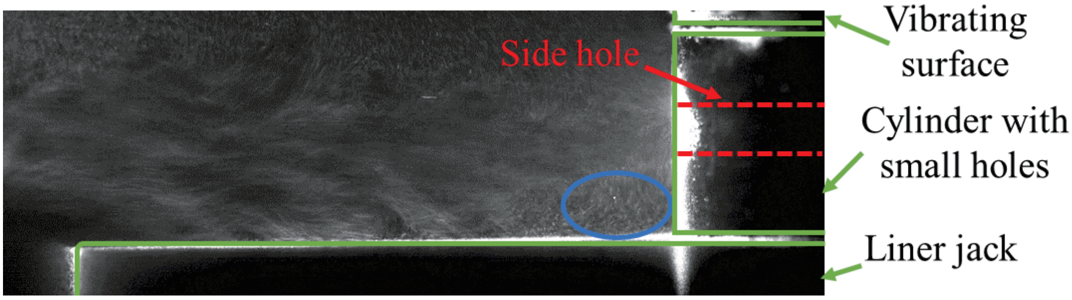

Fig. 7 Particle behavior around cylinder when not levitated (5,000 fps).