Problem of the Day
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A belt filter press is operated 14 hours per day. A cationic polymer solution, 0.5% polymer, is added to the digested sludge pumped to the press. On average, the press discharges 13,120 pounds of cake during the 14-hour run at a total solids concentration of 22%. The best performance is achieved when polymer is fed at a rate of 15 pounds polymer per dry ton. Calculate the polymer solution feed rate in gal/hr.

Introduction

While certification exams, especially Grades IV and V, in California love to ask questions about percent solids recovery from thickening and dewatering units, this is actually a chemical feed problem not a percent solids recovery problem. We have done many such calculations in previous Problems of the Day, but they dealt with chemical feed to either a flow or volume of water. Do not despair, we tackle this problem in exactly the same way and the units show us how.

Part of the difficulty operators have with math, as I have talked about many times, is the inconsistent terminology that is pervasive in the wastewater treatment industry. There is a classic example of this in today's problem, "The best performance is achieved when polymer is fed at a rate of 15 pounds polymer per dry ton." What do we mean by "dry ton"? I abhor the use of "wet" and "dry" when talking about thickening and dewatering sludges. To me, such vague terminology adds to the confusion of these kinds of problems. The bottom line is that "dry ton" means "ton of TS" because TS are always "dry."

Solution

The question asks for the answer in gallons of solution per hour (gal soln/hr). These units are entered between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left|\frac{\text{gal soln}}{\text{hr}}\right| = \underline{\hspace{6cm}}$$

The following list summarizes the information given in the problem statement expressed in the appropriate units:

1. Operation = 14 hr/d
2. Polymer (poly) concentration = 0.5% = 0.5 lb poly/100 lb soln
3. Solution density = 8.34 lb soln/gal soln (assumed since not given)
4. Poly dose = 15 lb poly/ton TS
5. TS concentration = 22% = 22 lb TS/100 lb cake
6. Cake production = 13,120 lb cake/14 hr

The units needed in the answer are gal soln/hr. The units gal soln appear in only one place in the list, No. 3, so it is entered so these units are in the numerator on both sides of the equals sign, as shown in bold.

$$\left|\frac{\textbf{gal soln}}{\text{hr}}\right| = \left|\frac{\textbf{gal soln}}{\text{8.34 lb soln}}\right|$$

We need to cancel the units lb soln. These only appear in one other place in the list, No. 2. This is entered so the unwanted units cancel, denominator and numerator.

$$\left|\frac{\textbf{gal soln}}{\text{hr}}\right| = \left|\frac{\textbf{gal soln}}{\text{8.34 } \cancel{\text{lb soln}}}\right| \left|\frac{\text{100 } \cancel{\text{lb soln}}}{\text{0.5 lb poly}}\right|$$

We need to cancel the units lb poly. These only appear in one other place in the list, No. 4. This is entered so the unwanted units cancel, denominator and numerator.

gal soln		gal soln	100 ~~lb soln~~	15 ~~lb poly~~			
hr	=	8.34 ~~lb soln~~	0.5 ~~lb poly~~	ton TS			

We need to cancel the units ton TS, but we only have lb TS in the list (No. 5). We convert ton to lb using a well known conversion factor so the unwanted units cancel, denominator and numerator.

gal soln		gal soln	100 ~~lb soln~~	15 ~~lb poly~~	~~ton~~	
hr	=	8.34 ~~lb soln~~	0.5 ~~lb poly~~	~~ton~~ TS	2,000 lb	

Now we have lb TS in the denominator which we cancel by entering No. 5 from the list so the unwanted units cancel, denominator and numerator.

gal soln		gal soln	100 ~~lb soln~~	15 ~~lb poly~~	~~ton~~	22 ~~lb TS~~	
hr	=	8.34 ~~lb soln~~	0.5 ~~lb poly~~	~~ton~~ ~~TS~~	2,000 ~~lb~~	100 lb cake	

We need to cancel the units lb cake. These only appear in one other place in the list, No. 6. This is entered so the unwanted units cancel, denominator and numerator. Note, entering No. 6 so lb cake cancel also puts the necessary units hr in the denominator.

gal soln		gal soln	100 ~~lb soln~~	15 ~~lb poly~~	~~ton~~	22 ~~lb TS~~	13,120 ~~lb cake~~
hr	=	8.34 ~~lb soln~~	0.5 ~~lb poly~~	~~ton~~ ~~TS~~	2,000 ~~lb~~	100 ~~lb cake~~	14 **hr**

Since all units have now canceled except those needed in the answer, the solution bridge is complete. The arithmetic gives the answer.

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gal soln		gal soln	100 ~~lb soln~~	15 ~~lb poly~~	~~ton~~	22 ~~lb TS~~	13,120 ~~lb cake~~
hr	=	8.34 ~~lb soln~~	0.5 ~~lb poly~~	~~ton~~ ~~TS~~	2,000 ~~lb~~	100 ~~lb cake~~	14 **hr**

100 x 15 x 22 x 13,120 ÷ 8.34 ÷ 0.5 ÷ 2,000 ÷ 100 ÷ 14 = **37.1 gal soln/hr**.

Discussion

Again, the trick to doing problems with the solution bridge is in the labeling. This is where you need to practice. Once you get the units correct in the labeling, though, the math takes care of itself. It's amazing and will not let you down!

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.