STATUS of DEVELOPMENT and PROSPECTS of BAGASSE STEAM DRYING

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1963 foundation of IPRO Industrieprojekt GmbH

IPRO is an independent and neutral engineering company for the sugar and food industries

located in
Braunschweig Warsaw, Poland (1999)

IPRO offers its clients worldwide

- Consultation (preparation of projects)
- Design (also for subprojects)
- Basic and detailed engineering
- Project monitoring and cost control

IPRO GmbH currently has a commitment of sixty staff

- Modernization of existing plants
- Design of new plants
• Introduction – Steam drying technology
• Prototype bagasse steam dryer
• Cow Candy steam drying experience
• Application of bagasse steam drying in the sugar industry
• Concluding remarks
Steam drying technology

- Reduced steam consumption
  - Modern German beet factories
    ~170 kg/t beet
- Steam drying technology
  - Late 1980’s development in Europe
  - More than 30 installations drying beet pulp for animal feed
  - Dryer provides 50 % of process steam
  - Beet factory fuel consumption reduced by 30 %
  - Not applied as yet in sugarcane factories
Energy and Material balance of a Steam Dryer for pressed beet pulp
Beet Pulp drying methods

**Energy flows in a factory with conventional high temperature dryer**

**Energy flows in a factory with a steam dryer**

**Water evaporation:**

**Beet sugar plant:**
10 kg/100 kg beet ($w_{DS} = 30 -> 90 \%$; $w_{Marc} = 4,5 \%$)

**By comparison:**

**Cane sugar plant:**
13,3 kg/100 kg cane ($w_{DS} = 50 -> 90 \%$; $w_{Fiber} = 15 \%$)

Scheme for a ~ 11.000 t/d beet plant
Steam drying technology

Adapting beet pulp to bagasse drying

- Beet pulp fluidises homogenously. Bagasse does not.
- Five times the mass flow of fibre when drying bagasse from 50% to 30%.
- Bagasse fibre is abrasive and contains more soil than beet pulp.
- Capital availability is greater in beet factories.
Prototype bagasse steam dryer

- Feed
- Discharge
- Vessel
- Bed
- Actuator
- Wood
- Burner
Prototype bagasse steam dryer

Bed rotation actuator

Plug feeder
Cow Candy Steam Drying experience

Three phases
1. Prototype, single bed dryer 2003 - 2004

Results
• Relatively minor but time consuming changes to dryer mechanical systems and material handling at all stages.
  • Modified leveller in the carrier to handle short-cut stalks, tops and trash
  • Changes to transition points in screw conveyors
  • Screen, carousel and drop zone improvements in the dryer
  • Rotary valve discharge from the dryer and buffer storage of product was not fit for purpose
• Plant capacity in 2011 was constrained by product handling
• Front-end operation (to product buffer store) operated reliably and could be controlled effectively by one operator. Product moisture content was stable at <10%
• Preliminary CFD and lumped parameter modelling were validated by plant data
The Biodry Concept

- **Bolt-on**
  - Extension of milling tandem
  - Operates in sync with crushing

- **Viable with no changes to normal milling or processing**
  - Excess bagasse generated by more efficient combustion
  - Compatible with drive replacement and steam consumption reduction

- **More effective than drying using boiler flue gas**
  - Air-heaters & economisers preferred & compatible with steam drying
Cow Candy Steam Drying experience
Cow Candy Steam Drying experience

**Harvest & Transport**

Energy for drying; combustion gas from coal

**Crush**

**Cane Pulp to Dryer**

**Syrup to Dryer**

**Juice to Evaporators**

**Steam to Evaporators**

Fibre + Syrup dried to <12% mc to packaging & transport

Steam drying of bagasse
Cow Candy Steam Drying experience

- Feed
- Carousel Drives
- Electrical Fan
- Flue gases from Combustor
- Vent (Waste) Steam
- Steam to Evaporators

Product
Cow Candy Steam Drying experience
Cow Candy Steam Drying experience
Cow Candy Conclusions

Challenges

• Greenfield development in a sensitive, coastal environment
• Processing of short-chop, stalks, tops and trash
• Novel process to produce a novel product
• Three fold increase in energy costs (coal and electricity) in nine years
• Low export prices due to high exchange rate
• High labour and construction costs in Australia

Conclusions

• Excellent prospects for niche production of animal feed in strategically located, sugarcane factories
• Project risks are significantly reduced by integration of a superheated steam dryer in a sugarcane factory to enhance energy production
• Drying capacity will be enhanced by more streamline steam flow, better use of the dryer envelope (more beds) and optimised residence times (carousel speeds)
• Finely divided bagasse will dry faster than the “chunky” pieces of stalk in CowCandy
• Bagasse can be reliably and efficiently dried to 10 % to increase its value for energy production in direct combustion or by further thermal processing.
Use of Bagasse Steam Drying

- Improvement of the gross calorific value (GCV)
- Improvement of boiler efficiency on GCV basis
- Increase in steam production
- No air emissions from drying!
- Reduced danger of bagasse ignition compared to flue gas dryers
- Increased power production
# Impact on steam boiler performance

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No drying</td>
<td>Flue gas drying</td>
<td>Steam drying</td>
</tr>
<tr>
<td><strong>Bagasse moisture</strong></td>
<td>%</td>
<td>50</td>
<td>42,5</td>
</tr>
<tr>
<td><strong>Energy lost from water in flue gas</strong></td>
<td>%</td>
<td>22,6</td>
<td>18,9</td>
</tr>
<tr>
<td><strong>Energy lost dry flue gas</strong></td>
<td>%</td>
<td>5,21</td>
<td>5,20</td>
</tr>
<tr>
<td><strong>Unburnt carbon losses</strong></td>
<td>%</td>
<td>2,5</td>
<td>2,5</td>
</tr>
<tr>
<td><strong>Radiation losses</strong></td>
<td>%</td>
<td>0,3</td>
<td>0,3</td>
</tr>
<tr>
<td><strong>Other losses</strong></td>
<td>%</td>
<td>0,4</td>
<td>0,4</td>
</tr>
<tr>
<td><strong>Gross calorific value</strong></td>
<td>kJ/kg</td>
<td>9.583</td>
<td>11.029</td>
</tr>
<tr>
<td><strong>Total steam generated</strong></td>
<td>t/h</td>
<td>148</td>
<td>156 (+ 5,5 %)</td>
</tr>
<tr>
<td><strong>Boiler eff. (GCV)</strong></td>
<td>%</td>
<td>~ 69</td>
<td>~ 72,7</td>
</tr>
</tbody>
</table>
Integration of bagasse steam drying

Boiler
175 t/h
10 900 kPa
535 °C

175

36.8

62.4
1100 kPa

56.5
12 kPa

Turbo-generator
33.4 MW

Condenser

54.5
200 kPa

54.7
200 kPa

Evaporation I. Effect

1.5

7.9

Deaerator

Condensate Heater

5.4

0.3

Mass quantities in t/h

Bagasse

Steam Dryer

123.2

68.5

Storage

31.7

Crushing rate : 10 000 t/d
416.7 t/h

Crop operation : 180 d/a

Electricity generation : 33.4 MW
Electricity demand : 10.8 MW
Surplus electricity generation : 22.6 MW
Sale of electricity during crop : 94 521 MWh/a
## Results of steam dryer integration

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1 No drying</th>
<th>Scenario 3 Steam dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total bagasse produced</strong></td>
<td>t 532,354 (at 50 % moisture)</td>
<td>t 295,834 (at 10 % moisture)</td>
</tr>
<tr>
<td>Bagasse for stops &amp; losses</td>
<td>t 15 971 (~3 %)</td>
<td>t 4 438 (1.5 %)</td>
</tr>
<tr>
<td>Excess bagasse for off-crop</td>
<td>t 238,357</td>
<td>t 132,833</td>
</tr>
<tr>
<td>operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual sugar production (pure sucrose)</strong></td>
<td>t 229,626</td>
<td>t 229,626</td>
</tr>
<tr>
<td><strong>Process steam on cane (during crop)</strong></td>
<td>% 26.7</td>
<td>% 26.3</td>
</tr>
<tr>
<td>Live steam on cane (crop)</td>
<td>% 34.8</td>
<td>% 42</td>
</tr>
<tr>
<td>Live steam (off-crop)</td>
<td>t/h 144.8</td>
<td>t/h 175</td>
</tr>
<tr>
<td><strong>Power production (crop)</strong></td>
<td>MW 29.13</td>
<td>MW 33.39</td>
</tr>
<tr>
<td><strong>Power production (off-crop)</strong></td>
<td>MW 40</td>
<td>MW 47.24</td>
</tr>
<tr>
<td><strong>Power consumption (crop)</strong></td>
<td>MW 8.33</td>
<td>MW 10.83</td>
</tr>
<tr>
<td><strong>Power consumption (off-crop)</strong></td>
<td>MW ~ 2</td>
<td>MW ~ 2</td>
</tr>
<tr>
<td><strong>Power export (crop)</strong></td>
<td>MWh 87,146</td>
<td>MWh 94,521</td>
</tr>
<tr>
<td><strong>Power export (off-crop)</strong></td>
<td>MWh 132,717</td>
<td>MWh 157,985</td>
</tr>
<tr>
<td><strong>Total annual power export</strong></td>
<td>MWh 219,863</td>
<td>MWh 252,507</td>
</tr>
<tr>
<td><strong>Specific total power export</strong></td>
<td>kWh/t cane 122</td>
<td>kWh/t cane 140</td>
</tr>
</tbody>
</table>
## Viability of bagasse steam drying

<table>
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<tr>
<th>Factor</th>
<th>Comments</th>
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</thead>
</table>
| Electricity  | • Price for delivery to grid >$80/MWh  
• Suitable offtake agreement  
  • Duration  
  • Payment terms |
| Investment   | • <$10Million extra for dryer  
• No difference in boiler/STG capex and bagasse storage  
  • Payback less than 5 years |
| Risks        | • Drying capacity – mitigated by upgrading elements of the “standard” vessel  
• Reliability – minimised by having two dryers and store of dry bagasse  
• Integration – requires proven engineering expertise  
• Completion – careful selection of fabricator and installation team with expert supervision |

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1 = New boiler for burning dry bagasse should cost less than a new boiler burning bagasse at 50% moisture. The steam turbine generator (STG) for the dryer installation will be slightly more expensive with extraction at 11bar. Storage of dry bagasse is suited for high density baling. Capex and opex for baling will be offset by a significant reduction in storage space and reduced risk of fire compared to storage of mill-run bagasse in bulk piles.
### Pros and Cons of bagasse drying

#### Bagasse steam drying

<table>
<thead>
<tr>
<th>Pro</th>
<th>Con</th>
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<tbody>
<tr>
<td>Improvement of boiler efficiency on GCV basis</td>
<td>Feeding and discharge of the steam dryer and boiler is tricky</td>
</tr>
<tr>
<td>Increased steam and power production</td>
<td>Baling of the dry bagasse required to avoid losses</td>
</tr>
<tr>
<td>No air emissions for drying</td>
<td>Boilers have to be modified for burning low moisture bagasse</td>
</tr>
<tr>
<td>Reduced danger of bagasse ignition compared to flue gas dryers</td>
<td>Investment costs relatively high</td>
</tr>
</tbody>
</table>
Concluding remarks

- The GCV of bagasse can be increased by approx. 80%.
- Boiler efficiency (GCV) can increase up to 15% \((\eta \sim 69 \rightarrow 84\%)\).
- Bagasse steam drying is another development step towards maximum power export to 140 kWh/t cane.
- Steam drying is an intermediate step for applying gasification.
- Steam drying is an environmental friendly technology.
- Considering a worldwide cane production of 1.200 Mio t cane/year approx. 168 TWh/year of “green” power could be exported by cane sugar factories!
THANK YOU!

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