OPTIMISATION OF DEWATERING CENTRIFUGES

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ABSTRACT

Biosolids disposal costs represent a significant proportion of a wastewater plant's operating budget and the optimization of biosolids dewatering offers the best opportunity for minimizing these costs. A generic systematic approach that can be used for optimization of any centrifuge will be presented, and results will be reported for the optimum settings determined in a case study at Maroochydore STP. The outcomes of the centrifuge optimization program were that the dewatered cake dryness was improved from 17% to 21%TS, and the operations team gained valuable knowledge and experience with regard to fine-tuning the centrifuge. The results indicated that maximizing the residence time in the centrifuge bowl and achieving optimum poly-sludge surface chemistry were the critical parameters for optimum dewatering performance.

KEYWORDS

Biosolids; centrifuge; dewatering; optimization.

1.0 INTRODUCTION

Maroochydore Sewage Treatment Plant (STP) is located approximately 100 km north of Brisbane and serves a population of about 95,000 EP. The plant has recently completed an upgrade, which incorporated the replacement of the sludge dewatering belt press with a high-speed centrifuge. Although the operators had many years of experience with belt presses, they had limited experience with centrifuges and consequently a centrifuge optimization program was carried out with the following objectives:

- To produce the driest practical dewatered sludge cake in order to minimize sludge transport costs.
- To minimize the operating cost associated with polyelectrolyte usage.
- To minimize solids recycle in the centrate by achieving optimum solids capture.

The quantity and characteristics of the biosolids generated at an STP depend on the wastewater characteristics and the treatment processes employed. The following is a brief description of the liquid treatment process and a more detailed description of the solids treatment process at Maroochydore STP. A biological nutrient removal (BNR) activated sludge process is utilised and it is supplemented with alum and methanol dosing to achieve effluent total N = 2 mg/L and total P = 0.2 mg/L (Thomas et al, 2009). Secondary effluent is treated with 10 μm disk filters and ultraviolet (UV) disinfection. Approximately 15% of dry weather flows are further disinfected with hypochlorite to produce Class A recycled water for reuse, and the remaining effluent is discharged to the Maroochy River.

The average sludge production that is processed through the centrifuge is approximately 5 T/d of dry solids, which comprises anaerobic digested sludge derived from a combined chemical-biological nutrient removal process. The sludge consists of a mixture of fermented primary sludge, waste activated sludge and alum sludge, and the solids treatment process stream at Maroochydore STP includes:

- Fermentation of primary sludge.
- Thickening of waste fermented sludge using rotary screen thickeners (RST).
- Thickening of waste activated sludge (WAS) using dissolved air flotation (DAF).

- Anaerobic digestion of thickened primary and secondary sludge.
- Dewatering of digested sludge using a centrifuge.
- Further drying of dewatered sludge cake using a Solar Dryer.
- Reuse of biosolids via application to agricultural land.

The weight of biosolids transported off-site depends on the evaporative drying performance of the Solar Dryer. However, evaporation is a function of seasonal climatic conditions and is outside the control of the operator (Thomas et al, 2008). Therefore, minimization of biosolids disposal costs must inherently go hand-in-hand with optimisation of the entire sludge treatment process, particularly the centrifuge dewatering process as described in this paper.

2.0 METHODS

A generic systematic approach that may be used for optimization of any centrifuge was adopted, and the objective was to determine the optimum settings for each of the following parameters:

1. Type of polyelectrolyte
2. Poly dose
3. Poly dilution water flow
4. Sludge feed flow
5. Centrifuge scroll torque setting
6. Centrifuge bowl pool depth and weir plate setting
7. Centrifuge bowl speed

The adopted approach for optimization of the centrifuge performance was based on varying one parameter at a time within its practical operating range and wherever possible keeping all other parameters constant. Generally the centrifuge was set-up with the desired control parameters, and then allowed to run for 30 minutes to reach steady state operation before samples were collected of the feed sludge, dewatered cake and centrate. The testing demonstrated that the feed sludge solids concentration did not vary hour-to-hour, and consequently this parameter was not sampled on every test run. Similarly the centrate quality from the centrifuge was excellent during virtually all test conditions, i.e. TS < 1500 mg/L and TSS < 200 mg/L. Since the centrate solids concentration was effectively constant throughout the testing, this meant that the main parameter used to evaluate centrifuge performance was the dewatered cake dry solids concentration.

The dewatered cake, feed sludge and centrate samples were analysed for total dry solids (%TS) using a Sartorious MA-35 moisture analyser, which had a weighing resolution of ±1 mg. The typical sub-sample size that was tested was 10 g.

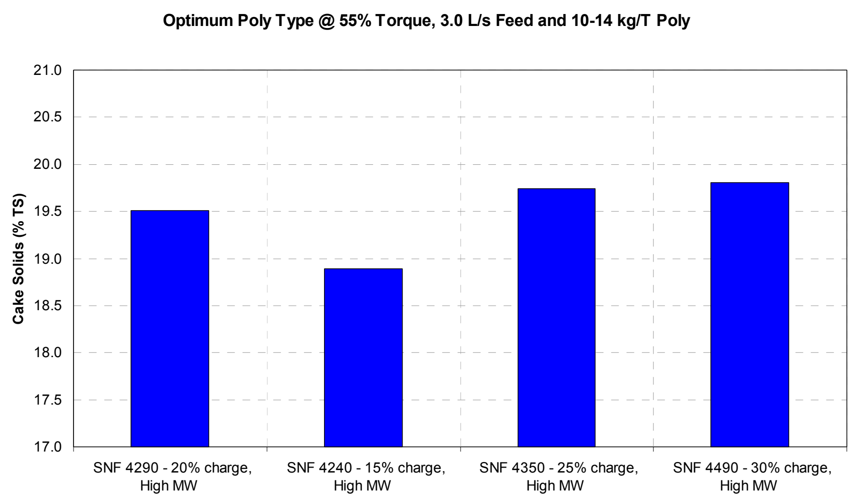
3.0 RESULTS AND DISCUSSION

3.1 Benefits of Centrifuge Optimization

The overall outcome of the centrifuge optimization program was that the dewatered cake dryness was improved from 17% to 21% TS. Financial analysis demonstrated that for a plant the size of Maroochydore STP, each 1%-point improvement in dewatered cake dryness corresponded to a saving of approximately $25,000 p.a. in biosolids transport costs. Therefore, the overall benefit of the centrifuge optimization program was equivalent to an annual saving of $100,000.

3.2 Type of Polyelectrolyte

Initial polyelectrolyte (poly) selection was based on jar tests carried out by the poly supplier, and it was found that the optimum poly was SNF 4290, with high molecular weight and 20% cationic charge density. Following the initial round of optimization of all other centrifuge parameters, the optimum type of poly was reviewed with full-scale trials, and further improvements in dewatering performance were found using SNF 4490, which also has high molecular weight but has a higher cationic charge of 30% (Figure 1). Generally, higher molecular weight poly is required for a centrifuge than a belt press due to the higher floc shear. Furthermore a higher cationic charge is required as the fraction of secondary sludge (WAS) increases in the sludge mix, which is consistent with the sludge characteristics at Maroochydore STP with a low primary:secondary ratio of 25%:75%.



<u>**Figure 1:**</u> ***Centrifuge dewatering performance with different types of poly***

3.3 Polyelectrolyte Dose

An iterative series of optimization tests were conducted under different conditions with poly doses varying in the range from 8 to 20 kg poly/T dry solids, and one set of results are shown in Figure . Generally the optimum poly dose was about 12 kg/T with minimal improvements in dewatering performance at higher doses.

The optimum poly dose of 12 kg/T was significantly higher than the design target value, which was 4.5 kg/T. The high poly usage is consistent with the author's and others (Young, 2008) experiences at STPs with high-speed centrifuges, and it seems they generally require significantly more poly than "conventional" centrifuges or belt presses, which have typical poly use of 5 kg/T. The benefit of high-speed centrifuges is that they achieve better sludge cake dryness, and the need for high poly doses is likely related to the higher shear that occurs at higher g-forces.

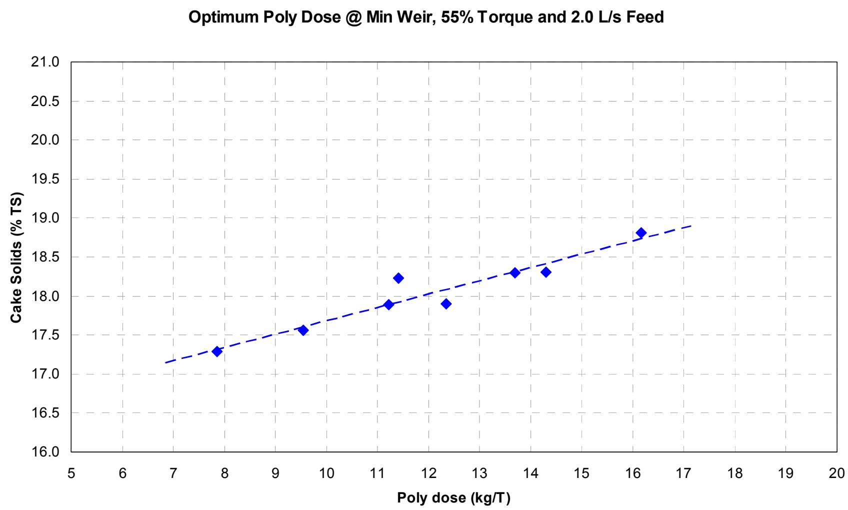


Figure 2: ***Affect of poly dose on centrifuge dewatering performance***

3.4 Poly Dilution Water Flow

Centrifuge performance was correlated with hydraulic residence time (HRT) in the centrifuge bowl, for example refer to the affect of sludge feed flow rate and bowl pool depth discussed below. However, centrifuge performance was not sensitive to the poly dilution water flow rate, with only a marginal improvement in dewatered cake dryness as the poly dilution water flow was progressively decreased from 2 L/s down to 0.3 L/s.

3.5 Sludge Feed Flow

The centrifuge performance was highly sensitive to the sludge feed flow rate (Figure). Although the rated capacity of the centrifuge was 3.5 L/s, its performance was significantly better at half that flow rate. Minimum flow rates to the centrifuge were achieved whilst still keeping up with daily sludge production by means of:

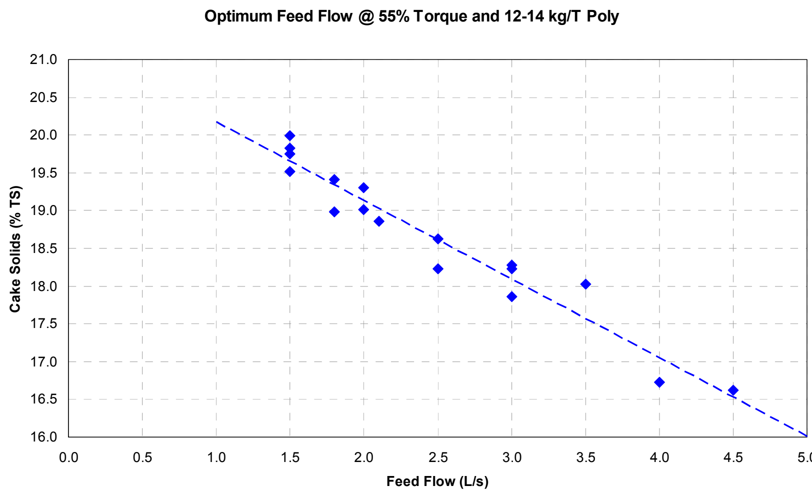
- Operating the centrifuge more-or-less continuously 24 hr/d, 7 d/wk.
- Optimizing the thickening performance of the RST and DAF such that the minimum volume of sludge was fed into the digesters each day.

3.6 Centrifuge Scroll Torque Setting

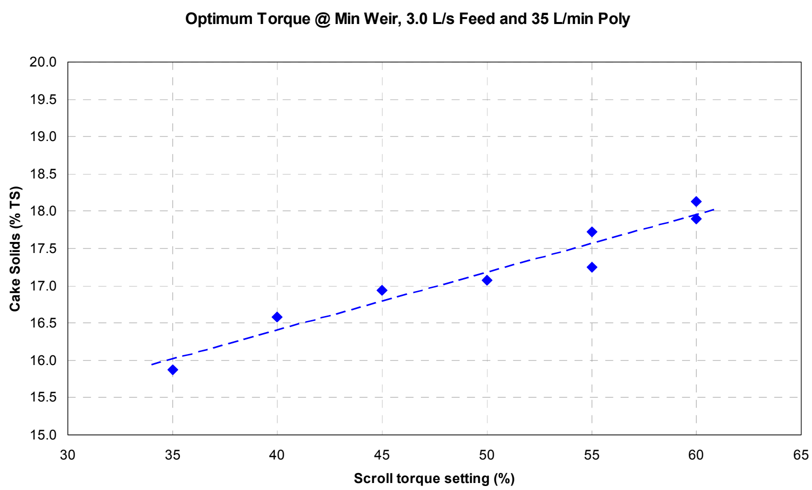
Dewatered cake dryness was fairly sensitive to changes in the scroll torque set-point, with higher torque producing better cake dryness (Figure). The optimum torque setting was in the range of 55 to 60%, which was the maximum recommended by the supplier.

3.7 Centrifuge Bowl Pool Depth and Weir Plate Setting

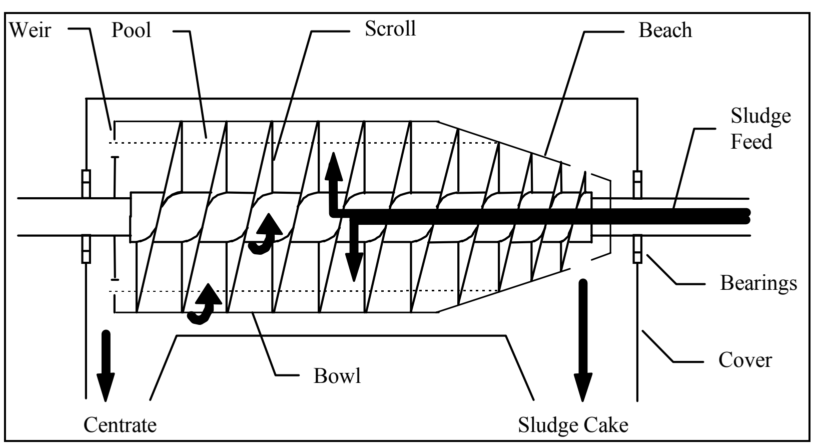
Centrifuges normally have adjustable weir plates on the cylindrical end of the bowl, which allow the operator to adjust the depth of water in the bowl (Figure 5). As the weir plates are moved towards the centre axis of the bowl the pool depth increases, but at the same time the length of the "dry" beach decreases. This increases the HRT in the bowl, which can improve centrate quality and solids capture performance, but decreases the length of the "dry" beach section where the final phase of dewatering takes place.



<u>Figure 3</u>: ***Affect of sludge feed flow rates on centrifuge dewatering performance***



<u>Figure 4</u>: ***Affect of scroll torque setting on centrifuge dewatering performance***



<u>Figure 5</u>: ***Schematic cross-section of a centrifuge***

The results of testing 3 different weir plate settings are shown in Figure 6. The minimum weir plate setting corresponded to a pool depth of 60 mm and the maximum tested was for a pool depth of 70 mm.

The improvement in dewatered cake dryness with increasing pool depth clearly illustrates the importance of increased HRT for better centrifuge performance.

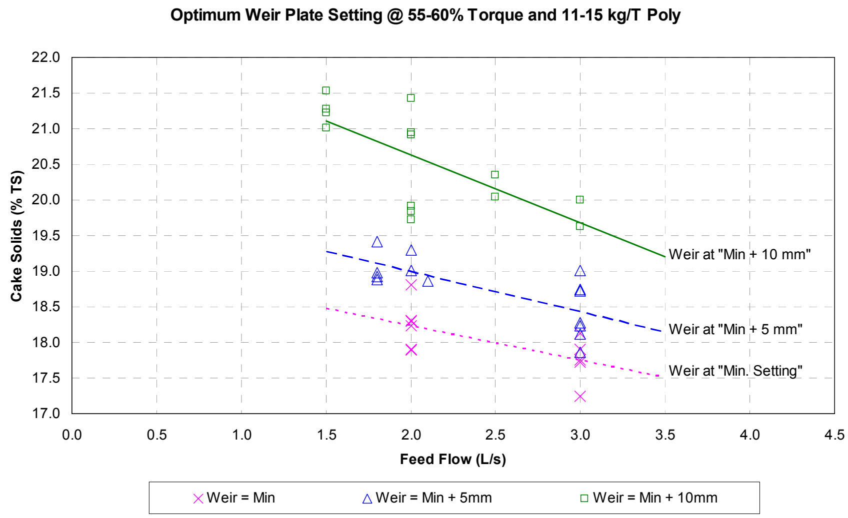


Figure 6: ***Affect of weir plate setting on centrifuge dewatering performance***

3.8 Centrifuge Bowl Speed

The centrifuge has a maximum allowable bowl speed of 3200 rpm. Compared to conventional centrifuges, higher bowl speeds generally result in better dewatering due to the higher g-forces that are applied to the sludge to separate the water and to compact the cake layer within the centrifuge bowl. There wasn't much difference in dewatered cake dryness as the bowl speed was decreased from 3200 rpm to 2800 rpm, however there was a definite decrease in dewatered cake dryness when the bowl speed was reduced to 2600 rpm or less.

4.0 CONCLUSION

The outcomes of the centrifuge optimization program were that the dewatered cake dryness was improved from 17% to 21% TS, which contributed to an annual saving of $100,000 in biosolids transport costs. Furthermore the operations team gained valuable knowledge and experience with regard to fine-tuning the centrifuge. The results indicated that maximizing the residence time in the centrifuge bowl and achieving optimum poly-sludge surface chemistry were the critical parameters for optimum dewatering performance.

5.0 REFERENCES

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