Proven Sand-Laden Manure Handling & Separation Technologies

A.W. Wedel, P.E., McLanahan Corp. 24 March 2009

What is the value of not handling sand-laden manure?

Sand bedding aside, manure contains grit (i.e. fixed solids)

- 2% on 150 pounds of manure
- 3 pounds FS pcd (per cow per day)
- 1,500 cows and FS @ 100 pcf

15 cu.ft. = 0.6 yd/d = 219 yd/yr!

Current digester projects...

<table>
<thead>
<tr>
<th>Dairy</th>
<th>Location</th>
<th>Herd Size</th>
<th>Start-up Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair Oaks Dairy #2</td>
<td>Fair Oaks, IN</td>
<td>3,500</td>
<td>7/2004</td>
</tr>
<tr>
<td>Green Meadow Farms</td>
<td>Elise, MI</td>
<td>3,800</td>
<td>7/2007</td>
</tr>
<tr>
<td>Central Sands</td>
<td>Nekoosa, WI</td>
<td>3,500</td>
<td>5/2008</td>
</tr>
<tr>
<td>Meadowbrook Dairy</td>
<td>Victorville, CA</td>
<td>2,800</td>
<td>5/2008</td>
</tr>
<tr>
<td>Bridgewater Dairy</td>
<td>Bryan, OH</td>
<td>3,000</td>
<td>9/2008</td>
</tr>
<tr>
<td>Fair Oaks Central</td>
<td>Fair Oaks, IN</td>
<td>10,500</td>
<td>6/2008</td>
</tr>
</tbody>
</table>

"The days of building big dirty dairies are over."

Midwest dairy producer (2009)
Recycled sand can safely be used to bed free stalls on dairy farms. Numbers of gram-negative, bacteria, coliforms, *Klebsiella spp.* and *Streptococcus spp.* are similar for both CS and RS when compared to each other at any time.

*Kristula et al.* (2005)

**Value of recycled sand for 1,500 cows (50+ pcd sand)**

85% RECOVERY

$93,000 per year

95% RECOVERY

$104,000 per year

$11,000 per year additional savings

**Rapid reuse of recycled sand—a cost benefit of separation**
Sand-manure separation systems are proven technology.

Manure handling no longer needs to be seen as a downfall of sand bedding!

Sand-manure separation...the choices

- Wastewater
- Traditional manure handling
- Mining

Traditional sand-laden manure handling

Traditional SLM handling!

What’s the difference?

Custom rate for payloader and operator = $125 per hour (Blair County, PA, 2009)
Q: What does it cost to run a 5 hp motor @ $0.1/KWh?

A: 40 cents per hour

- 10 hp = $1.00 per hour
- 20 hp = $2.00 per hour

Sand-manure handling… the choices

- Wastewater
- Traditional manure handling
- Mining

Sand → Sand system

Manure → Manure system

GMF processed 1,250,000 tons SLM in ten years.

System selection…

- Dilution added (scrape or flush)
- Advanced treatment (digestion, etc.)
- Water available (quality and quantity)
- Sand recovery (quality, quantity, consistency)
- Space
- Climate

Can’t consider separation without understanding of the complete system

- Conveyance method
- Downstream processes
Sand solutions...
- Conveyance to separation systems
- Back to basics—separation mechanisms.
- Successful systems—what it takes.

Advantages...
- No additional odor
- Shallow gutter
- Simple maintenance
- No reliance on recycled water

Horizontal Auger Cross-Section
- Screw flight
- Trough
- Bed of material
- Carry material below hanger bearings to reduce component wear

Horizontal Augers

Horsepower depends on auger length

<table>
<thead>
<tr>
<th>Auger Length (ft)</th>
<th>Required Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>36</td>
<td>5</td>
</tr>
<tr>
<td>48</td>
<td>5</td>
</tr>
<tr>
<td>60</td>
<td>7.5</td>
</tr>
<tr>
<td>72</td>
<td>7.5</td>
</tr>
<tr>
<td>84</td>
<td>10</td>
</tr>
<tr>
<td>96</td>
<td>10</td>
</tr>
<tr>
<td>108</td>
<td>10</td>
</tr>
<tr>
<td>120</td>
<td>15</td>
</tr>
<tr>
<td>132</td>
<td>15</td>
</tr>
<tr>
<td>144</td>
<td>20</td>
</tr>
</tbody>
</table>

At $0.10/KWh:
A 20 hp motor costs $2.00 per hour to run.
Vacuum Tanks

SLM Rule #1…
…do not under any circumstances attempt to gravity undiluted sand-laden manure.

Flume design…
- Channel installed at ¾% minimum.
- 1500+ gpm (40+ hp)
- Achieve 5 fps flow velocity
- Reliable quality water source.
- Topography helps or hinders.

Q: To flume 500 feet on 1% slope, with 2 ft diameter pipe, at what elevation below grade will pipe discharge?
A: 7 feet

Challenges with flume systems?

VOLUME
(1,500+ gpm)

SMS recycled water = 20 to 80 gpm

Q: Cost of pumping 2,000 gpm?
A: $2.00 per hour ($17,500 per year)!

Scenario:
- 4-row barns
- Collect manure at center
- Convey to processing area
Scenario:
- Five 4-row barns
- Collect manure at ends of barn
- Sloping site in one direction to processing area

Scenario:
- 4-row barn
- Gravity flow manure pit across center
- Convey to processing area

Scenario:
- Two 4-row barns (100’ spacing)
- Sloped site
- Collection to common area

Sand-Manure Separation— the mechanisms...
- Sand is held in manure’s gel-like mucosal (sticky) structure.
- Particle density of sand is more than twice that of “raw” manure.

Sand recovery and cleanliness is dependent upon...
- Sand gradation (coarseness/fineness).
- Quality of recycled water.
- Multi-stage storage or solids separation (preferred).

Sand is held in manure’s gel-like mucosal (sticky) structure. Particle density of sand is more than twice that of “raw” manure.

ASTM-C33 concrete sand for most effective separation.

Multi-stage storage or solids separation (preferred).
**Obtaining recycled water...**
- Two stage storage (TS>4%)
- Solids separator and two stage storage (TS<5%)
- Solids separator and closed loop (2-4% TS)
- Digester or other treatment effluent (TS<1%)

**Managing poor quality water. With increased solids (TS>2%)...**
- Decrease separation capacity. At 4% TS, either half capacity or double recycled water flow rate.
  - Substitute quantity for quality.

**Multi-stage storage (with or without LSS)...**
- Most often pump-to.
- Anaerobic decomposition increases viscosity.
- Coordinate water acquisition with storage filling and emptying.

**Closed loop for recycled water <2% TS...**
- Discharged from SMS at 5% TS
  - 30% solids
  - +10 gal/cow

**Challenges with flume systems?**
- **VOLUME (1,500+ gpm)**
- SMS recycled water = 20 to 80 gpm

**Solid Separators in closed loop yield most consistent recycled water.**
- Only variable factor is manure consistency.
Selecting a separation system...
- Low operation and maintenance
- High sand recovery
- Quick reuse of recycled sand
- Weather independent operation
- Less susceptible to poor water quality
- Cost
- Footprint

The options...

Mechanical systems
Gravity systems
Combination

Traditional SLM handling!

What’s the difference?

Value of Sand Inventory for 1,000 cows

<table>
<thead>
<tr>
<th>Days</th>
<th>Inventory</th>
<th>Sand cost ($/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$6.00</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>$450</td>
</tr>
<tr>
<td>5</td>
<td>$750</td>
<td>$1,000</td>
</tr>
<tr>
<td>7</td>
<td>$1,050</td>
<td>$1,400</td>
</tr>
<tr>
<td>10</td>
<td>$1,500</td>
<td>$2,000</td>
</tr>
<tr>
<td>14</td>
<td>$2,100</td>
<td>$2,800</td>
</tr>
<tr>
<td>30</td>
<td>$4,500</td>
<td>$6,000</td>
</tr>
<tr>
<td>60</td>
<td>$9,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>90</td>
<td>$13,500</td>
<td>$18,000</td>
</tr>
<tr>
<td>180</td>
<td>$27,000</td>
<td>$36,000</td>
</tr>
</tbody>
</table>

What can this money be doing for you today?
Flow enters the channel and flows 60 ft down. Sand settles along the length of the channel, and sand-free manure is discharged. Typical settling lane systems (300' x 100' = 30,000 sq.ft.) and settling channel systems (75' x 75' = 5,625 sq.ft.) are shown. Runoff water: 750,000 gallons vs. 141,000 gallons. Rinsed clean sand is shown, along with sand-laden manure in air and recycled water. Sand-laden manure is discharged from a manure discharge system.
Water added vs. sand removed

**Fresh water added**
- 1-2 gal/cow-day

**Sand removed**
- 3-4 gal/cow-day (45 lb sand/cow-day)

Net volume reduction.

System performance at FOD...

**Recovered sand quality**
- 1 to 2% organic solids
- 20 to 25% moisture

**Recovery of recyclable product**
- 98% recyclable product (7-14 day reuse)
- 98+ % total recovery
- No detectable sand at sand lane discharge.

Successful systems for high recovery of high quality sand...

- Select a sand type (ASTM C33) to facilitate separation.
- Use scrape systems where possible.
- Closed loop for consistent recycled water.

Minimize odor potential!

Wrapping it up...

- Sand-laden manure handling requires sand systems.
- “Mechanical” systems attain higher recovery (in excess of 98%), cleaner sand at a lower cost than “passive” systems.
- Select systems that allow for the adoption of manure treatment systems that may reduce odor, generate energy, and/or partition nutrients, perhaps with a payback.

Commitment, commitment, commitment...
“The days of building big dirty dairies are over.”

Midwest dairy producer (2009)

Sand-manure separation systems are proven technology.

Manure handling no longer needs to be seen as a downfall of sand bedding!