Fluid Levitating Tasting Experience

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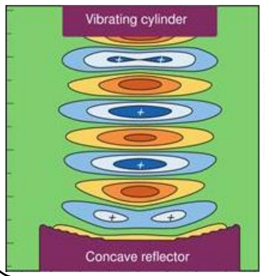
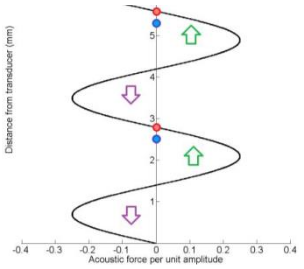
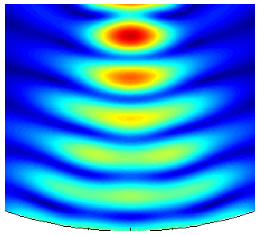
Introduction

Ultrasonic standing waves between an emitter and a reflector can be used to 'trap' or levitate small particles or droplets of liquid at nodal points. This project investigated the possibility of designing, developing and optimising a fluid levitation rig using ultrasound to levitate water stably such that a client could consume the droplets via a cocktail straw.

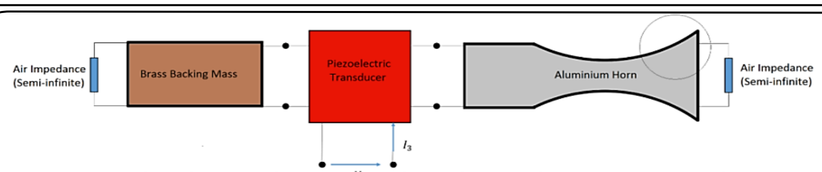
Horn designs





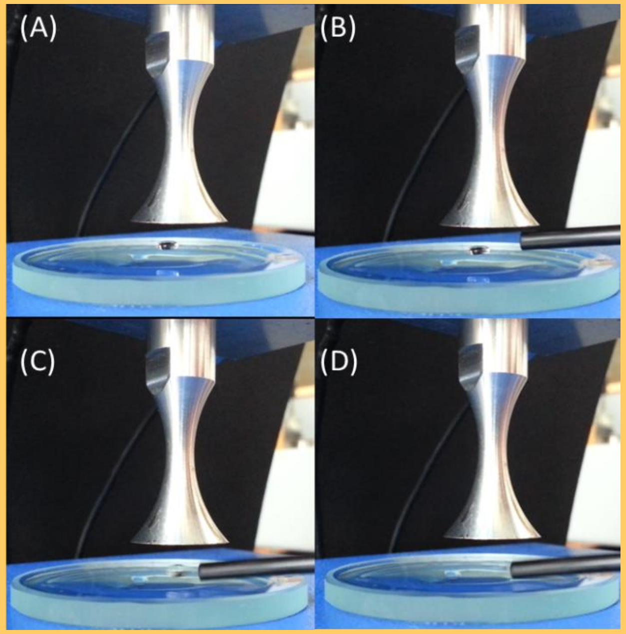


Huygens' and FE models were used to visualise the acoustic pressure field between different emitter and reflector combinations and to optimise transducer designs. The red areas signify high pressure with the blue, the lower pressure trapping regions.



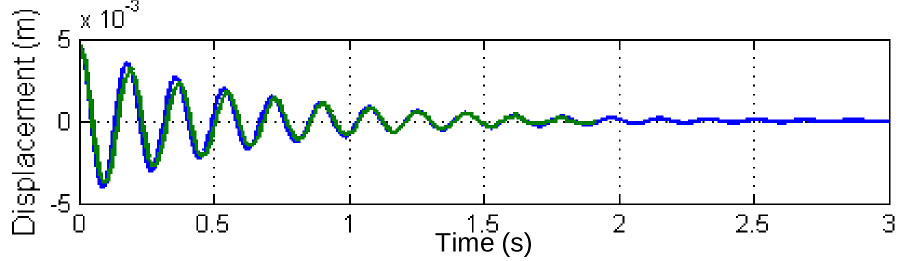
A Transmission Line Model (TLM) was used to evaluate acoustic wave output pressures of different aluminium horn designs. A TLM was developed alongside a particle swarm and gradient optimisation algorithm in order to design fully optimised aluminium acoustic horns (shown in red below) able to increase the output acoustic wave pressures by 150 times from the original aluminium horn design.

Tasting Experience



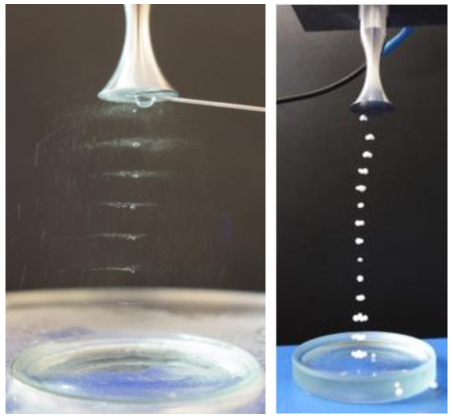
The single horn device allowed the consumption of stably levitated fluid droplets as seen above.

Image processing displacement tracking techniques were used to assess the horizontal stability of the device.



Displacement tracking was then used to calculate the effective spring stiffness and damping coefficients of the horizontal trap.

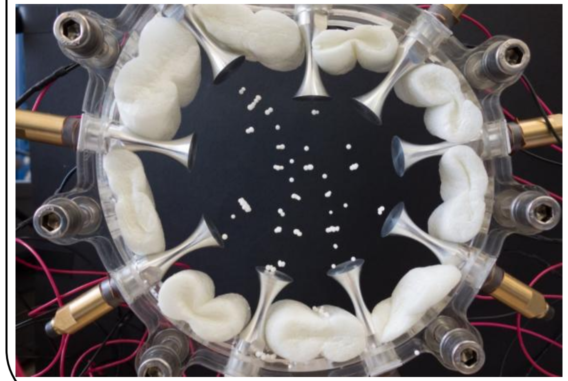
Single Horn Device



The single horn and reflector device was used to levitate a number of fluid droplets as well as to assess the horizontal stability of the trap.

Multiple Horn Devices

Two separate multiple horn devices were manufacture and tested. The Ultra-Snail (seen below) and the Stepped Horn device.



The Ultra-Snail was used to successfully levitate multiple polystyrene spheres at an array of nodal positions.

Conclusions

As many as four droplets were levitated using a single transducer. The largest water droplet levitated was between 3-4 mm in diameter. Later experiments managed to levitate droplets of high strength alcohol. The generated acoustic field was stable enough to allow the alcohol and water droplets to be consumed from the field with a cocktail straw.

Supervisor: Prof. B. Drinkwater

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