Operational and Economic Considerations of Using a Belt Press for Dewatering Soil Washed from Sugarbeets.

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Introduction

In 1995, the Minn-Dak's stockholders voted to increase their beet acreage from 76,000 to 100,000 as well as expand the plant capacity. It was clear that the existing mud ponds were not sufficient to handle the added mud after expansion. Up until that time, Minn-Dak personnel had operated two mud ponds. They pumped the dirt washed from the beets to a mud pond for dewatering. After a time, Minn-Dak personnel pumped the decanted water to the wastewater treatment system. It took up to thirty days for the dirt to settle enough to allow pumping. Odors from the mud ponds were nuisances in both the fall and spring. In addition, because it took about to dewatering, spring wastewater treatment was postponed one month exacerbating the odor problem.

Personnel would pump to one pond and clean the other each year. The volumes of the two ponds were 160,000 and 190,000 cubic yards. The pond capacity had been sufficient to hold the mud most years. Minn-Dak personnel generally cleaned the ponds in the winter because the partially frozen mud was easier to handle and odor was not strong. The volume of mud depended on the size of the crop and tare. Historically, the tare ranged between 2 and 8 percent for a given crop. The yield varied between 12 and 22 tons per acre.

The increase in beet acreage to 100,000 acres would mean that most years a single mud pond would not be able to handle all the dirt. In fact, if a large crop was harvested under wet conditions would bring in too much dirt for both the ponds. One option for Minn-Dak was to expand their ponds to continue operating as in the past. Management at Minn-Dak decided against this option because it would not help alleviate the odor problem. Instead, they choose to install two double-belt presses to dewater the mud as it was generated and haul it to its disposal site. American Crystal Sugar had installed a similar system a few years earlier at Moorhead, Minnesota.

Mud presses would have the several advantages. First, personnel would be able to process wastewater from the mud as it was generated, which would decrease the odor potential in both the spring and the fall. Second, because employees would handle the mud as it was generated, it would minimize the amount of summer handling and associated odors. Third, since mechanical dewatering resulted in lower moisture, the volume of mud handled would decrease. Historically, the dewatering in the ponds resulted in soupy mud that was only 15-to-25% solids while the presses would increase the solids content to about 50%. This would be a 60% reduction in the tonnage. Finally, personnel could manipulate the dryer mud easier and quicker than what had come from the ponds.

Installation

However, these advantages would come with significant costs. First Minn-Dak would need to purchase the presses, construct a building to house them and all ancillary equipment, add polymer to coagulate the mud for pressing, and finally have personnel available to operate the presses. Figure 1 is a schematic showing the layout of the building. The upper floor contains the belt presses, mud scroll and worker station. The lower floor contains the mud tank, the polymer mixing system, the polymer day tank, polymer storage, the acid boil-out system and the truck station. Minn-Dak started construction in and started operating the presses in January of 1998. The installation costs for the Minn-Dak's mud pressing system were as follows:

Building and construction costs	$630,000
Two Andritz double-belt presses at $ each	$469,000
Mud tank with piping	$220,000
Polymer system	$64,000
Mud scroll and live-bottom hopper	$112,000
Electrical and instrumentation	$186,000
Acid washing system	$32,000
Total	$1,713,000

Operations

Mud Conditioning

Like most aspects of the beet sugar process, consistency is the key to good mud pressing. Dirt removed from the beets during washing flows with the water to a settling clarifier. The dirt settles to the bottom and the clear overflow flows back to the fluming pumps. The mud is pumped off the bottom of the clarifier to the 6000-gallon mud tank inside the mud press building. A nuclear density meter measures mud density and controls the clarifier bridge speed to keep the mud going to the presses consistent. The operator targets a minimal amount of mud on the bottom of the clarifier to reduce mechanical and microbiological problems. If the clarifier is filling up with mud faster than the mud presses can handle it, the operator pumps the excess underflow to a mud pond. A three-horsepower stirrer keeps the mud from settling in the tank. A pump at the bottom of the tank pumps the mud to the mud presses.

Polymer Addition

On the way, polymer is injected and mixed in two venturi mixers. To prevent the mixers from plugging, an automated controller adds dilution water under sufficient pressure for the water to mixing at about 20 gallons per minute. The polymer starts coagulating the mud immediately. The polymer Minn-Dak uses to coagulate the mud is Nalco 7766^{+} anionic polymer supplied in 1,500 gallons tanks by the Nalco Chemical Company of Naperville, Illinois. Each supply tank contains a positive-displacement pumps that keeps the polymer suspended. Prior to use, the polymer is mixed with water by Poly Blend units that meter the dosage, regulate the water mixing, and provide uniform dilution and activation. Immediately after the mixing units, additional water is added (two gallons per minute). The system then pumps the diluted polymer to the day tank where the polymer is given time to activate. It is this conditioned polymer that the venturies mix with the mud stream. Minn-Dak has found it necessary to use high-quality water for polymer dilutions, as any suspended matter in the water will bind with the polymer, reducing its effectiveness.

Pressing

As the mud emerges from the pipe onto the belt press, it is lumpy like cottage cheese. Chicanes (plows) spread it out over the press's gravity-drainage zone. This helps expose the free water to the belt filter to aid drainage. By the time the mud has traveled across the gravity-drainage zone, the free water has drained away leaving wet-looking mud. At this point, the belt bends around a roller and the two belts come together to apply pressure to both sides of the slurry in the wedge zone. The final phase is the high-pressure zone. The pressing force is generated by wrapping the belts, with the slurry sandwiched between them, around a series of decreasing diameter rollers. Smaller rollers create larger pressing forces, squeezing out progressively more water. When the dewatering is complete the mud normally falls from the belt into the discharge scroll. Under these conditions the mud is like moist potting soil and is between 50-55% dry matter. At times the dirt is somewhat sticky and a polyurethane blade (doctor blade) scraping the belt will ensure all the dirt is removed.

To optimize the belt press operation, an operator needs watch three critical parameters. First, the mud must sufficiently dewater across the gravity drainage zone. If this occurs, the mud will press in the wedge zone and not squirt out from in between the belts. Second, the operator must place the right amount of solids on the press. If the operator overloads the belt, it will wear quickly. Third, the operator must distribute the solids evenly across the belt. An uneven spreading of mud will cause the belt to kink and soon break. Factors that affect these three include the mud density, mud pH, aging of the polymer, mud temperature, dilution water temperature, dilution water purity, amount of vegetative matter in the mud, scaling of the belts, and general condition of the belts.

Polymer cost

The cost of the polymer necessary for this system is significant. During the 1999-2000 campaign, Minn-Dak spent \$5.47 per ton of mud dry solids. Many operational factors enter into the exact polymer use. For example, if the Mud is below pH 7 the mud presses work well with half the polymer needed at pH 10. In addition, the cooler the mud, the more polymer solution is necessary to coagulate it. Between January 9, 2000 and February 18, 2000, Minn-Dak operated the belt presses for \$3.32 per dry ton. However, once Minn-Dak Started processing beets stored at the factory yard both frozen and unfrozen, the costs went up to \$6.77 per ton. Continued improvement in operations has whittled down the average cost per ton to \$3.71 for the 2000-2001 campaign through January 8.

Belts
Another significant cost is that of the belts. Each press uses two belts, each 84 inches wide. The longer belt is 907 inches long and costs $3500 while the shorter one is 541 inches long and costs $2,400. The belts are a nylon polymid blend belts with an air permeability of 470 cfm / sq.ft. During the 1999-2000 campaign, Minn-Dak used 7 long and 8 short belts at a total cost of $45,000. Through February 21, of the 2000-2001 campaign, Minn-Dak had used 5 long and 4 short belts. Minn-Dak operators have found several operational factors to cause the belt to ware quickly.

1. Uneven mud distribution causes the belt kinking
2. Application of too many solids on the belt causes stretching
3. Improper polymer amount (wet mud) causes poor tracking and belt-edge wearing
4. Improperly fastened belt seam causes seam separation
5. Setting the doctor blade too tight case excessive belt wearing
6. Malfunction of the belt tracking will cause the belt to catch the spray-water pans and tear
7. Improperly setting the belt tension cases premature belt stretching

Belt cleaning
The belt press came equipped with water sprays to keep the belts clean. Each press Minn-Dak operates requires 130,000 gallons per day of wash water. Minn-Dak uses either recycled wastewater (cleaned through the wastewater treatment system) or excess condensate, cooled by the addition of recycled wastewater. The used cleaning water drains to the flume for make-up water.

Since Minn-Dak uses milk-of-lime to control pH in the flume, this system contains a significant amount of calcium. As a result, the belts frequently become blinded with lime scale that needs to be removed. Minn-Dak has installed a system whereby operators can circulate sulfamic acid to the sprays of the press and back to a tank. After demineralizing the operators switch the system back to cleaning water. They determine if they should save the acid by checking its strength.

Economics

A simple economic comparison between mud press operation and mud-pond cleaning ia shown in Tables I and II. The comparison shown in Table I was calculated using is using a 2,000,000-ton slice, and a 3 % tare. The comparison in Table II shows that for a year with a higher tare (5 %) the mud press becomes the lower cost item under both polymer-usage scenarios.

Summary

Minn-Dak Farmers Cooperative has installed double-belt mud presses to reduce the environmental problem associated with mud pond operations. Operating the mud presses has eliminated the need of increasing the mud pond capacity, reduced the odor problems associated with cleaning the mud ponds, and allowed for timelier processing of wastewater. To proficiently operate the mud presses Minn-Dak personnel had to learn how variations in operating parameters changed performance. The total installation and operating costs of this project were similar to what it would have cost Minn-Dak to expand and continue operating its mud ponds

Table I: Economic Comparison of Mud Presses with Pond Cleaning for Two-Million Tons and 3% Tare

	Mud Press	**Mud Press**	**Mud Pond Cleaning**
Tons of dirt at 80% dry substance	48,000	48,000	48,000
% Solids of the mud	49%	49%	20%
Tons of mud to be hauled	97,959	97,959	240,000
Polymer cost per ton of dry solids	*$4.00*	*$5.00*	
Mud hauling costs at $3.20 per ton	$313,469	$313,469	$768,000
Polymer costs	*$192,000*	*$240,000*	
Annual mud press maintenance	$100,000	$100,000	
Depreciation*	$140,000	$140,000	
Total annual Cost	$745,469	$793,469	$768,000

*Straight-line, ten-year for the equipment and twenty-year for the buildings

Table II: Economic Comparison of Mud Presses with Pond Cleaning for Two-Million Tons and 5% Tare

	Mud Press	**Mud Press**	**Mud Pond Cleaning**
Tons of dirt at 80% dry substance	48,000	48,000	48,000
% Solids of the mud	49%	49%	20%
Tons of mud to be hauled	*163,265*	*163,265*	400,000
Polymer cost per ton of dry solids	*$4.00*	*$5.00*	
Mud hauling costs at $3.20 per ton	$522,449	$522,449	$1,280,000
Polymer costs	*$320,000*	*$400,000*	
Annual mud press maintenance	$150,000	$150,000	
Depreciation*	$140,000	$140,000	
Total annual Cost	1,132449	$1,212,449	$1,280,000

*Straight-line, ten-year for the equipment and twenty-year for the buildings