Advanced, Low-Cost, System for Algae Dewatering

Ashok Damle
Techverse, Inc.

Poster presentation
Algae Biomass Summit
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U.S. DOE SBIR Phase II Project

- Project Duration – August 1, 2016 – July 31, 2018
- Project Partners -

Techverse, Inc.
Advancing Energy Technologies

SmartFlow Technologies
Now for Biofuels!

AzCATI
Arizona Center for Algae Technology and Innovation

AFS BioOil™
Phase II Project Objectives

• Develop a two-stage algae dewatering system for >20% w/w algae paste from 0.05% w/w algae feed
• Achieve >30% capital cost reduction and >20% energy reduction compared to DAF/centrifuge
• Demonstrate concentration of 1% w/w algae to >20% w/w paste in a continuous membrane process
• Develop methodology for algae pre-concentration by gravitational settling (<0.05% w/w algae to >1% w/w)
• Different algae species of interest – Chlorella, Nanno.
Proposed Algae Dewatering Process

- Supernatant recycle to cultivation
  - 0.01% w/w Algae

- From ponds/PBRs
  - 0.05% w/w Algae

- Gravitational Settlers

- Membrane Filters
  - 1% w/w Algae
  - > 20% w/w Algae paste

- Permeate recycle to cultivation
  - 0% w/w Algae

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Phase II Project work Plan

• Task 1 - Gravitational settling studies (AzCATI)
• Task 2 – Design/Fabricate a 3-stage membrane dewatering skid to process 100 L/hr of 1% w/w algae feed to produce 5 L/hr of >20% w/w algae paste. (SmartFlow/Techverse)
• Task 3 – Skid Testing at AzCATI with 1% w/w pre-concentrated algae from raceway ponds at AzCATI. (Techverse/AzCATI)
• Task 4 – (Year 2) Skid Testing at AFS BioOil with 1% w/w pre-concentrated algae from PBRs at AFS BioOil. (Techverse/AFS)
• Task 5 - Process design for large algae flow rates with lowest possible cost as well as energy use (Techverse/SmartFlow)
• Task 6 - Techno-economic analysis (Techverse lead)
**Task 1 Gravitational Settling Studies**

- Bench-scale screening for settling studies will be conducted with a jar testing apparatus similar to that shown below and different algae/conditions can be evaluated for flocculation/settling behavior.

- In addition, standard settling velocity will be evaluated with simple settling testing using an Imhoff cone, in particular looking at total suspended and settled solids as a function of time.

- Primary algae strains of interest for the bench-scale testing will include commercially relevant algae species and include:
  - *Scenedesmus* sp.
  - *Chlorella* sp.
  - *Nannochloropsis* sp.
  - *Desmodesmus* sp.

- Range of cultivation/physical parameters will be explored that are known to affect settling behavior:
  - Freshwater or marine
  - Different size/shape algae (some natural settlers)
  - Auto-flocculation vs. coagulants
  - Nutrient replete vs. deplete (i.e., stressed) algae cultivation

- Develop general methodology for algae pre-concentration by gravitational settling (<0.05% w/w algae to >1% w/w algae concentrate)
SmartFlow's Patented "Open Channel" Membrane Module Technology

http://www.smartflow-tech-biofuels.com/consepadvancedsolutions.html
Advantages of SmartFlow Membrane Module

• Uniform flow pattern throughout the membrane module
  – Utilizes 100% of membrane surface area
• Equal fluid path length in all flow channels - Equal flow resistance
  – Avoids channeling and dead spots
• Uniform flow velocity over all of the membrane surfaces
  – Creates equal shear at all locations
  – Avoids deposits and fouling prone areas
• Patented rib design - uniform retentate channels (no porous spacer)
  – Easily handles fluids with high solids content, high viscosity
  – Allows producing high solids content algae concentrates
Task 2 – Membrane Algae Dewatering Skid

- Feed rate - 100 L/h
- Feed conc. - 1% w/w
- Continuous dewatering
- Concentrate - 5 L/h
- Product - >20% w/w
- # of stages – 3
- Total membrane area • 3.6 m²

To be tested at AzCATI soon
Task 3: Skid Testing at AzCATI

- Target culture density at harvest: minimum of 0.5 g/L (0.05% w/w)
- Ponds will be operated in “semi-batch” mode
- 20 m³ of culture volume from duplicate raceways (10 m³ per pond) will be harvested, combined, and pre-concentrated using membrane filtration to a final volume of 1 m³ at 1% w/w.
- Pilot trials will be conducted on the Techverse/SmartFlow pilot skid using the 1% w/w conc.
- Up to 4 strains/conditions will be tested at the pilot scale.

Twin 60 m² raceways with a culture volume 15 m³ per pond will be used for algae cultivation scale up for skid testing of the Techverse/SmartFlow membrane filtration pilot.

Typical growth curves (fall season) for Nannochloropsis sp. cultivation in 60 m² raceways at AzCATI.
Task 3: Skid Testing at AzCATI

• For pilot studies, membrane filtration will be used as proxy to achieve 1 wt % target for pilot testing (1000L of culture volume)
  - If appropriate conditions identified, pilot trials with one or more algae pre-concentrated through gravitational settling may be run through the Techverse/SmartFlow pilot to simulate target large scale 2 stage dewatering.
  - AzCATI has large settling tanks suitable for this task
Phase I – Single stage systems

Front view            Side view
Lab-scale system – 0.1 m² module

Field System
0.8 m² module
Photos of Algae Paste Discharge – Phase I

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Videos of Algae Concentration and Paste

- [https://youtu.be/_U-xKDeYiko](https://youtu.be/_U-xKDeYiko) - Algix pond algae – Phase I
- [https://youtu.be/pT4-PAntkA](https://youtu.be/pT4-PAntkA) - AFS BioOil PBR – Phase I
- [https://youtu.be/DKz1H6P6zgc](https://youtu.be/DKz1H6P6zgc) - Marine Algae – Phase I
- [https://youtu.be/nry1FInEXkU](https://youtu.be/nry1FInEXkU) - Marine Algae – Phase I
- [https://youtu.be/bzwTvJNB6o](https://youtu.be/bzwTvJNB6o) - Chlorella Algae – from DAF
- [http://youtu.be/O1tf8RM1VbE](http://youtu.be/O1tf8RM1VbE) - Fermented Algae
- [https://www.youtube.com/watch?v=phIJDQZ86sk](https://www.youtube.com/watch?v=phIJDQZ86sk) - Tomato Juice
- [http://youtu.be/fO2SwWbLt6k](http://youtu.be/fO2SwWbLt6k) - Potato starch
More information? Questions?

Contact:

Dr. Ashok Damle
Techverse, Inc.
919-454-8461
techverse@hotmail.com