HiFFUT – A New Class of Transducer

Project Meeting

19th March 2018

Dr Andrew Féeney
High Frequency Ultrasound Measurement

- Measurement of high frequency ultrasound in air using two FUTs, one as a transmitter and one as a receiver.
- Separation: 500 mm, but with the capacity for data acquisition at much greater distances.

Impedance Analysis

Mode Shapes from LDV

(0,0) Mode at 40.5 kHz

(1,0) Mode at 177.4 kHz

(2,0) Mode at 318.7 kHz
High Frequency Ultrasound Measurement

All data recorded with one FUT as a transmitter and one as a receiver separated by 500 mm.
High Temperature HiFFUTs

- Two high temperature HiFFUTs constructed.
- Custom pressure rig used to bond components together.
- A high temperature epoxy resin (EPO-TEK® 353ND) used.
- Titanium (Grade 2 ASTM) cap.
- PZ46 bismuth titanate (BiT) ceramic (Meggitt), 0.89 mm thick, 6.35 mm diameter.

Disc, cut from Ti sheet, with BiT ceramic bonded on top, forming the membrane

Recess cut into tubing

Prior to laser welding

Assembled Configuration

Ti tubing to act as transducer side-wall

Cap components fabricated from laser welding
High Temperature HiFFUTs

- LDV and microphone measurements (distance of 65 mm) undertaken at room temperature prior to thermal characterisation.
- Laboratory furnace (Pyrotherm) used for thermal characterisation, at 300 mm.

Experimental process:

**Phase 1**
- Measurement Oscilloscope
- Function Generator
- Acoustic Microphone, Brüel & Kjær BK 4138-A-015
- Laser Doppler Vibrometer, Polytec OFV-5000

**Phase 2**
- HiFFUT
- Laboratory Furnace
- Measurement with acoustic microphone

(0,0) mode, PZFlex FEA

(0,0) mode of HiFFUT 1 from LDV at 74.5 kHz
High Temperature HiFFUTs

Room temperature, 65 mm

150°C, 300 mm

Burst signal of 400 cycles at 20 \( V_{p-p} \)

HiFFUT 2 Response

Device held for \( \geq 15 \) minutes at each temperature increment
Measurement at High Pressure

- Full system assembled and tested, with a ratiometric pressure sensor (Honeywell) for pressure measurement.
- Two M.Phys. dissertation students have conducted tests on commercial FUTs and FUTs with oil in the housing.

**Thermal Detection Ltd High Pressure Insulated Wire Sealing Gland (HPPL)**
- Viton sealant
- Seals up to 2070 bar (at 20°C)
- Grade 316L stainless steel

**MK4 Hill Air Pump**
- 1/8” BSP Connection
- Rated up to 4000 psi (276 bar)

<table>
<thead>
<tr>
<th>Outside diameter [mm]</th>
<th>Wall thickness [mm]</th>
<th>Volume (l)</th>
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**Honeywell Pressure Sensor**
- 1/4”-18NPT Connection
- Rated up to 3000 psi (207 bar)
- Ratiometric

1. Pressurisation port for connection to the pump
2. Pressure vessel body
3. Removable panels for positioning transducers
4. Supports
5. Pressure gland ports for through-cabling

180 mm
Sample Data at High Pressure
Research Output (Sep. 2017 – Present)

PAPERS


PRESENTATIONS & PUBLIC ENGAGEMENT

• A. Feeney and L. Kang, demonstrators of ultrasonics and HiFFUT research to the public, XMaS Science Gala, University of Warwick, January 2018.
Next Steps

• Complete fabrication and testing of demonstrator piezoelectric HiFFUTs.
• Develop the second phase of HiFFUTs for high temperature applications, accounting for the outcomes from the first phase reported at the 2017 International Congress on ultrasonics.
• Construct and test a laser-welded HiFFUT.
• Design HiFFUTs for high pressure environments towards 200 bar.
## Project Gantt Chart

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<tr>
<th>Tasks/Deliverables</th>
<th>Month</th>
<th>1-8</th>
<th>7-12</th>
<th>13-18</th>
<th>19-24</th>
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Activity of PDRA1, PI & Technician

Activity of PDRA2, PI & Technician

Activity of PDRA3, PI & Technician

Activity of PDRA4, PI & Technician