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WARWICK

HiFFUT – A New Class of Transducer Project Meeting

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FLEXIM when measuring matters

DETECTRONIC FLOW MEASUREMENT AND DATA DELIVERY

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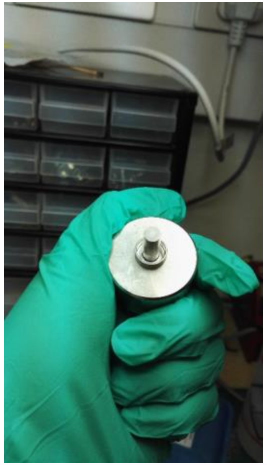
katronic

1 Electromagnetically-driven HIFFUTs

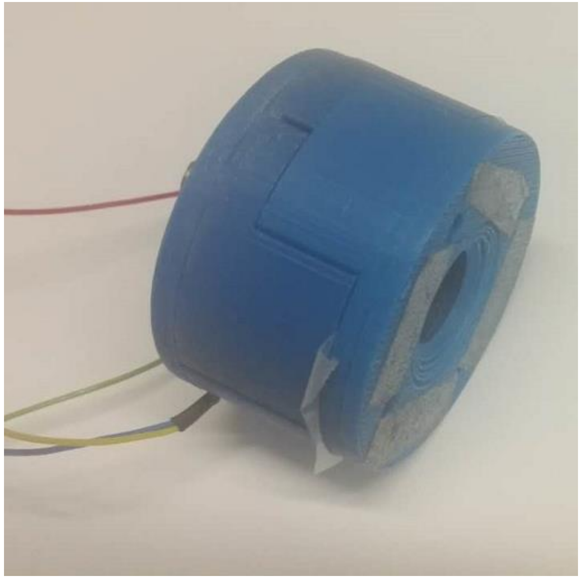
- The typical structure of flexural ultrasonic transducers is a piezoelectric ceramic bonded to an elastic plate, with a fixed boundary condition.
- Advantages of piezoelectric-based flexural transducers include high sensitivity, low power supply and low manufacturing costs.



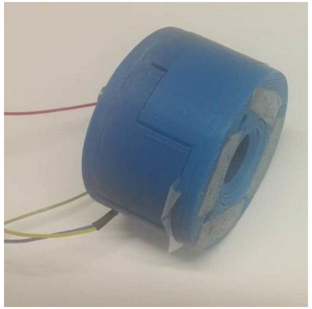



1 Electromagnetically-driven HIFFUTs

- 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



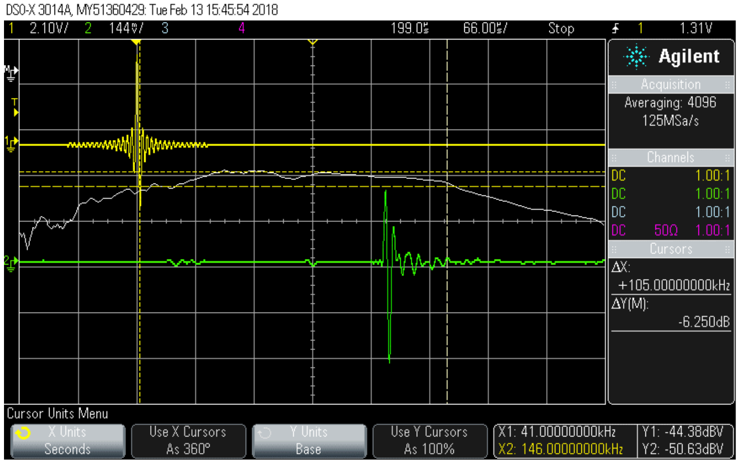
- Key features:

  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);

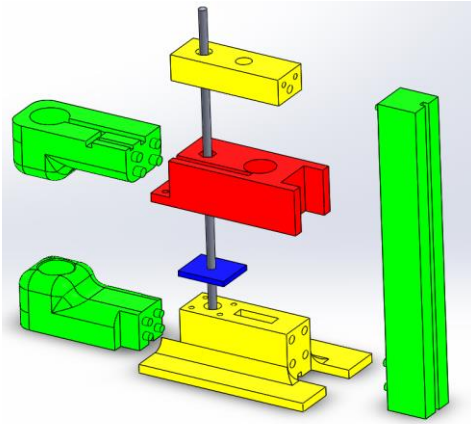
  High directivity (~ 5^{o} half beam angle);

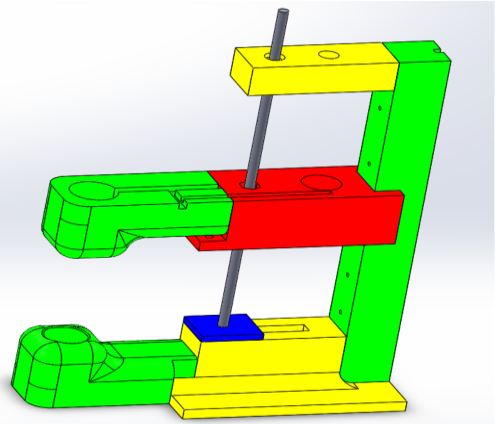


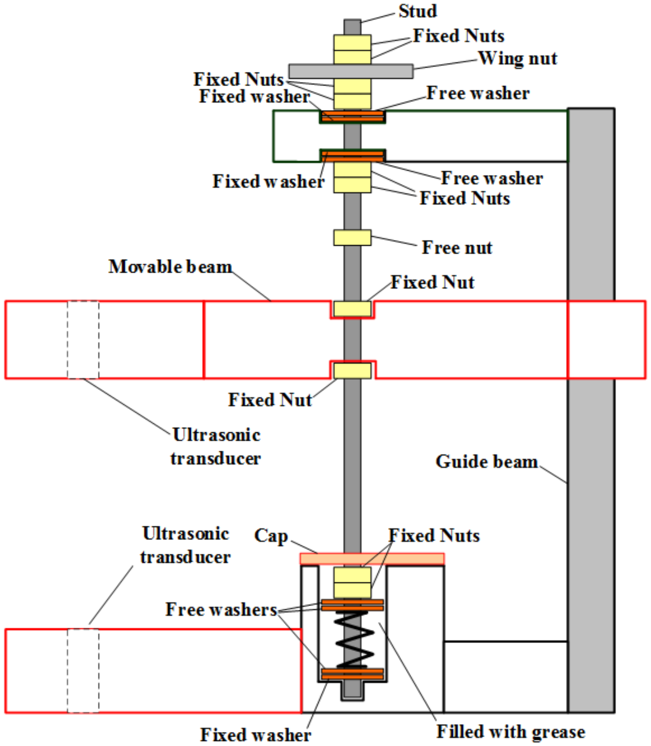
- Currently at commercial opportunities appraisal and application for patent stage. More details will be presented at the next meeting.

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.

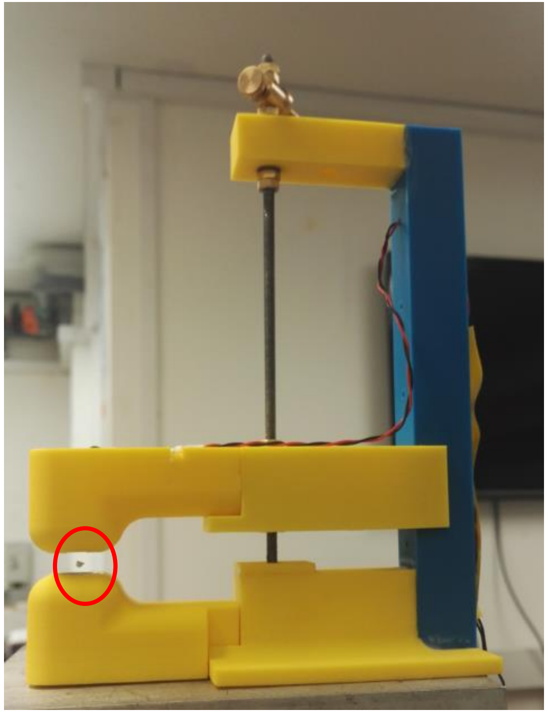




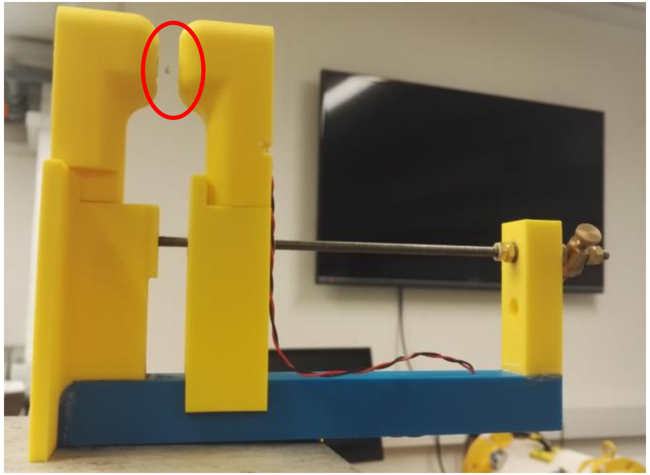


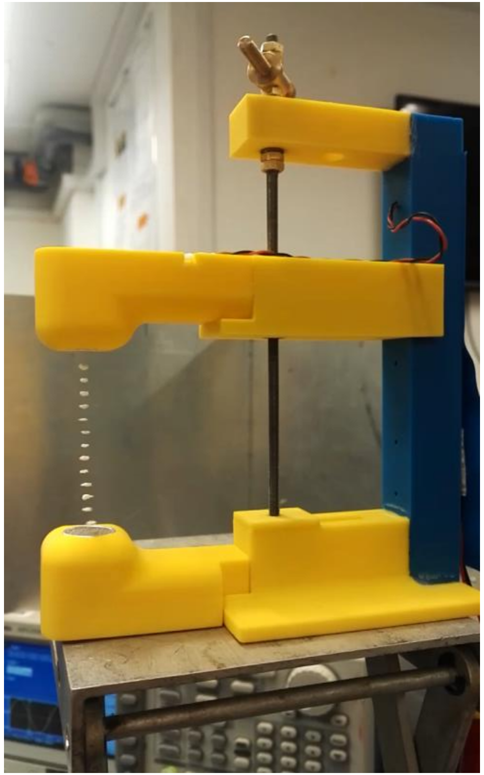
2 Ultrasonic Levitation – an application of ultrasound

- 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.



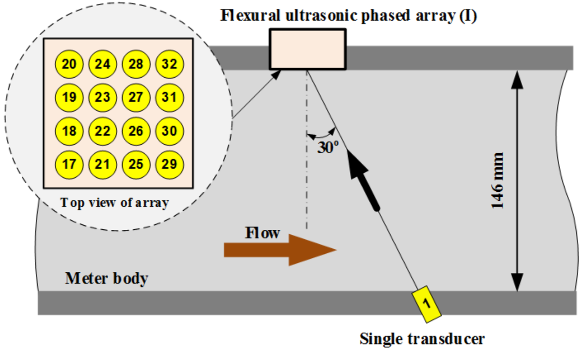
2 Ultrasonic Levitation – an application of ultrasound

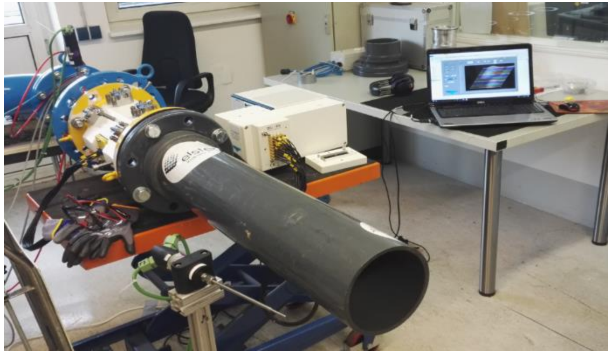


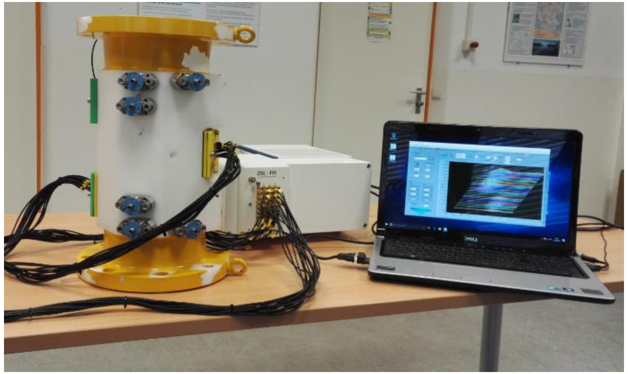


- The pressure with an input voltage of 20 Vpp is strong enough to levitate particles even when the transducers are placed horizontally.
- Multiple particles can be levitated at the same time when the input voltage is increased to approximately 80 Vpp.
- This technique can be potentially utilized in contactless manipulation of particles.

3 Flow measurement with flexural ultrasonic arrays







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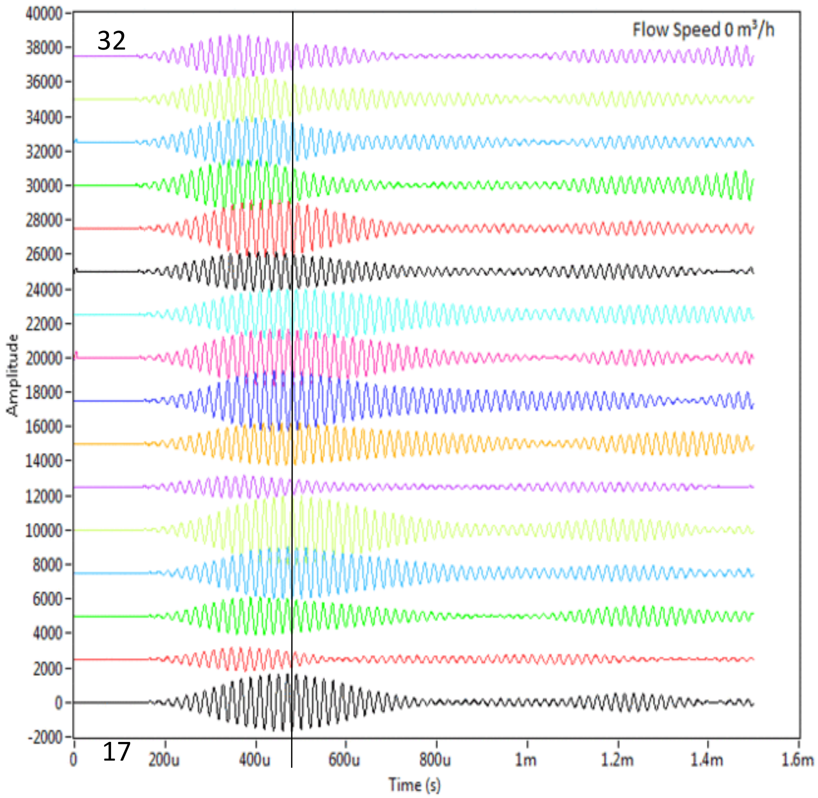
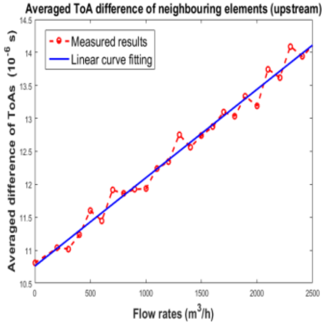
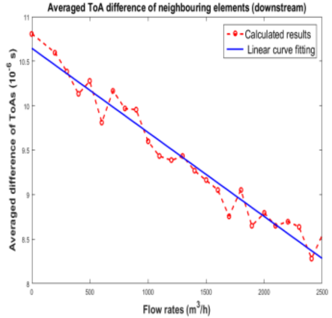


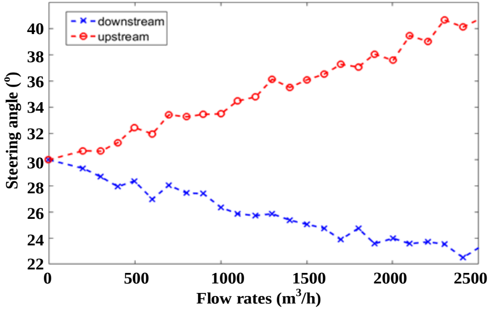
Upstream

Downstream





Variation of optimum steering angle with flow rates



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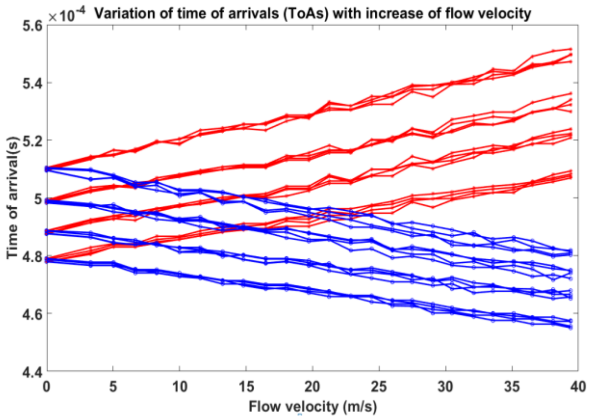

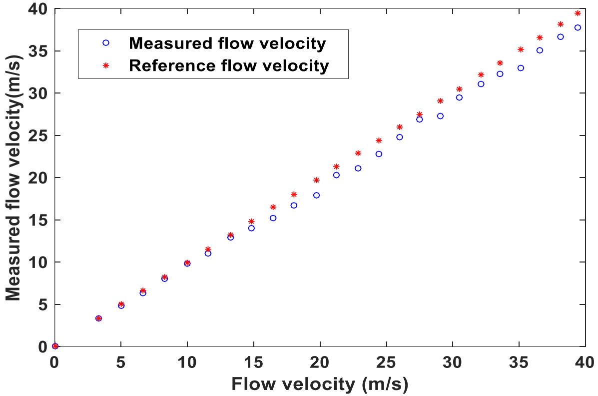

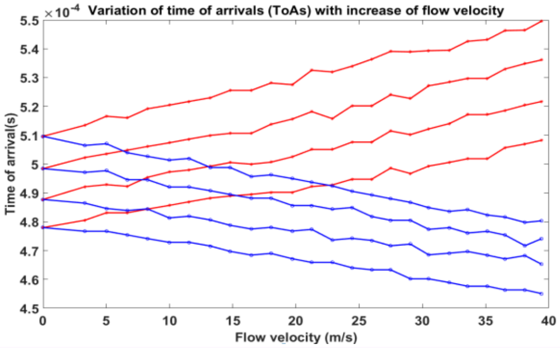

$$\bar{t}_{up} = \frac{1}{16}\times\sum_{i=17}^{32}\bar{t}_{up(1,i)}$$

$$\bar{t}_{down} = \frac{1}{16}\times\sum_{i=17}^{32}\bar{t}_{down(i,1)}$$

$$\begin{cases} \bar{t}_{down} = \dfrac{D}{\sin(\theta)\times[c+\bar{v}_P\cos(\theta)]} \\ \bar{t}_{up} = \dfrac{D}{\sin(\theta)\times[c-\bar{v}_P\cos(\theta)]} \end{cases}$$

$$\bar{v}_A = \frac{D}{\sin(2\theta)}\times\frac{\bar{t}_{up}-\bar{t}_{down}}{\bar{t}_{up}\times\bar{t}_{down}}\times k_c$$

$\bar{t}_{up}$: 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;

θ : an angle between ultrasonic path and diameter of pipe;

$\bar{v}_A$: averaged flow velocity over cross-section area of pipe;

k_c: 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.

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Thank you for your attention!

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