Biorefinery 1

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Oil Recovery and Refinement from Dry Grind Fuel Ethanol Facilities
Agenda

- Oil recovery economics
- Front end vs back end recovery
- Oil recovery systems
  - Disc stack system
  - Horizontal bowl
- Challenges in oil recovery
  - Density separation
  - Emulsion
  - Suspended solids
  - Intermediate density germ material
- Oil refinement
  - Removal of FFA, waxes and moisture
  - FFA for use as animal nutrition
Oil extraction for enhanced revenue

- Oil vs DDGS value
  - Oil = $0.26/lb
  - DDGS = $0.07/lb ($140/ton)

- Opportunity respecting market
  - 0.7 lbs oil = $0.18/bu
  - 16.3 lbs DDGS = $1.14
  - Total with extraction = $1.32/bu vs $1.19/bu
  - $0.13 * 38 million bu = $4.9 million/year
Front End vs Back End Recovery

- Centrifugal extraction is a reasonable commercial option
  - Slurry extraction
    - One commercial application to date
    - Very large amount of liquid to treat at very low oil concentration
    - \(0.33 \times 0.04 = 0.0132 = 1.3\%\) oil by volume
  - Syrup extraction
    - Method is commercial with different technologies applied
    - Approximately 1/10 the liquid volume to process
    - \(0.30 \times 0.2 = 0.06 = 6\%\) oil by volume
Oil Recovery Centrifuges

- Disc stack centrifuge
  - High g-force potential
  - Need to run “shot” type machine
    - Loss during the purge cycle
    - System out of balance for a brief period of time
    - Cleaning of stack problematic
- Horizontal bowl (tricanter)
  - Lower g-force potential
  - Continuous recovery of oil
  - Can “optimize” the weir skimmer setting
- Both systems challenged with buoyant suspended solids
Buoyant Solids Removal

- Buoyant solids
  - Small germ particles still containing oil
  - Collect at water/oil interface
  - Impede weir placement and oil recovery
- New system to screen solids out of feed
  - Screen syrup ahead of the oil recovery centrifuge
  - Solids are returned to de-fatted syrup
Oil Recovery Technical Challenges

- **Centrifugal extraction from syrup stream**
  - Syrup stream taken out of process at “proper” density
  - Steady control of density important for best recovery
- **Suspended solids inhibit oil extraction**
  - Higher suspended solids concentration = lower oil recovery
    - Slow migration of oil through aqueous phase
  - Oil gets trapped in suspended solids
    - Absorb oil like a “sponge”
    - Practical maximum is 85% oil recovery from syrup
    - Recovery above 70% is upper class performance
  - Viscosity too high for oil to rise through solids
...Technical Challenges

- Emulsification of oil a significant problem
  - Emulsion between water + oil + proteins
  - Emulsion that contains starch is harder to break
  - Emulsion stability and quantity varies significantly
  - Lower temperature evaporation makes stronger emulsion

- Methods for breaking emulsions
  - Heating emulsion to high temperature can break emulsion
  - Chemical additive to break the emulsion
    - Demulsifying chemical
    - Disrupt natural emulsifying agent
      - Not very effective on starch based emulsion
  - pH adjustment (expensive, not practical)
  - Chemical “free” methods of breaking emulsion
    - Ethanol to dissolve emulsifier into water phase
      - Most aggressive process, works on almost all emulsions
Emulsion Reduces Recovery

Oil Lbs/Bu. Projection @ 100% of Available Flow

- Base Free Oil
- Total Oil Content
- Advanced Oil Separation
- DDGS Quality "Theoretical" Max

0.36
0.34
0.42
0.43
0.18
0.75
0.86
0.83
0.93
0.81
0.57
0.65
0.62
0.70
0.61
0.36
0.34
0.42
0.43
0.18
Traditional Corn Oil Refining
Traditional Corn Oil Refining

1. **Flaking**
2. **Conditioning**
3. **Pressing**
   - Press Cake
   - Hexane
4. **Extracting**
   - Merci
   - Evaporating
   - Crude Corn Oil
5. **Filtering**
6. **Alkali Refining**
7. **Centrifuging**
8. **Washing**
9. **Vacuum Drying**
10. **Bleaching**
    - Bleaching Earth
    - Spent Bleaching Earth
11. **Filtering**
12. **Winterizing**
13. **Polishing**
    - Deodorizer Distillate
    - Deodorizer Distillate (flavor, odor, color, free fatty acids)
14. **Hydrogenating**
    - Catalyst
    - Bleaching Earth
15. **Post Bleaching**
    - Spent Bleaching Earth
16. **Polishing**

**Products**
- **Germ Meal**
- **Soapstock**
- **Salad & Cooking Oil**
- **Hydrogenated Oil**

**Inputs**
- **Corn Germ**
- **Crude Corn Oil**
Traditional Corn Oil Refining

Crude Corn Oil

FILTERING

Alkali

ALKALI REFINING

CENTRIFUGING

Soapstock (free fatty Acids, phosphatides, color)

Water

WASHING

Wash Water (residual soapstock)

CENTRIFUGING

VACUUM DRYING

Moisture

Bleaching Earth

BLEACHING

FILTERING

Spent Bleaching Earth

HYDROGENATING

Catalyst

FILTERING

WINTERIZING

Bleaching Earth

FILTERING

Wax

DEODORIZING

Deodorizer Distillate (flavor, odor, color, free fatty acids)

FILTERING

POLISH FILTERING

Salad and Cooking Oils

Salad & Cooking Oil

Hydrogenated Oil (base stock for margarine)
Post-Treatment of DCO
“High Quality” DCO

- Process removes waxes, free fatty acids, moisture from oil
  - Approximately 2/3 of traditional refining process implemented
- Product “competes” with soybean oil
  - Excellent for biodiesel process
    - No FFA to interfere with transesterification
  - Can be used as cooking oil?
- Free fatty acids
  - Soap stock not needed in industry
  - Animal nutrition can benefit from free fatty acids
Conclusions

- Oil recovery is a “necessary” part of dry grind ethanol
  - Potential $5 million additional revenue for 100 MMGY facility
- Many technical challenges have been overcome
  - Buoyant solids
  - Emulsions
- New direction is high quality DCO
  - Properties similar to soybean oil
  - Low FFA
  - Low moisture
  - Low waxes
References

- Oil recovery from syrup - US patent application 2008/0110577

- Buoyant solids recover - WO 2013/066885 A1

- Emulsion breaking by demulsifier - US 8,841,469 B2; US 8,962,059 B1

- Emulsion breaking with ethanol - US 8,192,627 B2

- Traditional corn oil refining - http://www.ccur.iastate.edu/samplecards/cereals/130.pdf

Questions

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