Problem of the Day

2014.Nov.25

Introduction

The Water Environment Federation is the trade organization for water professionals, including wastewater treatment operations professionals (http://wefcom.wef.org/home). Individual states, or groups of states, sponsor local chapters. On October 29, 2014, I gave a 6-hour Math for Operators Workshop at the annual conference of the Pacific Northwest Clean Water Association (PNCWA). PNCWA represents Idaho, Oregon and Washington (http://www.pncwa.org/). All operators should seriously consider joining their local association. In California it is the California Water Environment Association (http://www.cwea.org/).

Long story short: I randomly covered a series of math problems in the PNCWA workshop, and I have been requested by several attendees to send them the problems. Instead, I am going to post them here (starting with the 2014.Nov.04 Problem of the Day). They are good practice for all visitors to WWTT's Problem of the Day.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break before and after the problem statement so you can print it without looking at the solution. **See what you can do to solve the problem before looking at the solution**.

Discussion

Wastewater treatment is very expensive and getting more so at the same time ratepayers are demanding cost containment. There is a significant cost when operating a mesophilic anaerobic digester bringing the incoming sludge up to the operating temperature of the digester, typically 98-99° F. **The more water in the incoming sludge, the more expensive the heating requirement**. This is why thickening is such an important process upstream of an anaerobic digester. There is also a significant cost associated with trucking biosolids from the WWTP to the disposal site, whether it is a landfill or a land-application site. **The more water in the biosolids, the more expensive the trucking costs**. This is why dewatering is such an important process downstream of an anaerobic digester. **A key performance indicator of both thickening and dewatering processes is the percent solids recovery** or PSR (sometimes also called the solids capture efficiency) defined as:

$$\left| \text{PSR, \%} \right| = \left| \begin{array}{|c|c|} \hline \text{lb } TS_o & 100 \\ \hline \text{lb } TS_i & \\ \hline \end{array} \right|$$

where **lb TS_o = pounds of TS in the output** coming from the thickening or dewatering unit, and **lb TS_i = pounds of TS in the input** going to the thickening or dewatering unit (for more discussion, see http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.22.pdf). To do calculations involving PSR, WWTT defines the PSR very specifically as demonstrated in today's Problem of the Day. Today's problem also demonstrates how powerful the railroad track is! More to the point, today's problem is yet another example of the use of units in solving water and wastewater treatment math problems; indeed, all kinds of problems. In the certification and math review classes that WWTT does, many operators are initially reluctant to embrace the use of units because it seems tedious and time consuming. While this is most certainly true when just starting to use "the railroad track," with continuing patience and practice (practice, practice, practice!!!), the use of units will become second nature and, ultimately, proven **failsafe** and **foolproof**.

Problem of the Day

The cake from a dewatering centrifuge is discharged into an 18-yd^3 haul trailer. Given the following information, calculate how many hours it will take to fill the trailer:

- Trailer volume = 18 yd^3
- Percent solids recovery, PSR = 95.6%
- Digested sludge flow rate = 145 gpm
- Digested sludge TS concentration = 4.5%
- Cake TS concentration = 24.5%
- Cake density = 69 lb/ft^3
- **Calculate: hours to fill the trailer**.

Solution

It is very important to remember and get the hang of how WWTT expresses the PSR if given in a problem. In the current problem, a PSR of 95.6% is given. WWTT express this as:

$$95.6\%\ \text{PSR} = \left| \frac{95.6\ \text{lb TS}_c}{100\ \text{lb TS}_s} \right|$$

where TS_c is the TS (total solids) in the cake ("c" for "cake") and TS_s is the TS in the sludge ("s" for "sludge") even though the TS in the cake are the same TS in the sludge. Remember, in both thickening and dewatering the solids pass through the units unaltered and only water gets removed. In order to get a high PSR (desirable), relatively few solids should end up in the water returned to the liquid treatment train.

As always, the units needed in the answer are identified from the problem statement. The problem specifically asks for "... calculate how many **hours** ..." This unit (hr), then, is entered between thick vertical lines on the left-hand side of the equals sign. Hours is a unit of time. To start the railroad track out on the right-hand side of the equals sign, the only other unit of time in all the information listed is minutes in the digested sludge flow rate to the centrifuge, 145 gal sldg/min. This is converted to 8,700 gal sldg/hr by multiplying 145 x 60 = 8,700 (**60 min/hr**) in the list below. The problem information is listed below, including the density of the digested sludge which needs to be assumed since it was not given, **in the specific units needed for the railroad track**.

Problem of the Day: The cake from a dewatering centrifuge is discharged into an 18-yd^3 haul trailer. Given the following information, calculate how many hours it will take to fill the trailer:

- Trailer volume = 18 yd^3 cake
- Percent solids recovery, PSR = 95.6% = 95.6 lb TS_c/100 lb TS_s (from above)
- Digested sludge flow rate = 145 gal sldg/min = 8,700 gal sldg/hr
- Digested sludge TS concentration = 4.5% = 4.5 lb TS_s/100 lb sldge
- Digested sludge density = 8.34 lb sldg/gal sldg (assumed since not given)
- Cake TS concentration = 24.5% = 24.5 lb TS_c/100 lb cake
- Cake density = 69 lb cake/ft^3 cake
- **Calculate: hours to fill the trailer**.

$$\textbf{hr} = \left| \frac{\textbf{hr}}{8{,}700\ \cancel{\text{gal sldg}}} \right| \left| \frac{\cancel{\text{gal sldg}}}{8.34\ \cancel{\text{lb sldg}}} \right| \left| \frac{100\ \cancel{\text{lb sldg}}}{4.5\ \cancel{\text{lb TS}_s}} \right| \left| \frac{100\ \cancel{\text{lb TS}_s}}{95.6\ \cancel{\text{lb TS}_c}} \right| \left| \frac{24.5\ \cancel{\text{lb TS}_c}}{100\ \cancel{\text{lb cake}}} \right| \left| \frac{69\ \cancel{\text{lb cake}}}{\text{ft}^3\ \cancel{\text{cake}}} \right| \left| \frac{18\ \cancel{\text{yd}^3\ \text{cake}}}{} \right| \left| \frac{27\ \cancel{\text{ft}^3}}{\text{yd}^3} \right|$$

Since all the units have canceled except the one needed in the answer, **hr**, the math is done and the arithmetic gives the answer:

100 x 100 x 24.5 x 69 x 18 x 27 ÷ 8,700 ÷ 8.34 ÷ 4.5 ÷ 95.6 ÷ 100 = **2.63 hr**.

This problem is exactly like the 2014.Oct.23 Problem of the Day (http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.231.pdf) with one exception: the cake receiving volume has been doubled in this problem, from 9 to 18 yd^3 cake. Notice, as one would expect, this doubled the fill time from 1.32 to 2.63 hours (slightly off due to rounding).

Does the labeling and railroad track take some practice?

You bet!

Is it worth it?

Absolutely!