HiFFUT – A New Class of Transducer
Project Meeting

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1 Electromagnetically-driven HIFFUTs

- The typical structure of flexural ultrasonic transducers is a piezoelectric ceramic bonded to an elastic plate, with a fixed boundary condition.

- Advantages of piezoelectric-based flexural transducers include high sensitivity, low power supply and low manufacturing costs.
1 Electromagnetically-driven HIFFUTs

- Elastic plates with a fixed boundary can be driven electromagnetically, utilizing Lorentz force, magnetostriction force and/or magnetization force.

- Advantages of electromagnetically-driven ultrasonic transducers include no requirement of bonding, no soldering points on the plate, more flexibility of mode control and potential of wider band frequency response.

- A wideband electromagnetically-driven ultrasonic transducers for fluid-coupled applications have been designed and fabricated.
1 Electromagnetically-driven HIFFUTs

- Key features:
  - High sensitivity (~80 dB SPL at 100 mm with 7 Vpp input);
  - Wide bandwidth (-6 dB bandwidth: 40 kHz to 140 kHz);
  - Flat response (no obvious centre frequency);
  - High directivity (~ 5° half beam angle);

- Currently at commercial opportunities appraisal and application for patent stage. More details will be presented at the next meeting.
2 Ultrasonic Levitation – an application of ultrasound

- A 3D printed mechanical structure has been designed to hold two 40 kHz flexural ultrasonic transducers facing each other, where the distance between the transducers can be adjusted.
A standing wave with a wavelength of 8.6 mm is formed in the air by the constructive interference between the two ultrasonic transducers.

Small particles like polystyrene balls and droplets can be trapped in the antinodes of pressure of the standing wave.

The pressure at the antinodes is strong enough (with an input voltage 20 Vpp) to defy gravity, and the particles can hover in the air.
2 Ultrasonic Levitation – an application of ultrasound

- The pressure with an input voltage of 20 Vpp is strong enough to levitate particles even when the transducers are placed horizontally.

- Multiple particles can be levitated at the same time when the input voltage is increased to approximately 80 Vpp.

- This technique can be potentially utilized in contactless manipulation of particles.
3 Flow measurement with flexural ultrasonic arrays
3 Flow measurement with flexural ultrasonic arrays

Variation of optimum steering angle with flow rates
3 Flow measurement with flexural ultrasonic arrays

\[ \bar{t}_{up} = \frac{1}{16} \sum_{i,j} t_{up(i,j)} \]

\[ \bar{t}_{down} = \frac{1}{16} \sum_{i,j} t_{down(i,j)} \]

\[ \bar{t}_{down} = \frac{D}{\sin(\theta) \times [c + \bar{V}_P \cos(\theta)]} \]

\[ \bar{t}_{up} = \frac{D}{\sin(\theta) \times [c - \bar{V}_P \cos(\theta)]} \]

\[ \bar{V}_A = \frac{D}{\sin(2\theta)} \times \frac{\bar{t}_{up} - \bar{t}_{down}}{\bar{t}_{up} \times \bar{t}_{down}} \times k_e \]

- \( \bar{t}_{up} \): averaged time of flight measured upstream;
- \( \bar{t}_{down} \): averaged time of flight measured downstream;
- \( c \): velocity of ultrasound;
- \( \bar{V}_P \): averaged flow velocity over the projection of ultrasonic path on cross-section of pipe;
- \( D \): inner diameter of pipe;
- \( \theta \): an angle between ultrasonic path and diameter of pipe;
- \( \bar{V}_A \): averaged flow velocity over cross-section area of pipe;
- \( k_e \): meter factor.
4 Future research

- Optimization and characterization of the electromagnetically-driven ultrasonic transducers.
- Investigating and comparing electromagnetically-driven ultrasonic transducers working with different principles.
- Conducting high-temperature and high-pressure tests.
- Preparing papers and patents.
Thank you for your attention!

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