Case Study 8 – BELT PRESS

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8.1 Description of the System

Belt presses consist of two tensioned porous belts passing over and under various diameter rollers. Thickened sludge (gravity or polymer thickened) is subjected to...
increasing pressure as the belts rotate, squeezing the water out. Most belt presses require a polymer conditioning tank to dose the wastewater and to avoid excessive agitation prior to feeding into the belt press. All belts require appropriate tensioning to provide for three sequential pressure zones (Albertson et al. 1991). These are the gravity-drainage, the low-pressure and the high-pressure zones. The gravity drainage zone concentrates the solids, before the sludge sandwich is formed in the low pressure zone. If a firm sandwich is not produced in the low pressure zone, then the separated solids will fracture under the greater shear force applied in the high pressure zone. A key principle of belt presses is the formation of a firm solids cake to squeeze water through, capturing a greater proportion of the fines in the separated solids.

Sludge mixed with polymer is introduced and is spread evenly across the belt by a levelling baffle. The mixture is conveyed upward through the gravity draining zone. Thickened sludge is trapped between the two screens and is gradually subjected to increasing pressure. Shearing and compression occurs as the sludge travels around rolls of increasing diameter, due to the forces exerted by the independent pneumatic tensioning of both belts. The dewatered sludge is discharged away from the belts, which are scraped and pressure-sprayed before returning to be loaded with further sludge. Mechanical components of the separator include dewatering belts, rollers and bearings, belt tracking and tensioning system, controls and drives, belt washing system, and polymer dosing system (Figure 8-1).

The key features of the TEMA Series 500 Belt Filter Press are claimed to be:

- Automatic operation
- Low power requirements
- High dewatering capacity
- Maximum cake solids
- Proportional tracking
- Six different roll configurations suitable for all dewatering applications
- Belt widths from 0.25 to 3 metres
- Mobile or portable units are available
- Optional systems include polymer dosing, feed and belt wash pumps, conveyors and gravity drainage decks.

8.2 Manufacturer / Distributor

TEMA Engineers Pty. Ltd.
19 Fitzpatrick St
Reevesby NSW 2212

Phone: 02-9792 3555
Facsimile: 02 – 9792 3134
Email: temaeng@ozemail.com.au
Website: www.temaengineers.com
PHOTOGRAPH 8-2 – SOLIDS OUTPUT ONTO CONVEYOR BELT

PHOTOGRAPH 8-3 – BELT PRESS (SIDE VIEW)
8.3 Information Sources

The information presented in this case study is derived from the following sources:

- Manufacturer’s product information (including performance test data)
- Site inspection of units at KR Darling Downs Bacon (Toowoomba, Queensland), Wetalla sewage treatment works (Toowoomba), and Golden Circle Cannery (Northgate, Queensland)
- Pain et al. (1978) - Performance of four wastewater separating machines
- McKenney (Undated) - Dewatering dairy wastewater using polymer and belt press
- Moller et al. (2000) - Solid-liquid separation of livestock wastewater

8.4 Performance Data

8.4.1 Trial data from TEMA Engineers Pty Ltd.

The manufacturer supplied three sets of data. These were collected from commercial installations. No detailed information on the waste streams was given. The dryness of the cake solids increases as the TS concentration of the slurry increases. The rate of polymer usage is relatively consistent across the three very different slurries. No details are given, but presumably the polymer type would differ for the primary (primary sludge and slaughterhouse waste) and secondary wastewaters treated. The attributes of the slaughterhouse slurry would most closely resemble piggery flush water. Gravity thickening prior to the addition of polymer would most likely improve the slaughterhouse results, increasing the TS content of the solids to above 20% (stackable).

<table>
<thead>
<tr>
<th>Slurry characteristics</th>
<th>Polymer/t solids produced</th>
<th>Separator specifications</th>
<th>Effluent characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Flow rate</td>
<td>Belt width (m)</td>
</tr>
<tr>
<td>TS conc. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary sludge 3-5</td>
<td>3 kg/t</td>
<td>na</td>
<td>2.25</td>
</tr>
<tr>
<td>Digested sludge 2-4</td>
<td>4 kg/t</td>
<td>na</td>
<td>1</td>
</tr>
<tr>
<td>Slaughterhouse 0.5</td>
<td>4 kg/t</td>
<td>Na</td>
<td>Na</td>
</tr>
</tbody>
</table>

8.4.2 Pain et al. (1978) – Piggery and dairy wastewaters

Pain et al. (1978) evaluated the use of a prototype flat belt separator for cow and pig wastewaters and slurries containing from 4% to 15% TS. They were evaluating practical devices suitable for use in Britain, comparing the performance of a rotary
screen, vibrating screen, roller press and belt press. The belt press consisted of only one woven mesh belt, passing beneath a pair of spring loaded press rollers. As with the commercial belt presses, the solids in the wastewater form a coating over the surface of the screen. The press rollers squeeze water through the accumulated coating, effectively filtering out particles smaller than the mesh aperture of the screen itself. The TS content of the belt press solids was consistently higher than that of the rotary and vibrating screens, producing a solid that could be stacked with little seepage.

No specific details are given on the influent characteristics or history. The differences between the cow and pig wastewaters are not stated. However, for the flat belt separator, the removal efficiency for cow wastewater was considerably higher than for the piggery wastewater. The belt used for the cow and piggery wastewaters had effective mesh sizes of 1 mm and 0.35 mm respectively. Solids removal efficiencies for the piggery wastewater on a concentration basis ranged from 25-55% for influent concentrations of 4-8%. Solids removal efficiencies for the dairy wastewater on a concentration basis were approximately 65% for influent concentrations of 6-15%. The dairy wastewater contained sand particles. The poorer performance of belt press with the piggery wastewater was most likely due to the lower TS concentration of the wastewater, although the screen aperture used for the piggery wastewater was smaller.

8.4.3  M·Kenney (Undated) - Dairy wastewater

The objective of the study was to provide an economically attractive alternative to extend the radius of organic solids transport from nutrient rich to nutrient poor areas. The equipment used was a low permeability rated belt fitted with a single squeeze roller. Ancillary equipment included a chopper pump to transfer dairy manure from a sump to a stainless steel equalising tank. From here it was dosed with a cationic polyacrylamide polymer pumped into a flocculation tank fitted with a variable-speed, mixing rod.

<table>
<thead>
<tr>
<th>TABLE 8-2 – BELT PRESS PERFORMANCE ON DAIRY MANURE - M·KENNEY (UNDATED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry char.</td>
</tr>
<tr>
<td>TS conc.</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>5.4-8.3% DW-200 polymer</td>
</tr>
<tr>
<td>9.5-17.0 L/hr</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Unfortunately no trials were done in the absence of polymer. The TS concentrations of the slurry are high, suggesting that gravity thickening would not be required. At the rate of polymer applied (218-263 kg of polymer per ton dry solids produced) and the cost of the polymer (US$1.00/kg) chemical costing equated to US$6-7/cow/day. Polymer usage rates are 50 times higher than rates used in the municipal wastewater industry (3.6-4.5 kg/ton), and therefore not cost-effective. The exponentially higher polymer usage suggests that the polymer selection was not necessarily appropriate.
for the dairy wastewater. Data indicate that polymer usage should be of a similar order of magnitude for primary and secondary wastewaters, with the dairy wastewaters most similar to slaughterhouse waste. However, as no testing was done without polymer, conclusions on the compatibility of the polymer and wastewater cannot be drawn.

The solids recovery is very good, and the water content is very low (stackable). Little seepage would be expected during long-distance transport. The very high phosphorus removal rate also suggests that many of the finer particles were retained in the separated solids fraction. The lower nitrogen value (TKN) is as expected, given that a high proportion of nitrogen is in the dissolved phase as ammonia.

8.4.4 Moller et al. (2000) - Piggery wastewater

In this test, the objective was to separate the wastewater into a nutrient-rich, concentrated solid fraction suitable for road transportation. The wastewater was from a dairy and a piggery. Immediately before the test the stored wastewaters were stirred. The solid and liquid fractions of the separated fractions were characterised, and the energy consumption was also measured. No mention is made of either gravity thickening or polymer addition, or the flow rate into the separator.

The TS content of the solid fraction is 15.3% (w.b) and 19.2% (w.b) for the dairy and piggery wastewaters respectively (spadeable, and the piggery solids may be stackable). The equations used in the table are:

\[
E_t = \frac{U \times M_c}{Q \times S_c} \quad E_t = \text{Simple separation efficiency index}
\]

\[
U = \text{Mass of the solid fraction (kg)}
\]

\[
M_c = \text{Concentration of the component (g kg}^{-1}\text{, Dm, TP or TN)}
\]

\[
Q = \text{Amount of slurry treated (kg)}
\]

\[
S_c = \text{Concentration of the component in the slurry (g kg}^{-1}\text{)}
\]

\[
E_t' = \frac{E_t - R_f}{1 - R_f} \quad E_t' = \text{The reduced efficiency index}
\]

\[
R_f = \frac{U}{Q} \text{ solid fraction to total slurry ratio}
\]


<table>
<thead>
<tr>
<th>Waste charac.</th>
<th>Separator specs.</th>
<th>Effluent characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS conc. (%)</td>
<td>Flow rate</td>
<td>Belt filter pore diameter (mm)</td>
</tr>
<tr>
<td>Dairy 7.1 Na 1-2</td>
<td>19.0</td>
<td>TS 15.3</td>
</tr>
<tr>
<td>Piggery 5.7 Na 1-2</td>
<td>17.5</td>
<td>TS 19.2</td>
</tr>
</tbody>
</table>

\textsuperscript{a} RSE – Reduced separation efficiency
The reduced efficiency index is zero when no separation of solids occurs, and 1 when total separation occurs. The belt press removes 50% of the solids, but only 20% of the phosphorus in the piggery wastewater. Most of the phosphorus is in the form of phytate, the major storage component of phosphorus in grains. Pigs lack the enzyme to digest this, excreting it in the fine organic particle fraction of manure. The more complete digestive process in the cow results in less of the solids fraction being removed (29% for TS, and 15% for phosphorus), due to the higher proportion of fine particles.

If the removal efficiency is calculated on the influent and liquid effluent TS concentrations only (the most common figure quoted in papers and industry trial data - see equation below), then the relative performance of the belt press on the two different slurries changes from 50% to 22.5% efficiency for piggery wastewater, and from 29% to 32.4% for the dairy wastewater.

\[
\text{Efficiency} = \left( \frac{\text{TS in slurry} - \text{TS in liquid fraction}}{\text{TS in slurry}} \right) \times 100
\]

The apparent contradiction between the two sets of figures is because the dairy solids have retained a higher proportion of the liquid component of the wastewater, effectively concentrating the TS component in the liquid fraction. Ignoring the relative proportions of the flow in the liquid and solid fractions after separation can produce the contradictory results illustrated above.

### 8.5 Running Costs and Maintenance

Belt presses require a high degree of operator supervision, and operator training. The mechanical components of the separator include dewatering belts, rollers and bearings, belt tracking and tensioning system, controls and drives, belt washing system and polymer dosing system. The performance of primary treatment systems prior to the belt press stage is also a critical determinant of performance. Primary treatment commonly includes the removal of gross solids, and slurry thickening. Routine use of flocculant is essential, normally selected at installation using advice and the results of on-site testing from polymer chemical suppliers.

### 8.6 Practical Operating Issues

A good supply of water is needed for the pressurised spray belt washing unit. Gross solids must also be removed prior to pumping. Maintaining a constant flow rate into the belt press is essential, as is the compatibility of the flocculant and the belt operating speed. The belt press must be under cover.
8.7 Piggery Case Studies

Four piggery case studies have been analysed. These are a 200-sow and a 2000-sow unit operated under low flushing (5 L/SPU/day) and high flushing (25 L/SPU/day) regimes. Capital and operating costs were estimated using data supplied by the manufacturer. It was assumed that power costs $0.13/kWh and labour costs are $25/hr. Table 8-4 provides summarised capital and operating costs. The data shows a wide range of capital and operating costs (per year, per ML treated, per tonne of solids removed) depending on the size and type of piggery operation. These data must be considered preliminary only due to the lack of sound data on solids removal and the lack on on-going operating data at a commercial piggery.

### TABLE 8-4 – CAPITAL AND OPERATING COSTS OF BELT PRESS CASE STUDY

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>200-sow low-flush</th>
<th>200-sow high flush</th>
<th>2000-sow low-flush</th>
<th>2000-sow high flush</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of pigs</td>
<td>SPU</td>
<td>2,134</td>
<td>2,134</td>
<td>21,340</td>
<td>21,340</td>
</tr>
<tr>
<td>Flushing</td>
<td>L/SPU/day</td>
<td>5</td>
<td>25</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Hosing</td>
<td>L/SPU/day</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total effluent a</td>
<td>ML/yr</td>
<td>9</td>
<td>25</td>
<td>85</td>
<td>250</td>
</tr>
<tr>
<td>Effluent flow (24 hr)</td>
<td>L/s</td>
<td>0.27</td>
<td>0.79</td>
<td>2.7</td>
<td>7.9</td>
</tr>
<tr>
<td>Solids content of effluent</td>
<td>% TS</td>
<td>3.1</td>
<td>1.2</td>
<td>3.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Solids</td>
<td>t/yr</td>
<td>270</td>
<td>290</td>
<td>2,800</td>
<td>2,940</td>
</tr>
<tr>
<td>Data – TEMA Belt Press</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flowrate</td>
<td>L/s</td>
<td>2.1</td>
<td>2.1</td>
<td>5.8</td>
<td>11.6</td>
</tr>
<tr>
<td>Operation</td>
<td>Hr/day</td>
<td>3.0</td>
<td>8.9</td>
<td>11.2</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>Hr/yr</td>
<td>1,110</td>
<td>3,240</td>
<td>4,090</td>
<td>5,980</td>
</tr>
<tr>
<td>Solids Removal b</td>
<td>%</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>t/yr</td>
<td>54</td>
<td>29</td>
<td>560</td>
<td>294</td>
</tr>
<tr>
<td>Capital cost c</td>
<td>$</td>
<td>95,000</td>
<td>95,000</td>
<td>143,000</td>
<td>150,000</td>
</tr>
<tr>
<td></td>
<td>$/ML treated/yr</td>
<td>11,140</td>
<td>3,810</td>
<td>1,680</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>$/t solids removed/yr</td>
<td>1,780</td>
<td>3,270</td>
<td>260</td>
<td>510</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>kWHr/yr</td>
<td>15,870</td>
<td>46,390</td>
<td>136,750</td>
<td>208,170</td>
</tr>
<tr>
<td></td>
<td>$/yr (power)</td>
<td>2,060</td>
<td>6,030</td>
<td>17,780</td>
<td>27,060</td>
</tr>
<tr>
<td></td>
<td>Labour hr/day</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>$/yr (labour) d</td>
<td>1,830</td>
<td>1,830</td>
<td>3,650</td>
<td>5,480</td>
</tr>
<tr>
<td></td>
<td>$/yr (main) e</td>
<td>2,000</td>
<td>2,000</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Total</td>
<td>$/yr</td>
<td>5,590</td>
<td>9,860</td>
<td>25,430</td>
<td>36,540</td>
</tr>
<tr>
<td></td>
<td>$/ML treated</td>
<td>690</td>
<td>395</td>
<td>300</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>$/t solids removed</td>
<td>110</td>
<td>340</td>
<td>45</td>
<td>125</td>
</tr>
</tbody>
</table>

a Total effluent includes flushing water, hosing water, manure and drinking water wastage.
b While the manufacturer claims a higher solids removal percentage if the wastewater is thickened, this figure is adopted until better data is available.
c Capital cost includes a shed to cover the press and a manure collection sump with pumps and agitator.
d Labour for monitoring and maintenance costed at $ 25/hr
e Routine maintenance of pumps and agitators
8.8 Summary – Selection Criteria

8.8.1 Solids removed

There is limited data available on the removal efficiencies of belt presses with piggery wastewaters. Pain et al. (1978) found removal efficiencies with an experimental machine of approximately 25% for piggery wastewaters with TS concentrations of 4%. For typical flushed piggery wastewater (1-3%) removal efficiencies are likely to be less than 20%. To improve the performance of belt presses polymer dosing is required prior to separation. The manufacturer recommends polymer dosing to improve the solids separation efficiency and increase the TS concentration of the influent.

8.8.2 Capital cost

From Table 8-4, the capital cost could be $95,000 for a 200-sow piggery and $143,000 to $150,000 for a 2000-sow piggery. This includes the belt press, ancillary equipment, collection sump, agitator and pump. Additional polymer dosing equipment could cost an additional $15,000.

8.8.3 Operating costs

From Table 8-1, the operating costs could range from $400 to $690/ML of effluent treated for the 200-sow case studies and $150 to $300/ML of effluent treated for the 2000-sow case studies. Operating costs per tonne of dry solids removed range from $110 to $340 for a 200 sow piggery and $45 to $125 for a 2000 sow piggery. The lower costs reflect economies of scale with larger piggeries. Belt presses will have higher maintenance requirements that most screens. With thickening of the wastewater prior to belt press treatment, the operating cost per tonne of solids produced would be reduced by lowering the throughput of the machine and improving the solids separation efficiency.

8.8.4 Ease of operation

Belt filter presses require a high level of supervision from trained personnel. The ancillary equipment required to achieve good performance, includes grit and gross solids removal, polymer dosing, variable speed pumps to ensure a constant flow of influent, and a good water supply if an automatic belt washing system is selected. This system is not appropriate for a typical piggery.

8.8.5 Solids management options

The solids produced are stackable, provided that the wastewater is gravity-thickened first and that a compatible polymer is used. The separated solids could be composted with minimal additional bulking material required.
8.9 References


