Dewatering and Recovery of Anaerobically Digested Dairy Farm Solids

by

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Rexnord EnviroEnergy Technology Center Presented at the Ag Energy Independence Day, Lincoln, Nebraska Energy Cycle Conference

Acknowledgements

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In addition we thank Energy Cycle for making the arrangements for testing and the opportunity to apply belt press dewatering technologies to the Agribusiness fields.

Finally, acknowledgement is appropriate to Ken Pietila, our EnviroEnergy Technology Center test engineer who conducted the field tests at the Baum’s Dairy Farms, Inc.

Introduction

To date the major field of application for solids dewatering has been municipal waste treatment plant sludges. To show you how major this field is in the U.S. we treat domestic waste and develop 12,000 tons/day of solids to be dewatered and disposed. Ultimately this figure will be over 31,000 T/day. A major share of these sludges are anaerobically digested - thus there are some appropriate comparative aspects of solids handling and management, when dealing with human vs animal residues. Through the 1970’s it was popular to use vacuum filtration and incineration. Four major problems began to change the entire approach:

1. Energy and chemical costs increased and developed a need for use of alternative processes.
2. Air emission control of incinerators became a major concern as the EPA Clean Air Act was implemented.
3. The capital intensive incinerators became more unfavorable as EPA funding decreased.
4. Daily operation of a thermal process overtaxed operator skills and/or time. As more time was needed to control the treatment process and assure high quality effluent discharge to the receiving stream, less time was available for thermal destruction of sludge at the plant.

Thus in the last seven years there has been a major swing back to anaerobic digestion, and conversion to methane as the major source of energy to run the treatment plant. The major problem, of course is that the anaerobic process converts approximately 50% of the organics to methane and a considerable volume of solids remains for disposal. Currently, we see a strong drive to more effectively control the anaerobic process for a higher conversion of organics to methane.

Solids dewatering of anaerobically digested animal wastes has additional incentives over municipal, organic wastes. Rexnord has initiated a program to define the most appropriate, optimized dewatering technology for controlled recovery of:

a. Solids for use as bedding (mainly dairy) and/or protein for blended refeeding, or for use as a commercial potting soil.

b. Filtrate for fertilizer recovery - primarily soluble phosphorus, and nitrogen mainly ammonia and organic nitrogen.

Program Approach

Dewatering devices are generically classified as follows: Vacuum Filtration, Centrifugation, Filter Press and Belt Press.

Over the last 20 years, Rexnord has acquired or developed all of these devices for use on municipal and industrial sludges. Thus expertise was accumulated in the fields on laboratory bench, field pilot and full scale operating experiences. Figure 1 shows comparative features of each device.

These features show why the belt press has taken over a major position in dewatering. It is common to see that a belt press will pay for itself as a retrofit over existing vacuum filter equipment in two years due to savings of energy, manpower, chemicals and higher solids recovery.

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Thus our approach to the on-farm dewatering program is to initially use a bench belt filter simulator on site. There are three basic steps.

a. preconditioning (as required)

b. free drain water removal

c. pressure section dewatering

Figure 2, full scale press schematic, shows these three steps:

Variables of dewatering are identified as follows:

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cake Solids</td>
<td>Feed Rate</td>
</tr>
<tr>
<td>Solids Recovery</td>
<td>Feed Solids</td>
</tr>
<tr>
<td></td>
<td>Polymer Dosage (if required)</td>
</tr>
<tr>
<td></td>
<td>Type of cloth or wire media</td>
</tr>
<tr>
<td></td>
<td>Belt Speed</td>
</tr>
<tr>
<td></td>
<td>Belt Pressure</td>
</tr>
<tr>
<td></td>
<td>Source, i.e., poultry, dairy or blends, etc.</td>
</tr>
</tbody>
</table>

We recently completed dewatering feasibility field tests at the Baum Dairy and would like to share these results with you. Figure 3 is a tabulation of test results including:

a. Existing centrifuge performance.

b. Bench belt press tests without polymer.

c. Bench belt press tests with polymer.

Several preliminary findings are significant:

a. A drier cake - 19.6% vs 27.6% solids can be produced with a belt press. At the same time, solids capture is upgraded from 25% to 35%. (Normally higher recovery rates produce a wetter cake because the finer fraction of solids are associated with a higher bound water content.)

b. Polymer pretreatment can enhance performance further with solids recovery rates of up to 74%, with only slight fall off in cake consistency.

c. A major portion of the fine suspended solids or near colloidal solids are highly concentrated in protein and phosphorus, \( P_2O_5 \).

With a process flow of 20,000 gal/day the centrifuge can recover 32,600 lbs dry solids, containing 1560 lbs protein or a ratio of 0.05 lbs protein or 4.5% protein.

This compares with the belt press at 49,980 lbs/day, containing 3,665 lbs protein or 0.073 lbs protein or 7.3% protein.

Or a 2.9 gain in protein recovery over the centrifuge.

In actual operation, we would anticipate operation of the best press with and without polymer as follows:

a. For the quantity of bedding desired, and a dryer cake, the unit would be run without polymer.

b. Where a higher protein cake is desired, polymer would be used. A second potential for cake solids exists - sale and use of the material as a potting soil. Again the belt press drier cake, has an enhanced value of phosphorus in \( P_2O_5 \), 1500 mg/Kg for centrifuge cake vs 4440 mg/Kg for belt press cake with polymer.

Again on a daily basis the following would apply:

<table>
<thead>
<tr>
<th></th>
<th>Total dry</th>
<th>Total lbs/day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solids/Dry</td>
<td></td>
</tr>
</tbody>
</table>

\[
\begin{array}{|c|c|c|}
\hline
\text{Centrifuge cake} & 1500 & 32,600 & 250 \\
\text{Belt Press Without} & 2610 & 49,980 & 435 \\
\text{Polymer} & 4440 & 44,650 & 740 \\
\end{array}
\]

\[
\begin{array}{|c|c|c|}
\hline
\text{Source Analysis} & \text{Total Solids} & \text{Protein} & \text{Phosphorus} \\
\text{Centrifuge cake} & 1500 & 32,600 & 250 \\
\text{Belt Press With} & 2610 & 49,980 & 435 \\
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\end{array}
\]
Figure 4 also illustrates the comparative protein, phosphorus, P$_2$O$_5$ and potash K$_2$O contents of the centrifuge and belt press cake, with and without polymer.

**Overall Performance Analysis**

Repetitive dewatering tests are conducted to identify controlling or ranking independent variables. Normally at least 10 runs are required to accurately establish each variable's influence on cake solids or solids recovery.

For the solids recovery for the dairy farm anaerobically digested solids we were able to establish this with relatively few runs - six in total.

Results via computer regression analysis are:

Solids Recovery $% \cdot R = 17.6 \cdot P^{0.083} \cdot B_5^{0.34} \cdot B_T^{0.13}$

Where $P$ = Polymer dosage, lb/ton

$B_5$ = Belt Speed, fpm

$B_T$ = Belt Tension, lb/in

More useful is the fact that

Polymer Dosage influence is 51.2

while

Belt Speed is only 1.2

and Belt Tension is 0.4

**Conclusions**

1. Preliminary field tests on anaerobically digested dairy farm show that solids management may be significantly improved through the application of filter belt press technologies.

2. Advantages are:
   a. Dryer cake formation
   b. Higher Solids capture
      • current practice 25%
      • 35% without polymer
      • 74% with polymer
   c. Selective enhancement of cake content
      • increased protein content
      • increased P$_2$O$_5$ phosphorus content
   d. Controlled product formation
      • animal bedding
      • protein for refeed
      • fertilizer for potting soil and nursery use.

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