Development of Novel Process Intensification Device, Acoustic Driven Packing Material

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University Coalition for Fossil Energy Research

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http://www.caer.uky.edu/powergen/home.shtml
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.

Available Fields of Use

- CO₂ Capture
- General Acid Gas Scrubbing
- Stripping
- Distillation
- General Separations

Market Opportunities
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.
Testing the effects of sonication on CO₂ removal in a bench scale counter current absorption column
Results

- Baseline (no acoustics/particles)
- Baseline + Particles (no acoustic)
- Particles + Acoustic (100% power)
- Particles + Acoustic (25% power)

- 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
- 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?**

<table>
<thead>
<tr>
<th>Load</th>
<th>Shape</th>
<th>Operation</th>
<th>Reflected Waves</th>
<th>Reactive Load</th>
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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 CO₂ 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 CO₂ 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?
**Pro’s**

1. Great acoustic coverage
2. No air gap

**Con’s**

1. Vibrates entire column
2. Many transducers

**Concerns**

1. Power consumption
What if we could combine the two designs?

- Reduce air gap from 0.5” to 0.24”. Which is about 1/8” with acoustics active.
- Solve the weight support issue.
- Keep the number of transducers needed to a minimum.
- Keep the acoustic vibrations concentrated on the packing.
- Generate higher acoustic efficiency.

Hybrid Design
Acoustic Simulation: Hybrid Design

freq(1) = 19912 Hz

Surface: Total displacement (mm)
A 30% mass transfer enhancement can reduce absorber costs by up to 26%

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

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