Development of Novel Process Intensification Device, Acoustic Driven Packing Material

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University Coalition for Fossil Energy Research

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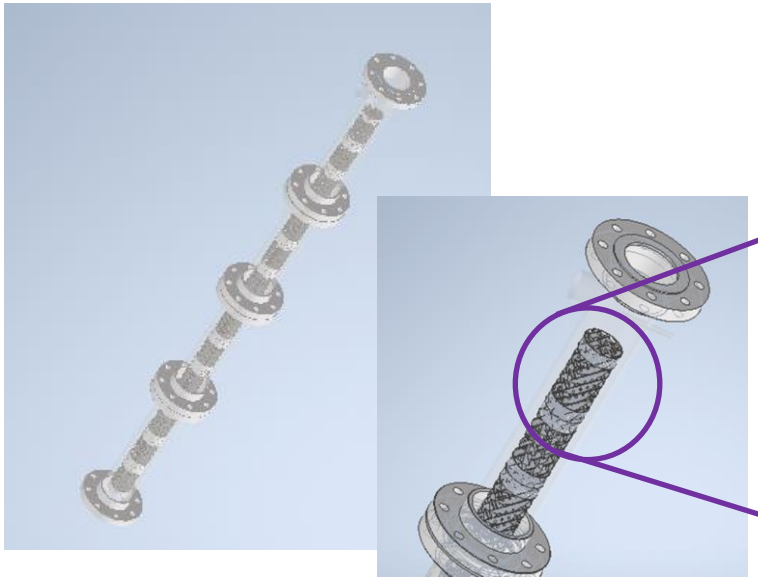
What is Packing Material?

- Packing material provides additional surface area for reactions, such as, mass transfer to occur.
- Most packing materials are composed of dense corrugated sheets of metal.
- Research and development into advanced packing materials seek to increase available surface area, improve liquid/gas distribution, and reduce capital costs while minimizing pressure drop.

Market Opportunities

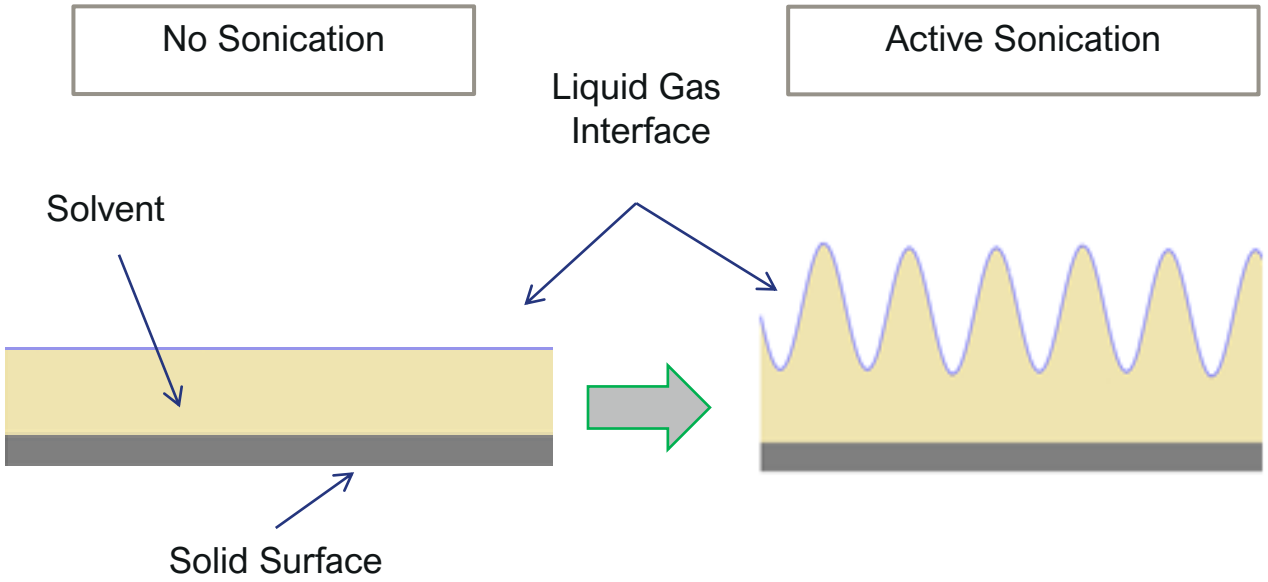
Available Fields of Use

CO_2 Capture
General Acid Gas Scrubbing
Stripping
Distillation
General Separations



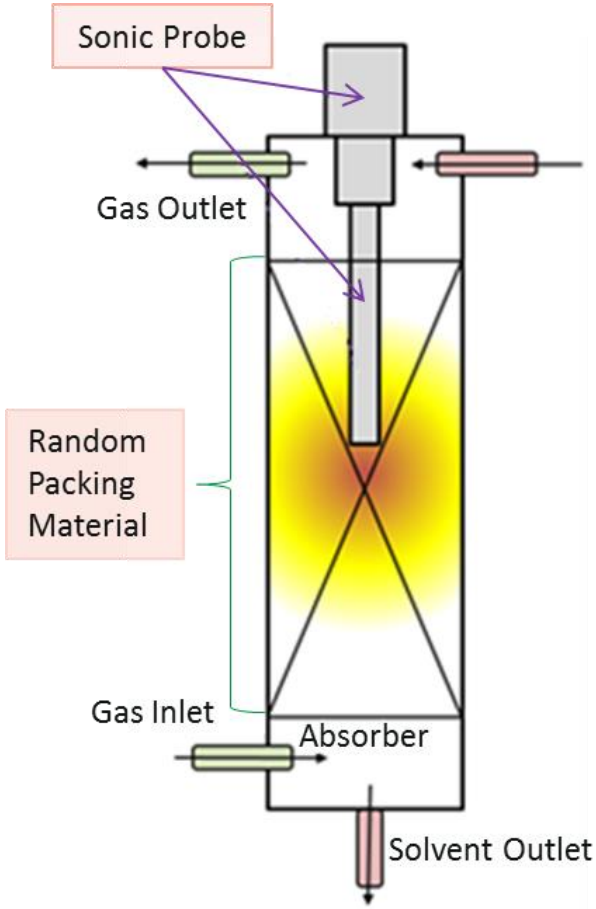
Mechanism

- A propagating surface wave in a liquid film will increase the film's surface area and localized gas-liquid mixing increasing absorption rate.



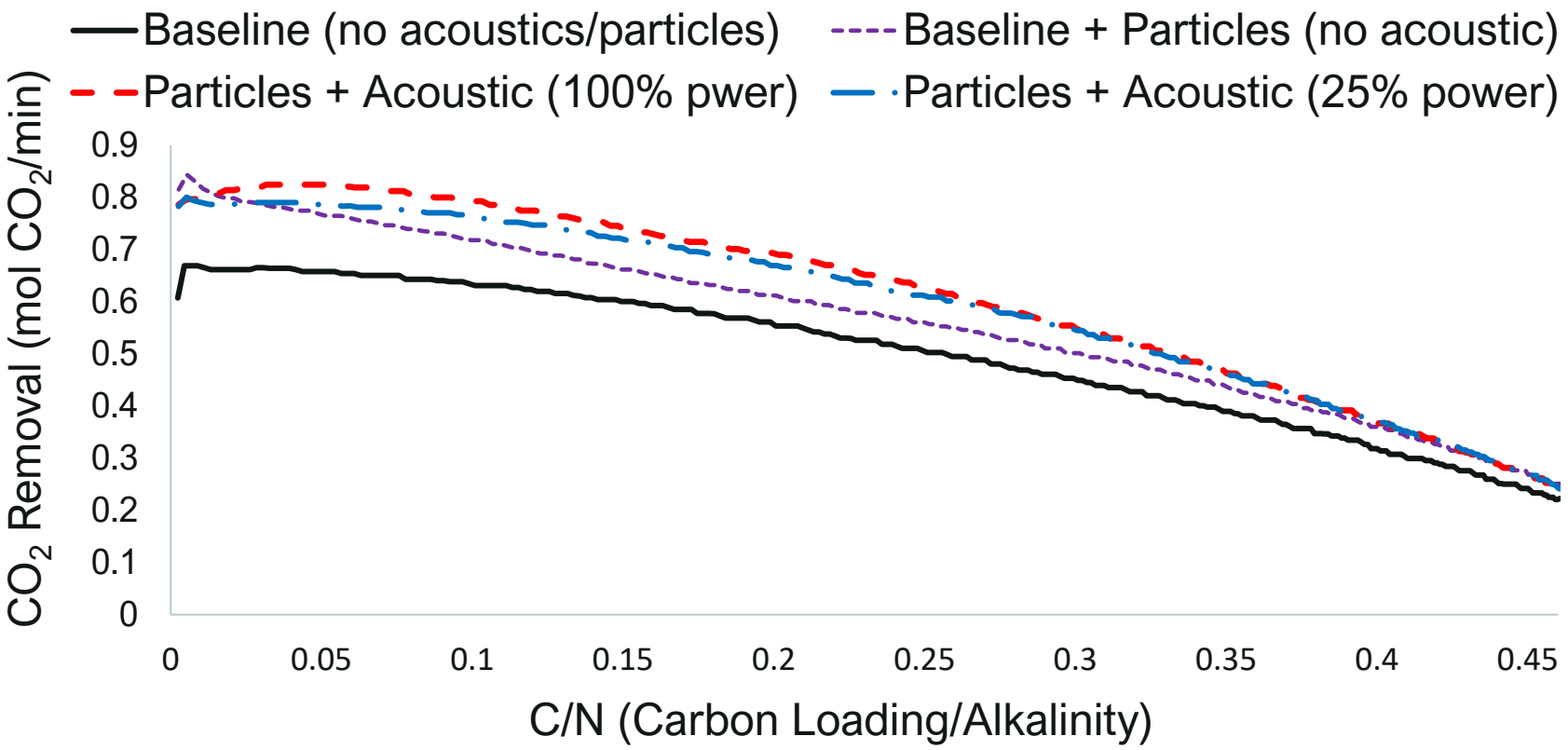
- Acoustic Streaming: Flow in a fluid driven by the absorption of high amplitude acoustic oscillations.
- Micro Turbulence: A form of turbulence that varies over distances on the micrometer scale.
- Acoustic amplitude: Observed to be positively correlated with an increase in solvent absorption rate

Proof-of-Application



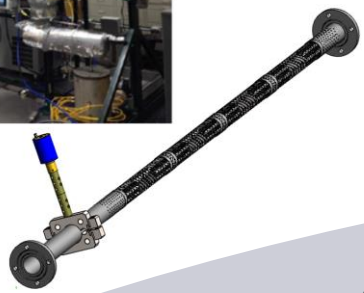
Testing the effects of sonication on CO_2 removal in a bench scale counter current absorption column

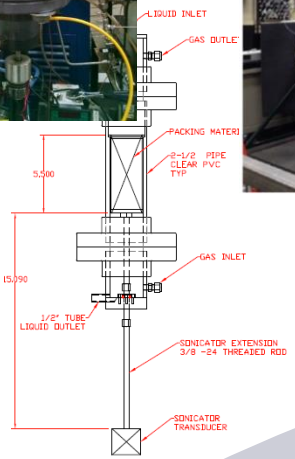
Results

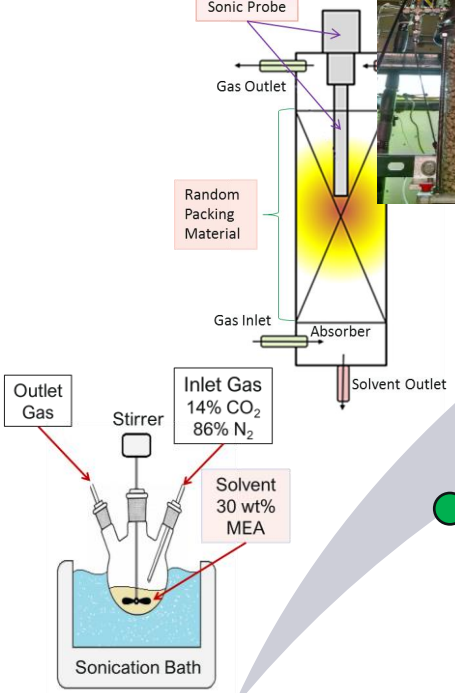


- 21-25% absorption increase with particle additive.

The Path Forward







Proof of Concept

Proof of Application

First Working Prototype

Bench Scale Testing (Current)

Pilot Scale Testing

Full Commercial Deployment

Research Goals

Solve resonance issue with the use of an advanced acoustic generator provided by MPI Ultrasonic.

What effects resonance frequency?

LoadShape Operation Reflected Waves Reactive Load

Design and construct a column that can accommodate and optimize the acoustic driven packing material

Test the performance of the column on UK CAER's 30 L/min CO_2 capture bench unit at known optimal conditions.

Compare the performance of the column at different acoustic amplitudes with baseline experiments.

Effectiveness of fine solids additive

Multiple Solvents Tested

Investigate energy consumption and scalability.

UK CAER's 30 L/min CO2 Capture Bench Unit

- 3" diameter absorber column with attach stripping unit
- Latest NI controls management system
- Pressurized stripping unit
- Bottled CO_2 and house nitrogen

Multiple acoustic amplitudes will be used for each test

Test with 30 wt% MEA
Test with 30 wt% MEA + fine solids
Test with Uky-CAER Solvent
Test with Uky-CAER Solvent + fine solids

Wire Design

Pro's

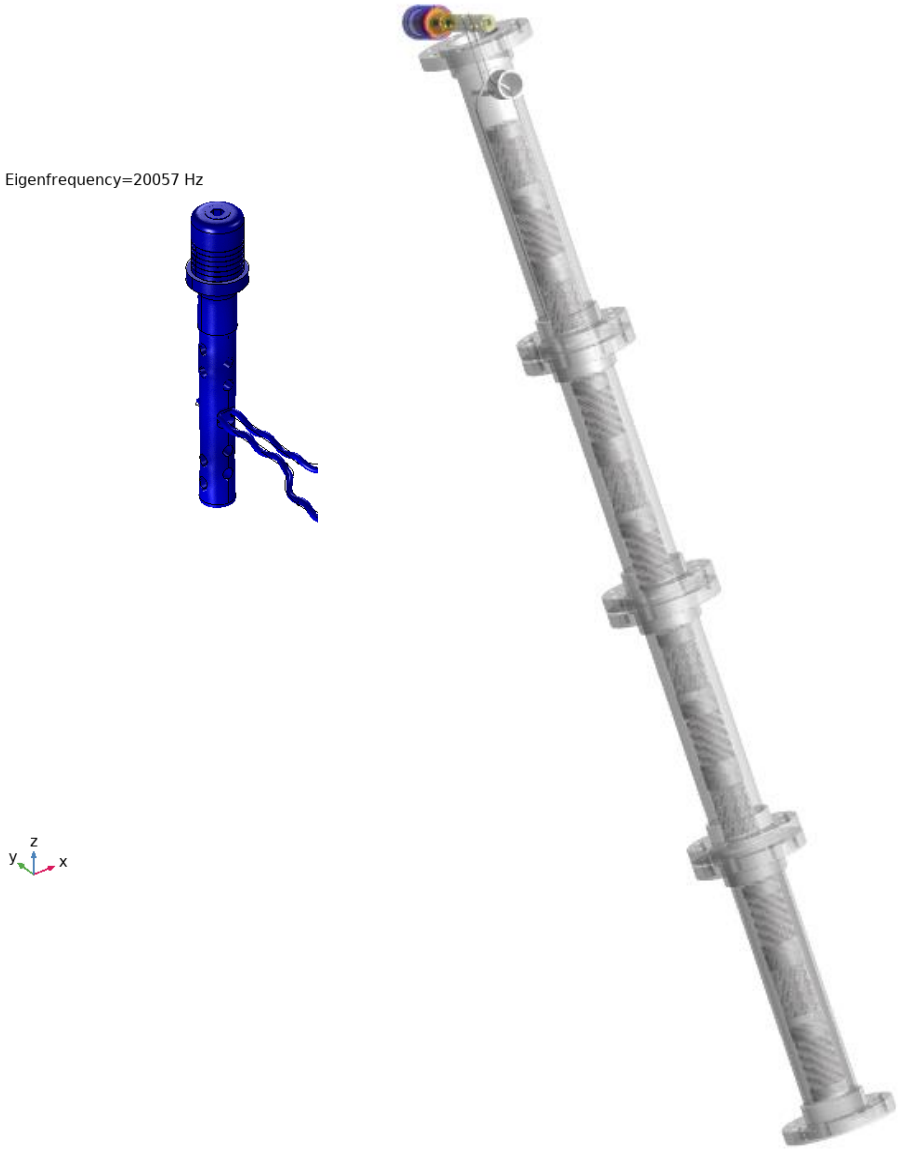
1. Only 1 Transducer
2. Acoustics is isolated to the packing

Con's

1. 0.5" Air Gap
2. Poor Acoustic Efficiency

Concerns

1. Weight Load?



Tube design

Pro's

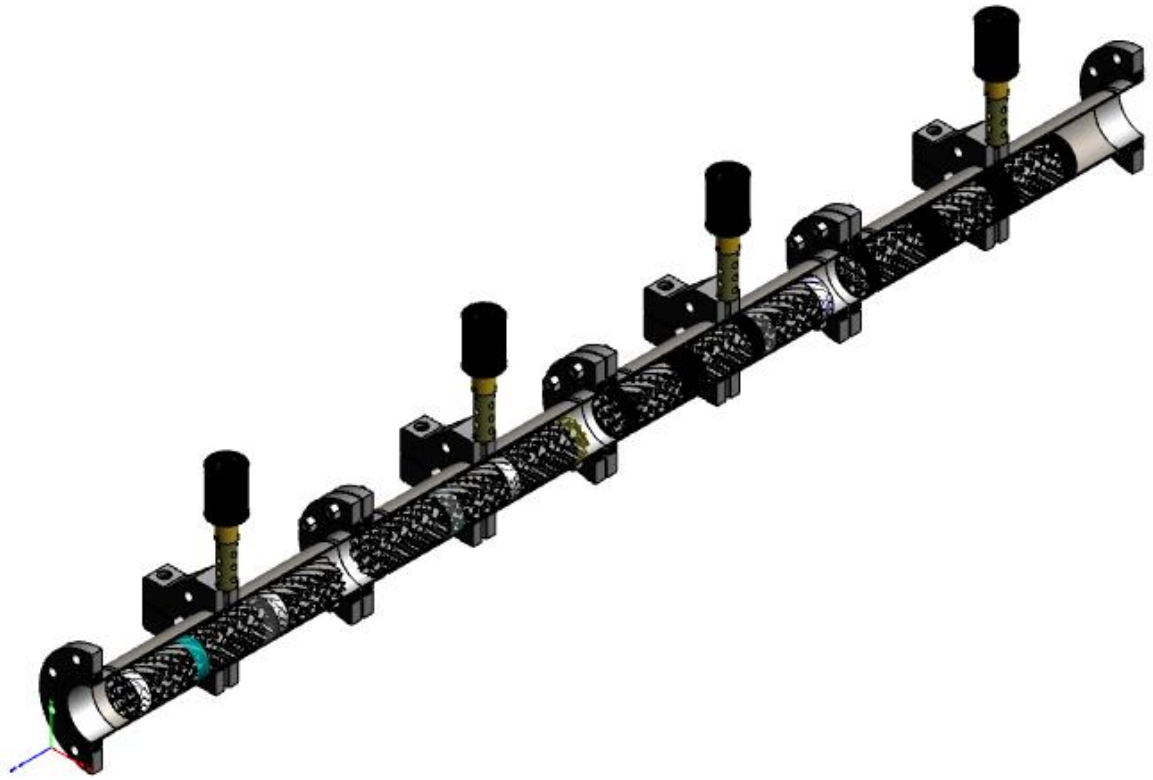
1. Great acoustic coverage
2. No air gap

Con's

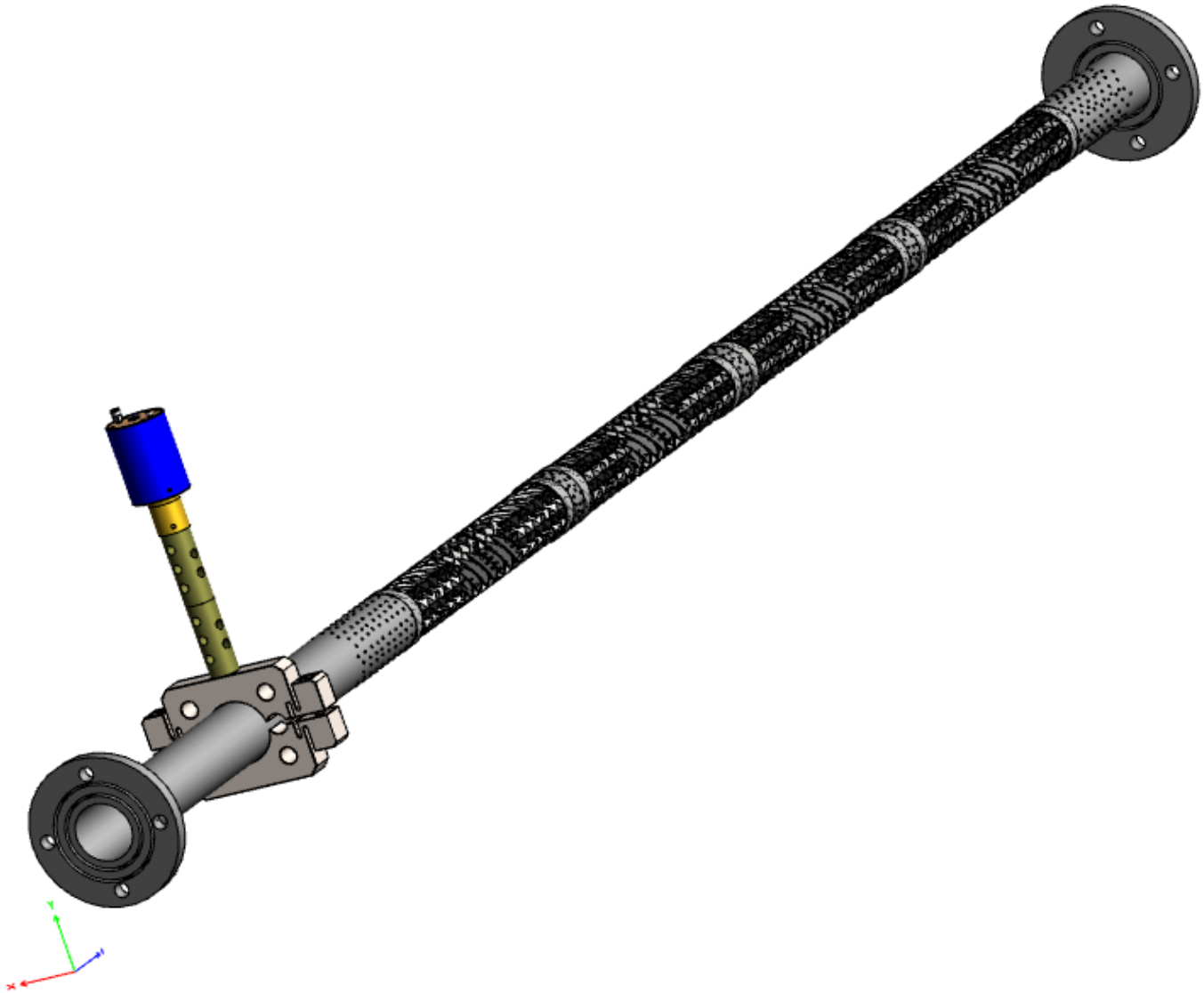
1. Vibrates entire column
2. Many transducers

Concerns

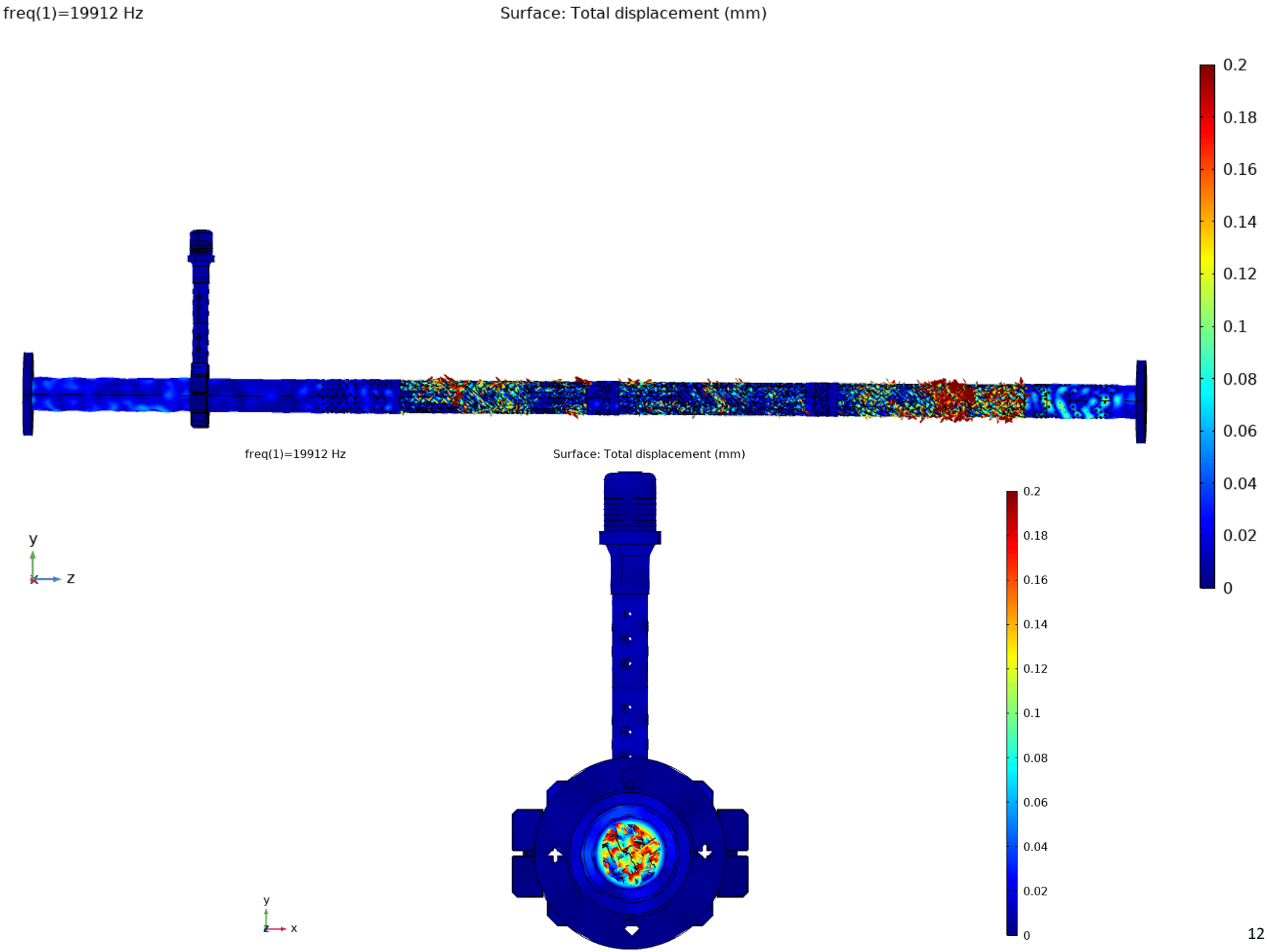
1. Power consumption



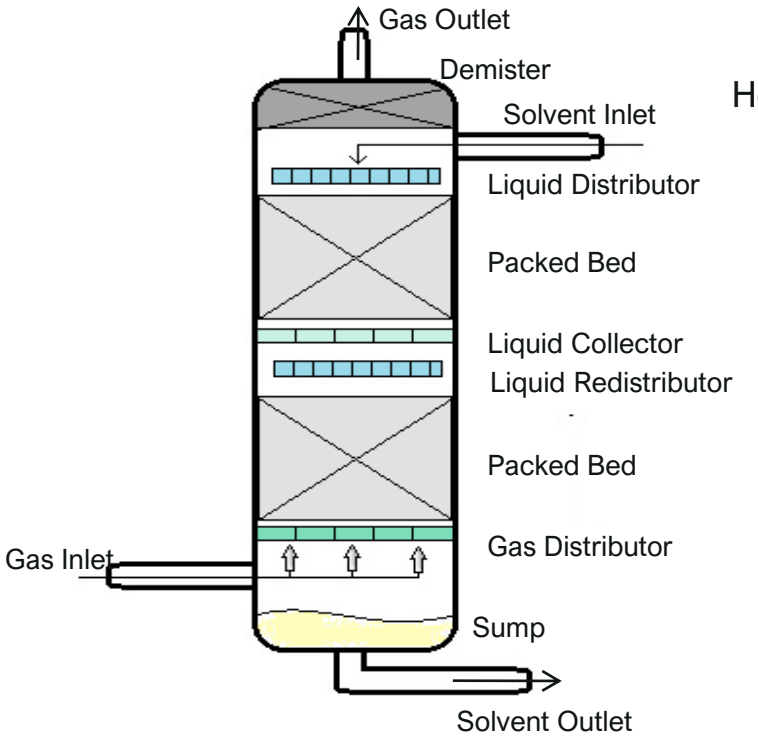
Hybrid Design



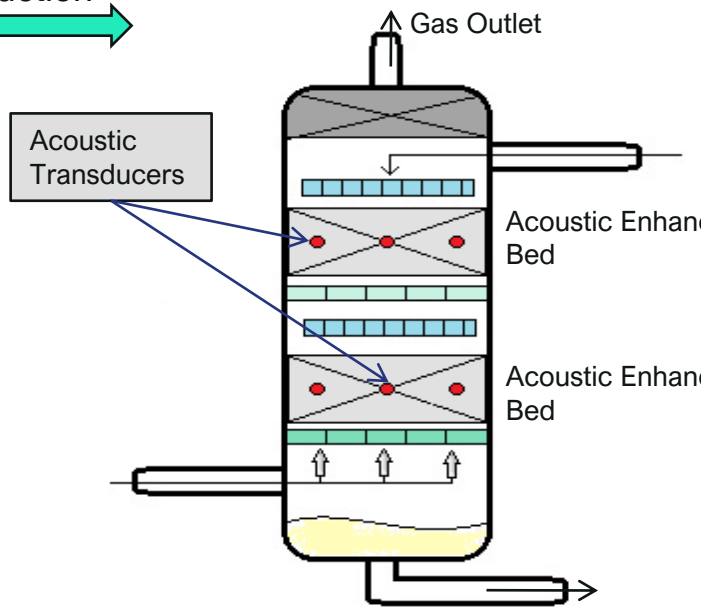
Acoustic Simulation: Hybrid Design



Cost Reduction



Height Reduction



Current UKy-CAER Cost Estimate (60 ft Absorber): **$84.6 Million**

With Acoustic Packing (42 ft Absorber): **$62.1 Million**

A **30%** mass transfer enhancement can reduce absorber costs by up to **26%**

Acknowledgement

Thank You

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Thank you