The use of efficient heat transfer equipment is an essential requirement for the maximized recovery of low grade energy that is available in a crushing plant. The plate exchanger technology for use in bulk solids lends itself to this purpose by allowing for a larger heat transfer area without requiring a larger footprint or space. The paper explores the science behind accurate thermal modeling that is required to achieve an accurate temperature profile for the beans and/or seeds passing through a bank of heat exchanger plates. A heat transfer model in a slow moving bed of bulk solids requires a three dimensional Fourier series calculation based on thermal conductivity. It differs vastly from conventional use of U values to evaluate heat exchanger performance. The paper discusses options to quantify the overall energy savings in operating a soybean crushing plant by utilizing new sources of low grade waste heat or even improving the efficiency of waste heat recovering systems in place. The paper will also cover a comparison with traditional equipment used as pre-heaters and conditioners in an oilseed crush plant.
UTILISATION OF PLATE TECHNOLOGY IN OILSEEDS PREPARATION PLANTS FOR MAXIMIZED ENERGY RECOVERY

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Calgary, AB, Canada
Topics

1. Soybean Processing – Conventional Technologies for Drying/conditioning

2. Indirect Heat Transfer
   a) Efficiency comparison
   b) Design features
   c) Waste heat recovery options

3. Hot De-hulling & Cold De-hulling – Energy savings

4. Plate Heat Exchanger Advantage Summary

4. Questions
Soybean Processing

Cold Dehulling

- Bean Cleaning
- Drying / Cooling / Tempering
- Cracking
- Dehulling
- Conditioning
- Flaking
- Extraction

Hot Dehulling

- Bean Cleaning
- Conditioning
- Partial Cracking
- Dehulling
- Cracking
- Dehulling
- Flaking
- Extraction

Hulls
Conventional Technologies

- Direct Air Drying
- Fluid Bed Drying
- Rotary Drum Drying
- Others
  - Flash Drying
Conventional Technologies

PRINCIPLE OF OPERATION
• Blow hot air across the product
Conventional Technologies

HOW IT WORKS:
1. Unsaturated air has moisture carrying capacity
2. Hot air has greater moisture carrying capacity
3. Blowing hot air across product serves two purposes:
   a) *Heats the product*
   b) *Removes moisture from product*

Typical efficiency: 30-65%

Simple. Yet highly inefficient.
Conventional Technologies

INHERENT INEFFICIENCIES

1. Typical efficiency: 30-65%
2. Requires processing of very large quantities of air
3. Results in high stack losses
4. Larger fans are required
5. High power consumption
Solution – Indirect Heat

Thermal efficiency >90%

Efficient heat recovery

Dramatically increases the moisture carrying capacity of the air.

Minimizes the required air for moisture removal.

Temperature Profile through Exchanger
Plate Heat Exchangers for Solids

**Level Control**
Maintains product level above the plate bank
Models available to suit the application

**Vertical Plates**
Satisfy the required surface area for heat exchange
Can be accessed/removed/replaced individually

**Discharge Feeder**
Maintain mass flow of the product
Models available to suit the application
Plate Heat Exchangers - Efficiency

- Direct Air Heating
  35-65 % efficiency

- Plate Heat Exchangers
  > 90 % efficiency
Plate Technology Makes the Use of Low Grade Heat Possible

- Increased the heat transfer surface area

**PLATES**
Heat transfer surface area: **50m²**
per 1m³ of volume.

**TUBES**
Heat transfer surface area: **24.5m²**
per 1m³ of volume.
Conditioner With Energy Recovery

Preheating section

Drying section

- HOT WATER IN
- STEAM IN
- AIR IN
- CONDESATE
- COOL WATER OUT

RECOVERED ENERGY

PRODUCT OUT
Plate Heat Exchangers - Efficiency

Advantages

1. Product is heated indirectly

2. Air acts only as the carrying medium to remove moisture

(only a small amount of air is required)
Plate Heat Exchangers - Efficiency Advantages

Psychrometric Chart
High Temperature (SI Units)

1. Ambient Air
2. Heated Air
3. Saturation Point of Air with Conventional Dryer
4. Saturation Point of Air with Solex Dryer/Conditioner

Moisture Carrying Capacity
- 0.044 gm/kg
- 0.015 gm/kg
- 0.008 gm/kg

10% Relative Humidity
20%
40%
60%
80%
100%
120%

Dry Bulb Temperature (°C)
## Energy Savings

### Cold Dehulling

- Bean Cleaning
- Drying / Cooling / Tempering
- Cracking
- Dehulling
- Conditioning
- Flaking
- Extraction

<table>
<thead>
<tr>
<th></th>
<th>Drying &amp; Conditioning</th>
<th>Extraction</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2000 TPD</strong></td>
<td>15°C, 9%</td>
<td>65°C, 8.5%</td>
<td></td>
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<tr>
<td><strong>5300 KW-H</strong></td>
<td></td>
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<tr>
<td>Conventional Technology</td>
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<td></td>
<td></td>
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<tr>
<td>65 % Efficiency</td>
<td></td>
<td></td>
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<tr>
<td><strong>1500 KW-H</strong></td>
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</table>

**Recoverd waste energy**

**ENERGY SAVING**

- 3450 KW-H
- or 11.2 MBtu/Hr

- 535,000 $/yr
- @$6/MBtu
Energy Savings

Hot Dehulling

- Bean Cleaning
- Conditioning
- Partial Cracking
- Dehulling
- Cracking
- Dehulling
- Flaking
- Extraction

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<tr>
<td>2000 TPD 15C, 11%</td>
<td>65C, 8%</td>
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</tbody>
</table>

- Conventional Technology
  - 65% Efficiency
- Solex Dryer
  - 90% Efficiency

Recovered waste energy

- 7500 KW-H
- 1500 KW-H

ENERGY SAVING

- 4500 KW-H
- or 13.8 MBtu/Hr
- 655,000 $/yr
- @$6/MBtu
Flexible Operation

- Run each bank individually on different heat source
- Independent control of Temperature and Moisture
Accessibility

Manifold and Flexible Connections
• Flexible stainless steel hoses allow for thermal expansion
• Individual threaded connections allow for plate removal
• All connections are outside the product stream

Plate banks inspection and Maintenance
• Easy access for cleaning and inspection purposes
• Plates can be individually removed
• Additional doors can be fitted
Reduced Installation, Operational and Maintenance Costs

- Absence of moving parts
- Smaller footprint
- Efficient heat transfer
## Soybean Conditioner Technology Comparison

<table>
<thead>
<tr>
<th>Feature Comparison</th>
<th>Fluid Bed Technology</th>
<th>Rotary Drum</th>
<th>Plate Heat Exchanger</th>
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<tbody>
<tr>
<td>Energy Consumption</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
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<tr>
<td>Installed Capital Cost</td>
<td>High</td>
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<tr>
<td>Maintenance / Wear</td>
<td>High</td>
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<tr>
<td>Modular Construction</td>
<td>Difficult expansion</td>
<td>Difficult expansion</td>
<td>Easy expansion</td>
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<tr>
<td>Compactness</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td>Air Required / Emission</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
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Questions