Chapter 10 - Conservation.

10-1) $C_P = 58{,}000$ mg/L nickel
$Q_D = 0.05$ L/min
Evaporation is negligible
Dead rinse tank is 200 L and starts with clean water

Plot C_D with time

$Q_m = Q_D +$ evaporation losses $= 0.05$ L/min $+ 0 = 0.05$ L/min.

$C_P >> C_D$.

Flow into dead rinse tank $= Q_D C_P$

At 1 min: $0.05\text{ L}(58{,}000\text{ mg/L}) = 2{,}900\text{ mg}$

$2{,}900\text{ mg}/200\text{ L tank} = 14.5\text{ mg/L}$ in dead rinse tank.
as $C_P >> C_D$ amount leaving is negligible.

At 2 mins. $0.10\text{ L}(58{,}000\text{ mg/L}) = 5{,}800\text{ mg}$.

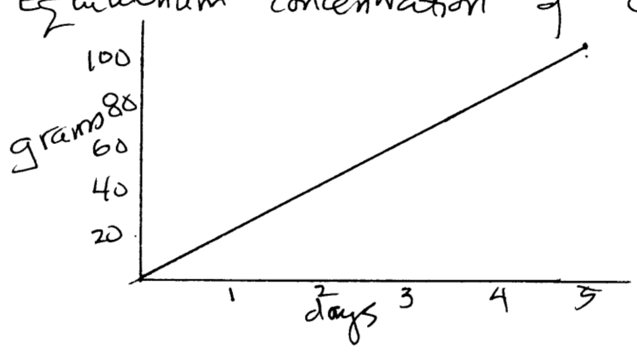
$5{,}800\text{ mg}/200\text{ L} = 29\text{ mg/L}$ in dead rinse tank.

Similarly at 3 min: 43.5 mg/L is concentration in dead rinse tank.

So concentration increases at approximately 14.5 mg/min.
$= 870$ mg/h $= 20.9$ g/day ≈ 21 g/day.

$$C_D = \frac{Q_D C_P + Q_m C_m}{Q_D + Q_m} = \frac{0.05\text{ L/min}(58{,}000\text{ mg/L}) + 0}{0.05\text{ L/min} + 0.05\text{ L/min}} = 29{,}000\ \frac{\text{mg}}{\text{L}}$$

Equilibrium concentration of $C_D = 29{,}000\text{ mg/L} \times 200\text{ L}$
$= 5{,}800{,}000$ mg



Nickel concentration in dead rinse tank as a function of time.

10-1) continued.

The final concentration in the dead rinse tank is 5,800,000 mg = 5,800 g.

As the time beyond 5 days continues, the concentration in the dead rinse tank becomes significant and removal in the dragout and the makeup water becomes important. and the curve of the nickel concentration in the dead rinse tank as a function of time becomes less steep until it becomes horizontal at a concentration in the dead rinse tank of 5,800 grams.

10-2) C_P = 58,000 mg/L nickel
Q_D = 0.05 L/min
Single running rinse tank
Operation is 24 h/day.

What Q_R will give only C_1 = 15 mg/L.
How much nickel is lost in rinse water per day?
What is nickel concentration in rinse water effluent?

a) $$Q_R = \frac{Q_D(C_1 - C_P)}{(C_R - C_1)} = \frac{0.05\ \text{L/min}\ (15\ \text{mg/L} - 58{,}000\ \text{mg/L})}{0 - 15\ \text{mg/L}}$$

$$= \frac{2{,}899}{15}\ \text{L/min} = 193\ \text{L/min}.$$

b) $Q_R C_1$ = 193 L/min × 15 mg/L = 2,895 mg/min.

In 24 hours: 2,895 mg/min × 60 min/h × 24 h/day

= 4,168,800 mg/day = 4.17 kg nickel lost in 24 hour day.

c) Concentration in the dragout is the same as the concentration in the effluent and the same as the concentration in the single rinse water tank.

or C_1 = 15 mg/L.

10-3) Same as 10-2) but two countercurrent rinse tanks replace the single running rinse tanks.

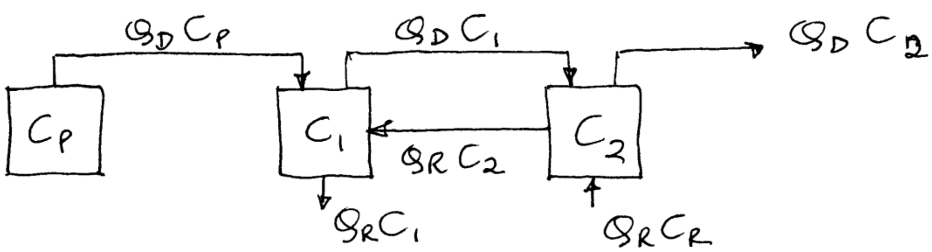
$C_P = 58{,}000$ mg/L Ni
$Q_D = 0.05$ L/min
$C_n = 15$ mg/L = max. Ni conc. in final rinse tank $= C_2$

a) What is Q_R.

$$Q_R = \left[\left(\frac{C_P}{C_n}\right)^{1/n} + \frac{1}{n}\right] Q_D$$

$$= \left[\left(\frac{58{,}000}{15}\right)^{1/2} + \frac{1}{2}\right] 0.05 \text{ L/min} = \left[62.18 + 0.5\right] 0.05 = 3.13 \text{ L/min.}$$

b) What is Ni conc. in rinse water effluent?



mass balance equation $\quad Q_D C_P + Q_R C_2 = Q_D C_1 + Q_R C_1$

$$(0.05 \times 58{,}000) + (3.13 \times 15) = C_1 (0.05 + 3.13)$$

$$C_1 = \frac{2{,}900 + 46.95}{3.18} = 926.7 \text{ mg/L.}$$

c) How much Ni is lost in rinse water wasted per day?

$$Q_R C_1 = 3.13 \text{ L/min} \times 926.7 \text{ mg/L} = 2{,}900 \text{ mg/min.}$$

$$2{,}900 \text{ mg/min} \times 60 \text{ min/h} \times 24 \text{ h/d} = 4{,}176{,}000 \text{ mg/d}$$
$$= 4.176 \text{ kg/d.}$$