Most operators excel at running their centrifuges, but for many, it is simply continuing to do what has been done in the past. However, there are a number of actions that operators can take to further optimize centrifuge operation to further improve performance and/or reduce chemical costs. Rare is the centrifuge installation that will not benefit from one or more of the four optimization tools described in this module.

1) Change Polymer Addition Point(s)

The difference in polymer dose between the best and the worst addition point(s) can be 20% of your polymer budget! If you are using only one addition point, what are the chances that it's the best one? The centrifuge manufacturers generally recommend four addition points:

1. Internal at the feed tube
2. Immediately ahead of the feed tube
3. ~9 to 12 meters (25 to 40 feet) ahead of the centrifuge feed tube
4. ~20 to 25 meters (50 to 70 feet) ahead of the centrifuge feed tube

The difference among these addition points is how much mixing and flocculation takes place before entering violent acceleration in the feed zone of the centrifuge. No one can predict with any accuracy the optimal addition point. Trial and error is the only way. Plus, the optimal addition point may change with summer/winter sludge, with a new polymer, or with better optimization as described below. That being the case, it’s important for the engineer/operators to design the system to make it easy for operators to change the addition point. Probably the best setup is a manifold as shown in Figure 1. It’s easy to see where the polymer is going, and very easy for the operators to open one valve and close another to change the addition point. The best place to install a manifold is in a convenient spot where the operator can easily see the effect of a change, typically convenient to the centrifuge operator interface. The operator can easily redirect the polymer from the current addition point to a different point by opening one valve and closing another, while seeing the effect the polymer change had on the torque. Plus, the polymer supply is right there.

Figure 1: Manifold with one polymer line running to each addition point
2) Change the Pond Setting

There are two rotating elements in a centrifuge: The outer bowl assembly, and inside the bowl assembly or conveyor (sometimes called a scroll). The difference between the speeds of these two elements is referred to as the “differential RPM” (or the relative speed). The differential RPM controls the removal rate of the solids in the centrifuge. High differentials stir up the settled solids, reducing efficiency, so the key to good results is operating at low differential RPMs, and to do that, you have to raise the pond setting. Here’s why.

All wastewater dewatering centrifuges operate with the liquid discharge higher than the solids discharge. This means that on startup, the solids discharge is the lowest point, so feed spills out the solids end for a while until the centrifuge “makes seal.” The difference in the fixed solids diameter and the variable liquid diameter is the differential head ($\Delta H$), which creates a hydraulic pressure that extrudes the cake. You might assume the differential RPM is the only thing that moves cake out of the centrifuge, but it isn’t. The cake removal rate from the centrifuge is a function of both the differential RPM and the differential head. In a car, you change the gear ratio (first, second, third, etc.) to achieve a speed range, and then use the accelerator pedal to fine-tune the speed. In the centrifuge, you set the pond to establish the differential head, and then adjust the differential RPM to fine-tune the cake removal rate. Figure 2 shows a cross-section of a centrifuge.

$$\text{Cake Removal Rate} = \Delta H + \Delta \text{RPM}$$

For this to work well, the differential RPM has to be quite low. Why would increasing the pond setting by 6 mm (1/4 inch) make a huge difference in the cake removal? Well, if the $g$ force at the pond surface is less than at the bowl wall, perhaps $\sim 1,000 \, g$, the small increase in pond depth is equivalent to a head of water 6 mm x 1,000 g = 6 meters high (1/4 inch x 1,000 g = 21 feet). That is a significant pressure pushing the cake out of the centrifuge. Deeper ponds nearly always increase performance because they allow operation at lower differential RPMs. Higher performance can be expressed as higher feed rates, dryer cake, or lower polymer dose. If you use the improvement to get dryer cake, keep in mind that cake dryness is proportional to cake viscosity, and in turn cake viscosity is proportional to torque, so you can also expect to see higher torque. If you open your centrifuge and look at the actual discharge opening (see Figure 3) and the opening is 15 to 20 mm or larger, there is room for deeper ponds. Order a set of dams from the centrifuge manufacturer, or have them made up locally; they are easy to reverse engineer.
With some manufactures, there is no room in the centrate ports for deeper ponds. This means you are already operating at the extreme limit of adjustment, and the manufacturer’s design limits the centrifuge’s performance, as in Figure 4.

3) Dilute and Age the Polymer

Polymer vendors recommend 0.2% active polymer concentration, and a minimum of 40 minutes of aging for dry polymers, and 20 minutes of aging for emulsion polymers. A common false economy in plant design is an inadequate polymer mixing system that at best can mix down to 0.5% and then relies on post-dilution of the polymer to reach the manufacturer’s recommended solution strength of 0.2%. Usually post-dilution doesn’t make a noticeable improvement in performance, and operators assume that thicker polymer is OK. It is much more likely that it proves that post-dilution is ineffective. It is very difficult to mix a thick viscous liquid with a much less viscous one, and even with a mixing device, the solution is still not homogeneous. Try it yourself: add 200 mm of water to 200 mm of 0.4% active polymer solution, and pour it from beaker to beaker, counting the pours until it becomes a smooth homogeneous solution. Most people give it up after 50 to 100 pours when it still isn’t homogeneous.

It is much better to mix the polymer to the proper concentration the first time. Often you can test thinner make-down solutions by making up a thin batch, and run at the same dosage for an hour or so before you run out of polymer. That should be enough time to see (and document) an improvement. If you have the capacity to run with thinner polymer, there is no need to make one big change and risk upsetting the system – instead, each day, dilute the polymer a little more, keeping records on the performance. If proper dilution saves even 10% of the polymer cost, it would justify adding larger polymer pumps, etc. to pump the higher volume of polymer.

Aging of polymer is also really important. Dry polymers require at least 30 to 40 minutes of aging. More is better, to reach full activity. Indications of inadequate aging occur when dewatering has been down for a while, and the polymer gets extra aging, sitting in the storage tanks. If performance on last night’s polymer is great first thing in the morning, but you need more polymer when a fresh batch comes through, you can conclude the aging time is inadequate. One last bit, while diluted polymer does degrade slowly, if a solution sits for a weekend, you probably won’t notice the difference; even sitting for a week it will be OK to use. When it is weeks old, it may be too degraded to perform well.

Emulsion Polymers

It is possible to simply pump emulsion polymer into a mix tank, but this is not as effective as using a commercial make-down system. Emulsion polymers will work without aging, but only reach full activity with ±15 to 20 minutes of aging time. An inexpensive way to test this is to utilize a homeowner-grade hot water heater. No need to hook it up to electricity, it just acts as a wide spot in the pipe. The polymer solution enters the bottom of the tank, and the aged solution exits out the top. At a 10 GPM polymer rate, a 200-gallon tank adds 20 minutes of aging. Because the tank is rated for 80 PSI of pressure, you probably don’t need another pump. Of course, this is not a permanent solution to the problem, but with documentation of the savings achieved in the test, you may be able to justify the capital costs to upgrade the system (see Figure 5).
4) Worn Caulk Strips

Does your centrifuge “cycle,” meaning the vibration and noise rises over a period of 5 to 15 minutes, then drops fairly suddenly to normal? Do you see the centrate cycle from light to dark, back to light? Or does one centrifuge take a lot more (20%) polymer than another? The most common cause of these problems is worn caulk strips (some centrifuges have grooves) on the beach. In all screw conveyors, the sludge has to slide on the conveyor and stick to the trough/centrifuge bowl. Centrifuges have strips tack welded to the conical section, and at the bowl from the feed zone to the beach. When these strips are worn away, or even rounded over (see Figure 6), they will cause the centrifuge to plug intermittently. The torque then rises, the controls increase the differential RPM to bring the torque down, and the centrate goes dark. Eventually, the sludge in the cylindrical end will push the plug out, torque drops, the centrate clears up, and scrolling resumes for a while until the slipping and plugging begins again. The operator will also see the vibration rise for a time, and then drop back quite suddenly; this is quite noticeable on trend lines. It is a relatively easy to remove and replace the strips. The strips themselves can be made up locally, or purchased from an OEM or most centrifuge repair shops. It is quick work to grind the welds on the worn ones, and tack weld the new ones in place of the old (see Figure 7). Because you are welding identical strips symmetrically around the bowl, it is unlikely to affect the balance. Or you could have a repair shop do it. Subpar performance of the centrifuge costs money every hour it runs; in fact, by the time most plants notice the subpar performance, the lost efficiency cost far more than the cost to repair the damaged caulk strips.
Further Reading:
Operation of Municipal Wastewater Plants, Manuals or Practice No. 11, Volume III Solids Processes, 2008.
Polymers pp 33–29
Centrifuges pp 33–71


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