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Decanter Centrifuges in the Sugar Industry.

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Broadbent Centrifuges.

www.broadbent.co.uk
www.decanter.uk.com
www.centrifugals.com
Decanter Centrifuges in the Sugar Industry.

Contents:

• Decanter types, application and principles of operation.
• Typical process performance.
• Sugar applications.
  • Beet
  • Cane
    • Comparisons: Decanter - RVF.
    • Process summary & discussion.
    • Future work.
Decanter Centrifuges - applications & types.

- **Solid bowl decanters.**
- Screen bowl decanters.
- Three phase decanters.
- Options include:
  - Fume tight decanters.
  - Fully sealed pressure decanters.
  - Variety of materials of construction.
  - Abrasion resistance.
  - Variable scrolling speeds.
- **Industrial applications for decanters span a wide range of industries including:**
  - Plastics (ABS, PTA, PVC, HDPE, BPA etc)
  - Minerals (Coal, Potash, Borax)
  - Chemicals, Chemical effluents, Municipal effluents.
  - **In the sugar beet and cane industries.**
Decanter Centrifuges – solid bowl type.

Principle of operation.

- Solid / liquid slurry feed.
- Driven pulley.
- Epicyclic gearbox.
- Conical bowl or 'Beach'.
- Conveyer
- Liquid discharge.
- Solid discharge.
- Main bearing.
- 1 of 2
- Decanter casing.
- Decanter bowl.
- Decanter bowl.
Decanter Centrifuges.

Decanters: Sedimentation, not filtration.

- Filtration (RVF, Belt press, Plate & Frame etc) ....
  - Most of the liquor flows through the cake. The majority of the fines are captured as they pass through the cake.
- Sedimentation (Decanter) ....
  - None of the liquor flows through the cake. The liquor overflows and tends to carry fines with it.
Decanter Centrifuges.
Cake dryness and solids recovery.

• For most decanters applications cake dryness and/or solids recovery are generally the important parameters.

• Cake dryness is fixed primarily by:
  • particle size & shape.
  • particle porosity.
  • G.
  • time on the dry beach.
  • liquor viscosity.

• Solids recovery / centrate clarity fixed primarily by:
  • SG difference.
  • particle size & shape.
  • liquor residence time.
  • liquor viscosity.
Cake dryness & solids recovery.

- Decanter users normally require dry solids & a good recovery.
- This leads to competing requirements for space in the decanter to maximize both dryness and recovery.
- Designs can be optimized by adjusting:
  - bowl length.
  - ratio of parallel to conical section.
  - angle of conical section.
  - Number of conveyor flights and pitch.
  - Gearbox ratio.
  - Bowl speed.

Settling distance \( \propto \frac{(\text{Density difference}) \times G \times \text{Time} \times (\text{Av Particle size})^2}{(\text{Liquor viscosity})} \)

Cake initial drainage \( \propto \frac{(\text{Av particle size})^2 \times (\text{centrifugal G}) \times (\text{Time at G})}{(\text{Liquor viscosity}) \times (\text{Cake thickness})} \)
Decanter Centrifuges.
Process capabilities and performance.

Typical range of process performance for decanters.....

- Feed slurry 3 - 50% solids W/W.  
- Discharged solids 4 - 80% liquid W/W.  
- Solids recovery 40% - 99.95% W/W.  
- Throughputs 3 - 300 M³/Hr.  
- Rotational speed 500 - 3500 RPM.  
- Centrifugal force 400 - 3000 G.  
- Power consumption 25 - 450 KW.  
- Feed temperature -69°C - 180°C  
- Case pressure. Vacuum - 10 barG

<table>
<thead>
<tr>
<th></th>
<th>Cane mud example</th>
<th>Beet wash example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed slurry</td>
<td>6%</td>
<td>15%</td>
</tr>
<tr>
<td>Discharged solids</td>
<td>72%</td>
<td>50%</td>
</tr>
<tr>
<td>Solids recovery</td>
<td>87%</td>
<td>80%</td>
</tr>
<tr>
<td>Throughputs</td>
<td>1000 G.</td>
<td>500 G.</td>
</tr>
<tr>
<td>Centrifugal force</td>
<td>90°C</td>
<td>20°C</td>
</tr>
<tr>
<td>Power consumption</td>
<td>0 barG</td>
<td>0 barG</td>
</tr>
<tr>
<td>Feed temperature</td>
<td>0 barG</td>
<td>0 barG</td>
</tr>
</tbody>
</table>
Decanter Centrifuges – Sugar applications.

Decanters have been tested and used in a variety of applications within the sugar industry.

- **Beet:**
  - Dewatering soil from beet wash water.
  - De-sweetening carbonitation lime mud.
  - Raw juice pre-treatment.
  - Pond cleaning.

- **Cane:**
  - Cane mud processing.
  - Removing fly ash from flue gas scrubber slurry.
  - De-sweetening phosphate scum.
Dewatering soil from beet wash water (1).

In use in North America .....  

• Decanters used to enhance the 1 'G' separation of beet wash water clarifier and to supplement the capacity of belt press filters.  
• Decanters have been in use for approximately 10 years.  

A reference:  

• *Application of decanter centrifuges in the beet sugar process.*  
Dewatering soil from beet wash water (2).

Water from beet washing plant.

- Sand traps
- Decanter
- Clarifier
- Centrifugal mud pump.
- Floc unit if required.
- Optional settling pond and / or further processing.
- Centrate
- Solids 50% w/w to store / land.

Recovered water returned to beet washing line.

Basic schematic.
Dewatering soil from beet wash water (3).

- After 10 years use and approx 30,000 tons of dry solids removed each year per m/c.
Dewatering soil from beet wash water (4).

- Stackable solids:
  - 50% W/W solids.
  - Per 900x2500 mm decanter:
    Dry solids rate approx 5-10 tph.
    Feed rate 300 USgpm 70 M³/hr.
Dewatering soil from beet wash water (5).

Feed suspended solids against solids recovery.

No flocculant added. G = 500.
(C) Broadbent Ltd.
Dewatering soil from beet wash water (6).

Feed suspended solids against solids recovery.
For various decanter speeds.

No flocculant added. Data collected over 40 day period.
(C) Broadbent Ltd.
Dewatering soil from beet wash water (7).

Typical mass balance.

**FEED + DILUTION**

- Susp solids content %: 11.60
- Flow rate CuM/hr: 38.4
- Flow rate US gpm: 169
- Density / SG: 1.08

**Decanter**

**CENTRATE**

- Susp Solids content %: 3.50
- Density / SG: 1.005

**CAKE**

- Total solids %: 52.9
- Susp solids content %: 51.5
- Solids recovery %: 74.9

**750 x 2250mm solid bowl decanter.**
Balance based on suspended solids. No flocculent added.
Cane mud - Processing clarifier underflow (1).

Cane mud filter station.
Possible problems.

• Sucrose loss in cake.
• Solids recovery - recirculation of fine material.
• Power consumption.
• Water consumption.
• Wear.

Why consider using something other than an RVF?

• Potential benefits.
  • Save bagacillo for the boilers.
  • Less operators / easier automation.
  • Less space required.
  • Lower capital costs.
  • Less invert sugar.

• Possible problems.
Cane mud - Processing clarifier underflow (3).

Decanters tried before in India, Mauritius, Australia ...

Some references:


Cane mud - Processing clarifier underflow (4).

Schematic of mud processing via parallel decanter and RVF streams.
Basic washing in a solid bowl decanter.
Cane mud – Decanter washing (2).

Improvements ....

- Barrier added to route wash into cake.
  - UK patent: 11/049627 / 0402630.8.
Cane mud – Decanter washing (3).

125 USgpm with variable split between wash and dilution.

Dilution drops cake pol from 7.52 to 4.78 (64%), washing drops it to 2.04 (27%)
Comparison RVF / Decanter.
Sugar losses (1).

• How much sugar is lost as pol in cake?

Consider the example of a mud filter station producing 10 Tonnes dry mud per hour. (e.g. 20,000 TCD raw mill)

<table>
<thead>
<tr>
<th></th>
<th>Decanter</th>
<th>RVF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cake moisture %W/W</td>
<td>70%</td>
<td>77.5%</td>
</tr>
<tr>
<td>Cake Pol</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Bagacillo ratio %</td>
<td>0%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Notes:
1) Bagacillo ratio is the dry bagacillo divided by the dry mud.
2) Decanter data is taken from extensive tests on a full scale plant using both decanters and RVFs.
Comparison RVF / Decanter.

Sugar losses (2).
Comparison RVF / Decanter.

Sugar losses (3).

10 T dry mud

5 T dry bagacillo

10 T dry mud
Comparison RVF / Decanter.

Sugar losses (4).

- 23 T water.
  Cake 70% water W/W
- 10 T dry mud
- 52 T water.
  Cake 77.5% water W/W
- 5 T dry bagacillo
- 10 T dry mud
Comparison RVF / Decanter.

Decanter:
- Cake: 33 T/hr
- POL: 3.0%
- Sugar: 1.0T (33x3.0/100)

RVF:
- Cake: 67 T/hr
- POL: 1.5%
- Sugar: 1.0T (67x1.5/100)

Sugar losses (5).
Comparison RVF / Decanter. Sugar losses (6).

Cake pol summary:
• The cake moisture is less from a decanter & there is no bagacillo in the decanter cake. So …
  • for the *same amount of mud solids* the decanter cake volume is about half that of the RVF.
  • for the same *sugar loss* the decanter cake can be twice the POL of the RVF cake.
Comparison RVF / Decanter.
Flocculent use.

**To achieve good solids recovery (>80%) flocculent addition is required.**

- A variety of flocculants have been tried and testing is continuing.
- Dosing is dependent on mud pH with best results when pH > 9.
- Typical dosing rate with the correct pH are from 20-50 ppm.
- Costs are estimated at around US$70k per 165 day crop for a 20,000 tcd mill.
Cane mud: Decanter mass balance (1).

**FEED + DILUTION**
- Susp solids content %: 4.27
- Flow rate CuM/hr: 39.9
- Flow rate US gpm: 175
- Sucrose %: 10.1
- ML dissolved solids %: 13.3
- ML purity: 75.7
- Dilution CuM/hr: 10.3
- Flocculent ppm on feed: 23

**WASH**
- Rate CuM/hr: 20.3

**CENTRATE**
- Susp solids content %: 0.35
- Sucrose %: 6.1
- Cent liquor diss solids %: 7.84
- Cent liquor purity: 77.6

**CAKE**
- Sucrose %: 2.92
- Total solids %: 28.0
- Total moisture %: 72.0
- Susp solids content %: 24.3
- Total solids % sucrose: 10.4
- Sugar recovery %: 95.4
- Solids recovery %: 87.1

Wash + Dilution % feed: 76.7
Cane mud: Decanter mass balance (2).

**FEED + DILUTION**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Susp solids content %</td>
<td>6.45</td>
</tr>
<tr>
<td>Flow rate CuM/hr</td>
<td>51.3</td>
</tr>
<tr>
<td>Flow rate US gpm</td>
<td>225</td>
</tr>
<tr>
<td>Sucrose %</td>
<td>9.7</td>
</tr>
<tr>
<td>ML dissolved solids %</td>
<td>12.9</td>
</tr>
<tr>
<td>ML purity</td>
<td>75.3</td>
</tr>
<tr>
<td>Dilution CuM/hr</td>
<td>7.1</td>
</tr>
<tr>
<td>Flocculent ppm on feed</td>
<td>32</td>
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**CENTRATE**

<table>
<thead>
<tr>
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<th>Value</th>
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<tbody>
<tr>
<td>Susp Solids content %</td>
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</tr>
<tr>
<td>Sucrose %</td>
<td>7.4</td>
</tr>
<tr>
<td>Cent liquor diss solids %</td>
<td>9.44</td>
</tr>
<tr>
<td>Cent liquor purity</td>
<td>78.4</td>
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**WASH**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate CuM/hr</td>
<td>21.4</td>
</tr>
</tbody>
</table>

**CAKE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose %</td>
<td>3.20</td>
</tr>
<tr>
<td>Total solids %</td>
<td>29.4</td>
</tr>
<tr>
<td>Total moisture %</td>
<td>70.7</td>
</tr>
<tr>
<td>Susp solids content %</td>
<td>25.3</td>
</tr>
<tr>
<td>Total solids % sucrose</td>
<td>10.9</td>
</tr>
<tr>
<td>Sugar recovery %</td>
<td>91.2</td>
</tr>
<tr>
<td>Solids recovery %</td>
<td>97.3</td>
</tr>
</tbody>
</table>
Cane mud: Decanter mass balance (3).

**FEED + DILUTION**
- Susp solids content %: 7.33
- Flow rate CuM/hr: 18.9
- Flow rate US gpm: 39.9
- Sucrose %: 10.0
- ML dissolved solids %: 13.1
- ML purity: 76.2
- Dilution CuM/hr: 10.3
- Flocculent ppm on feed: 42

**CENTRATE**
- Susp Solids content %: 2.28
- Sucrose %: 6.1
- Cent liquor diss solids %: 7.66
- Cent liquor purity: 79.4

**CAKE**
- Sucrose %: 2.80
- Total solids %: 26.3
- Total moisture %: 73.7
- Susp solids content %: 22.7
- Total solids % sucrose: 10.7
- Sugar recovery %: 95.0
- Solids recovery %: 51.7

WASH
- Rate CuM/hr: 18.9

Decanter

Wash + Dilution % feed: 73.2
Cane mud: Decanter progress over time ...
Comparison RVF / Decanter. Capacity (1).

Authoritative sources [Ref 1] suggest that:

- As a general standard around 0.6 M² of filter area is required per tonne of cane crushed per hour.
- An improved standard is to provide a mud solids loading (excluding fibre) of 1 t/h per 100 M² of filter area.

How much can a single 900 x 3000mm decanter processes?

Comparison RVF / Decanter. Capacity (2).

Based on site testing in a large raw mill the capacity comparison between RVFs and decanters is:

- **RVFs**: A total filter area of 900 M$^2$ is required to process the underflow of 1000 USgpm.
- **Decanters**: Each decanter is currently processing 175 – 225 USgpm of this feed.
- Between $1,000 / 175 = 5.7$ and $1,000 / 225 = 4.4$ decanters are required to process the 1,000 USgpm of underflow.
- ... so a single decanter is equivalent to an RVF with a filter area of $900 / 4.4 = 204$ M$^2$ to $900 / 5.7 = 158$ M$^2$ (mean 180 M$^2$).
Comparison RVF / Decanter.
Capacity (3).

For a single 900 x 3000mm decanter:
• Operating at a feed rate of 40 M$^3$/h (175 USgpm) and assuming:
  • 6% W/W mud solids in the feed (no bagacillo)
  • 90% suspended solids recovery.

• This is a mud solids output of 40 x 0.06 * 0.9 = 2.67 T/h.
• Which would be equivalent to a filter with an area of 267 M$^2$. 
Comparison RVF / Decanter.
Capacity (4).

Filter is 16’ x 32’
(4.9 x 9.8 M).
Filter area 180 M²
Comparison RVF / Decanter.
Space requirements.

**RVF 180 M² with 4.9 x 9.8 M drum.**
- Assume footprint is +1 M on width and +1.5 M on length.
- Footprint is then 5.9 x 11.5 = 67 M².

**Decanter 900 x 3000 mm.**
- Including frame and case etc dimensions are 3.15 x 5.7 M.
  - Assume footprint is + 1 M on width and +1.5M on length
- Footprint is then 4.15 x 7.2 = 30 M².
Comparison RVF / Decanter. 
Power requirements.

<table>
<thead>
<tr>
<th></th>
<th>Decanter 900 x 3000 mm</th>
<th>RVF (Ref 2) 180 M²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main drive</td>
<td>127 kW</td>
<td>-</td>
</tr>
<tr>
<td>Lubrication pumps</td>
<td>2 kW</td>
<td>-</td>
</tr>
<tr>
<td>Filter drive</td>
<td>-</td>
<td>10 kW</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>-</td>
<td>97 kW</td>
</tr>
<tr>
<td>Bagacillo screen</td>
<td>-</td>
<td>4 kW</td>
</tr>
<tr>
<td>Bagacillo fan</td>
<td>-</td>
<td>20 kW</td>
</tr>
<tr>
<td>Mud mixer</td>
<td>-</td>
<td>2 kW</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>129 kW</strong></td>
<td><strong>133 kW</strong></td>
</tr>
</tbody>
</table>

Note: RVF data is scaled from data in Ref 2 for a 100 M² filter. Factor used 1.5.

**Ref 2:**  
Comparison RVF / Decanter.
Bagacillo / energy saving.

For a 20,000 TCD mill assume:
- Mud solids in the clarifier underflow are 1.5% on cane.
- Bagacillo ratio is 50%.
- ... then the bagacillo usage for 165 day crop is 20,625 tonnes.

Decanter doesn’t require any bagacillo.
- 20,625 tonnes saved.
- Calorific value is 8,300 BTU/Lb. (19,300 MJ/Tonne).
- This is 110,000 MWhrs per 165 day crop.
- Assuming US$0.02 per kWhrs generated and 50% efficiency this is $1.1M per crop.
Comparison RVF / Decanter.

Water consumption.

Water (cake wash + dilution) for the decanter is 10-15% more than the RVF cake wash.

- Decanter wash + dilution is 50 - 75% of feed.
- RVF wash is around 150% on filter cake.

For example, a 20,000 TCD mill:

- **RVF**: With cake moisture 77.5%, bagacillo ratio 50%. Mud solids in feed 6.5%
  ... then RVF wash consumption is approx 10 M³/h.
- **Decanter**: As above but with cake moisture 70%.
  ... the decanter water consumption is 11.5 M³/h.
Comparison RVF / Decanter.
Other benefits?

**Juice temperature.** The decanter operates at atmospheric pressure so ...

- No cooling effect cause by the RVF vacuum system.
- Reduced juice heating requirements.
- Avoids microbiological losses as liquor remains above 75°C.

**Decanter simple to control.**

- High turndown ratio 3:1.
- Easy automation and detection of solids rate.
- Routine maintenance requires the decanter to be stopped briefly every 6 months.
Comparison RVF / Decanter. Wear & Maintenance (1).

- Feed compartment (1).
- Solids discharge ploughs (6).
- Solids discharge ports (5).
- Conveyor tiles (4).
  - Liquor end.
  - Feed ports (2).
  - Bowl wall radially out from feed ports (3).
  - Conveyor tiles (4).
  - Solids end.

Areas prone to wear.
Comparison RVF / Decanter.
Wear & Maintenance (2).

- Wear:
  - Little wear evident after approx 5000 hours operation.
  - Views show: Conveyor tiles, Feed ports and Solids discharge ports.
Comparison RVF / Decanter.
Future work.

**Development continues, current goals are:**
- Reduce dilution water to near zero.
- Reduce floc consumption to 25ppm max.
- Maintain cake pol below 3.0.
- Investigate higher speed (+20% on G).

**Longer terms other applications will be investigated:**
- Solids removal in diffuser applications where boiler tube wear is an issue.
- Juice centrifugation to speed up clarification and reduce colour formation.
Thank you for your attention.

... any questions?