A Numerical Model for Three-Dimensional Analysis of Vibration-Induced Flow

生産技術研究所　革新的シミュレーションセンター　長谷川研究室
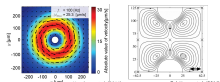
http://www.ysklab.iis.u-tokyo.ac.jp

Vibration-Induced Flow (VIF)
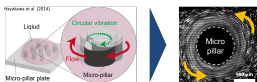
For controlling flows and associated transport and mixing

Standard two-dimensional analysis

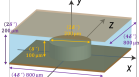Under the two-dimensional assumption

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To develop a numerical tool to analyze three-dimensionality of VIF

Numerical procedure

■ Computational domain and governing equations

$$\frac{\partial u_i}{\partial t} + u_i \frac{\partial u_i}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{1}{Re}\frac{\partial^2 u_i}{\partial x_j \partial x_j} + f_i - \eta\phi u_i$$

$$\frac{\partial u_i}{\partial x_i} = 0$$

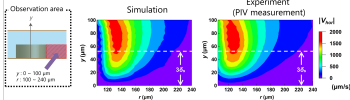**Vibration parameter :** $f = 1000$ Hz, $A = 4$ μm

■ Time averaging of flow field

1. Tracking virtual fluid particle by using an instantaneous flow
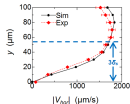2. Connecting start and end points

Vertical distribution of azimuthal velocity magnitude

■ Contour plots in r-y plane

Observation area

Simulation

Experiment (PIV measurement)

- Similar trend in terms of the peak position of $r = 130$ μm at $40 < y < 80$ μm
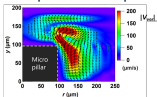- The velocity decays as the position gets closer to the bottom wall

■ Vertical distributions

- Both profiles agreed well
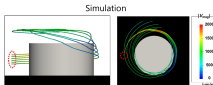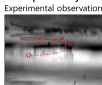- Velocity values increased towards the tip of the pillar

Visualization of three dimensionality of the flow

Vector plot in the vertical plane

Vertical motion is generated

Particle paths subjected to the mean flow

Experimental observation

Simulation

- Tracer particles performed a three-dimensional motion
- The similar path could be seen in experimental observation

Summary

Succeeded in reproducing three-dimensionality of Vibration-Induced Flow
➡ **Numerical code was validated by experimental measurement**