Progress on developing value-added uses for distillers grains: current and evolving opportunities

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Progress on developing value-added uses for distillers grains: current and evolving opportunities

Abstract
This presentation is on recent developments with distillers grains (DG) which are a valuable co-product in the ethanol process.

Disciplines
Agriculture | Bioresource and Agricultural Engineering | Oil, Gas, and Energy

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Progress on Developing Value-Added Uses for Distillers Grains: Current and Evolving Opportunities

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OVERVIEW

1. Ethyl alcohol
2. Coproducts
3. Ongoing research
4. New opportunities
5. Concluding thoughts
ETHYL ALCOHOL
# Ethyl Alcohol – The Fuel of the Future

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1860</td>
<td>Nicholas Otto (b. 1832, d. 1891), a German inventor, used ethanol to fuel an internal combustion engine</td>
</tr>
<tr>
<td>1896</td>
<td>Henry Ford’s (b. 1863, d. 1947) first automobile, the quadricycle, used corn-based ethanol as fuel</td>
</tr>
<tr>
<td>1908</td>
<td>Hart-Parr Company (Charles City, IA) manufactured tractors that could use ethanol as a fuel</td>
</tr>
<tr>
<td>1918</td>
<td>World War I caused increased need for fuel, including ethanol; demand for ethanol reached nearly 60 million gal/year</td>
</tr>
<tr>
<td>1940</td>
<td>The U.S. Army constructed and operated a fuel ethanol plant in Omaha, NE</td>
</tr>
</tbody>
</table>

Ethanol was extensively used as a motor fuel additive prior to the end of World War II (ca. 1933).
The first distillation column for the production of fuel ethanol was invented by Dennis and Dave Vander Griend at South Dakota State University in 1978/1979.
DDGS Historically

• Many people have asked what the fuel ethanol industry is going to do about the growing piles of non-fermented leftovers

  – “Grain distillers have developed equipment and an attractive market for their recovered grains” (Boruff, 1947)
  – “Distillers are recovering, drying, and marketing their destarched grain stillage as distillers dried grains and dried solubles” (Boruff, 1952)

• This question has been around for quite some time, and it also appears that a viable solution had already been developed as far back as the 1940s
DDGS Historically

• In the 1940s / 1950s
  - 17 lb (7.7 kg) of distillers feed was produced for every 1 bu (56 lb; 25.4 kg) of grain that was processed into ethanol
    • Similar to today
  - But over 700 gal (2650 L) of water was required to produce this feed (Boruff, 1947; Boruff, 1952; Boruff et al., 1943)
    • vs. < 4 gal. of water today
Growth of U.S. fuel ethanol industry

Feb. 2011: 204 plants, 13,771 Mg/y
RFS: 15,000 Mg/y of biofuel by 2015
Since 1950s, generally 5 to 9% of total U.S. energy supply has been renewable

US EIA, 2011
COPRODUCTS
ETHANOL COPRODUCTS

Distillers Dried Grains with Solubles

Condensed Distillers Solubles

Distillers Wet Grains
COPRODUCT PRICES

![Graph showing DDGS Price Relative to (%)]
COPRODUCT VALUES

![Graph showing price variations over time for SBM, DDGS, and Corn across different dates from January 2011 to November 2011.]
COPRODUCT VALUES

![Graph showing the values of ethanol, DDGS, and DDGS value as a percentage of total revenue from October 2009 to December 2011. The x-axis represents the dates, and the y-axes represent the value in dollars per bushel and the DDGS value as a percentage of total revenue. The graph illustrates the fluctuations in values over time.]
COPRODUCT RESEARCH

- As ethanol industry grows, supply of coproducts will grow

- Balance = key to sustainability
ONGOING RESEARCH
ONGOING RESEARCH

- Fuel
  - vs.
- Food
  - vs.
- Feed
  - vs.
- Plastics
  - vs.
- Chemicals
  - vs.
- Other uses

**Goals:**
- Augment current uses
- Develop new market opportunities
- Develop/optimize processes and products
- Improve sustainability

**Context:**
- Application of physics and chemistry to biological systems
- Manufacturing with biological polymers: proteins, fibers, lipids
ONGOING RESEARCH

• Material handling
• Pelleting/densification
• Aquaculture
• Human foods
• Plastic composites
<table>
<thead>
<tr>
<th>Sieve Opening Size (mm)</th>
<th>Scale bar</th>
<th>Scale bar</th>
<th>Scale bar</th>
<th>Scale bar</th>
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<tbody>
<tr>
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<td>3.91 mm</td>
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</tr>
<tr>
<td>0.210</td>
<td>0.26 mm</td>
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</tr>
</tbody>
</table>
MATERIAL HANDLING
z = a + bx + cy

x = AoR (°)
y = HR (-)
z = MFR (g/min)

R² = 0.99
Error= 2.42

MFR < 100 = Poor Flow
100 < MFR < 120 = Fair Flow
MFR > 120 = Good Flow
z = a + b/x + cy

x = AoR (°)
y = HR (-)
z = Moisture content (% db)

R^2 = 0.71
Error = 4.50

Moisture < 9.9 (Good Flow)
9.9 < Moisture < 17.5 (Fair Flow)
17.5 > Moisture (Poor Flow)
PELLETING/DENSIFICATION

Current process used in industry

Dryer

Conveyor

Storage

Conveyor

Loadout

New pelleting process proposed by this study

Steam

Storage

Loadout
# PELLETING/DENSIFICATION

<table>
<thead>
<tr>
<th>Mag. x</th>
<th>DDGS</th>
<th>Mfg A</th>
<th>Mfg B</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td><img src="image1.png" alt="Image" /></td>
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<tr>
<td>200</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Resulting slack costs and costs of pelleting for each rail car due to differing DDGS sales prices and annualized pelleting cost
a) breakeven occurs at points of intersection
PELLETING/DENSIFICATION

Resulting slack costs and costs of pelleting for each rail car due to differing DDGS sales prices and annualized pelleting cost

b) magnification of the intersections clearly shows the proportion of DDGS which needs to be pelleted to achieve breakeven
Percent of DDGS pelleted, $p$ (%), required to achieve breakeven increases as both DDGS Sales Price, $s$ ($/ton), and Pelleting Cost, $Cop$ ($/ton), increase.