ICM Feedstock Lessons Learned

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ICM’s Generation 2.0 Front-End Processes

Feedstock

Feedstock washing

Pretreatment

Flash

Patent-Pending
Feedstock Process Challenges

- Demonstration problems will Scale Up
- Unit operations with greatest difficulty:
  - Milling
  - Feedstock conveying
  - Pretreatment feeding
  - Solids/Liquids separation
  - Slurry pumping
Milling

- Moisture of product impacts issues
- 2” bale grinding
- Modified rotary air locks – lower impingement
- Transitions very important to keep swept

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VS

- Stationary plates not ideal
- Tub Ground (1 in–2 in length) Feedstock Delivered to Pilot
- Rat holing in storage silo
  - Self cleaning
- Variable moisture changes during milling
NARA – Northwest Advanced Renewables Alliance

Post milling

Post hydrolysis
Transportation

- Tramp/dirt in material
  - Hard on equipment
  - Ash buffering
- Microbial Contamination
- Plugging
  - Silos
  - Transport lines
  - Baghouse at filters
  - At slurry tank
    - Floaters (SG)
    - Sinkers (ES)
- At Pretreatment (PT)
  - Clogging at the slurry pump and check valve presented continual problems
  - Pretreatment pump tripped out multiple times due to thermal overload
- After PT
  - At flash line – briquettes, scaling
  - At flash valve
  - At slurry cooler – viscosity
Washing

• Necessary to reduce acid requirement for pretreatment

• Previous experiments show an increase in yield with feedstock washing with significant improvement on xylan conversions.

• Frees sugar from feedstock so not degraded in pretreatment
  • If recovered; not easy for non-collocated plant
  • Water used as cook water in starch plant providing benefit
  • Samples showed trace amounts of sugar loss during washing.

• Ion levels in the water fluctuated as a result of using recycled water as well as removing dirt and debris from the feedstock.

• Wash water solids showed less than 1% across the batches.
Feedstock [Non]-Agnosticism

- Feedstocks process differently
  - Switchgrass = floaters; difficult to wet thoroughly → poorer washing
  - Energy Sorghum = sinkers; difficult to maintain %TS into front-end
Water Sources and Recycling

<table>
<thead>
<tr>
<th>Gen2 process</th>
<th>Source</th>
<th>Process upset scenario</th>
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</thead>
<tbody>
<tr>
<td>pretreatment</td>
<td>syrup evaporator condensate (cook water)</td>
<td>ethanol if dropping alcohol in beer bottoms</td>
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<tr>
<td>feedstock washing</td>
<td>sugar evaporator condensate</td>
<td>sugar from foaming event</td>
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<td>methanator effluent (cook water)</td>
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<td>CO2 scrubber bottoms (cook water)</td>
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Syrup Evaporators

Pilot Methanator
Remaining Needs

- **Storage**
  - Improved storage stability
  - FIFO feedstock supply
    - Avoid year to year carryover
    - Rotating harvests throughout year?
  - Can storage time be used to make it better?
    - pretreat/ensile
    - Destoning
    - washing

- **Harvesting**
  - Single pass for ag wastes
  - Wet field harvest solution?
  - Reduced tramp

- **Milling**
  - Pelleting, et al, to allow for silo storage and bulk transport instead of bales
  - If a blended feedstock, milling that gives higher consistency downstream

- **Washing/Wetting**
  - Remove ash from process without adding a huge water load to plant

- **Quality consistency; too difficult for a plant to have to be shifting pretreatment with varying input composition**
ICM Low Solids Approach

**Low Solids**
- Superior heat and chemical transfer
- Precise temperature control
- Low complexity equipment

**Process robustness**
- Low enzyme requirements/high yields

**Disadvantages**
- Contamination pressure
- Water and energy integration
- Larger equipment
- Boiler demand

**Process Requirements**
- S/L separation & sugar evaporation
- Co-location

**Process Accommodates**
- Feedstock washing
- Diversified co-products
Process Scale - Fouling

Energy Sorghum  Switchgrass  Cleaning Considerations
### Process Scale

- Process areas range from highly organic to highly inorganic scale

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<th>Sample ID</th>
<th>Batch ID</th>
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<th>ICP (ppm) Al</th>
<th>ICP (ppm) Ca</th>
<th>ICP (ppm) Mg</th>
<th>ICP (ppm) P</th>
<th>ICP (ppm) S</th>
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