Leaching Example

A source of ore containing NaCl has been located. The mined material contains $\frac{0.2 \; tons \; NaCl}{ton \; of \; insoluble \; ore}$. The strong extract exiting stage 1 is to have a concentration $\boldsymbol{y_1 = 0.20}$. We need to recover 85% of the incoming salt using pure water as the solvent

If 5 tons of insoluble are to be processed per hour what is:

a) The required flow rate of water
b) The required number of ideal stages

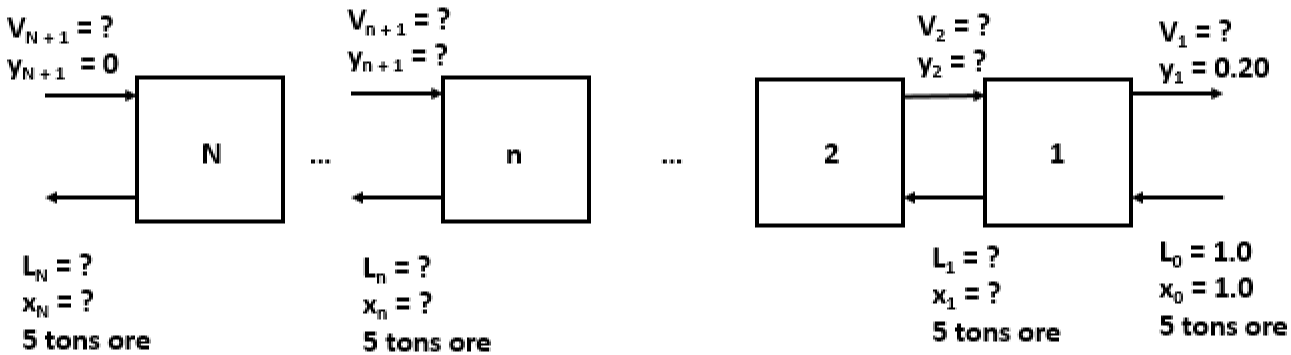
Solution Retention Data:

Solution Concentration in Mass % NaCl	Tons of solution retained per ton of exhausted rock
0	0.30
4	0.50
8	0.80
12	1.00
16	1.10
20	1.15

One hour basis:

$$\boldsymbol{5 \; tons \; ore * \frac{0.2 \; tons \; salt}{ton \; of \; insoluble \; ore} = 1.0 \; tons \; NaCl}$$

The battery of leaching vessels has the following information:



Problem states that we will recover 85% of the NaCl in the extract:

$$y_1\,V_1 = 0.85 * \ (x_0\,L_0) = 0.85 * 1.0 = 0.85\ \ tons\ NaCl\ in\ V_1$$

$$1.0 - \ 0.85 = 0.15\ tons\ NaCl\ in\ L_N$$

Problem also states that $y_1 = 0.20$ $\quad\therefore V_1 = {}^{0.85}/_{0.20} = 4.250\ ton\ solution$

Because the flows are very non-constant we need to begin by solving for x_N iteratively.

From the retention data on the attached chart and table we can calulate L_N based on a guess of x_N. Then, because we know how much salt in the exiting raffinate, we can calculate what the concentration x_N that would correspond to the value ofcalculated value of L_N. If the value of x_N calculated as a function of L_N does not match the value used when we determined L_N then the guess of x_N was incorrect and we need to iterate.

Guess $x_N = 0.06$

Interpolating the retention data leads to $0.65\ \frac{tons\ solution}{ton\ raw\ ore}$

$$\therefore\ L_N = 0.65\ \frac{tons\ solution}{ton\ raw\ ore} * 5\ ton\ ore = \ 3.25\ ton\ solution$$

Then $x_N = \frac{0.15 \ ton \ salt}{3.25 \ ton \ solution} = 0.046$ This does not match the value of x_N we used to determine L_N

Guess $x_N = 0.051$

Interpolating the retention data leads to $0.5825 \ \frac{tons \ solution}{ton \ raw \ ore}$

$\therefore \ L_N = 0.5825 \ \frac{tons \ solution}{ton \ raw \ ore} * 5 \ ton \ ore = \ 2.913 \ ton \ solution$

Then $x_N = \frac{0.15 \ ton \ salt}{2.913 \ ton \ solution} = 0.0515$ This does match within our ability to read the graph.

Solution Balance across the entire battery:

$$L_0 + \ V_{N+1} = L_N + \ V_1$$

$$1.0 + \ V_{N+1} = 2.913 + \ 4.25$$

a) $V_{N+1} = 6.16 \ tons \ of \ water$

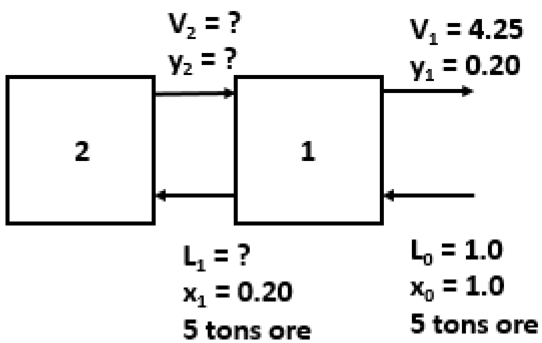
In order to determine the number of stages we need to construct an operating line. We already have two points:

$(x_N \, , y_{N+1}) = (0.051, 0)$ and $(x_0 \, , y_1) = (1.0, 0.20)$

The next step is to do balances around stage 1

We know that for ideal stages $x_n = y_n$, therefore $x_1 = y_1 = 0.20$

From data we know that for $x_1 = 0.20$ there are $1.15 \frac{tons\ solution}{ton\ raw\ ore}$ and therefore $L_1 = 1.15 * 5 = 5.75\ ton\ solution$



Solution Balance

$$L_0 + V_2 = L_1 + V_1$$

$$1.0 + V_2 = 5.75 + 4.25$$

$$V_2 = 9.0\ tons$$

NaCl Balance

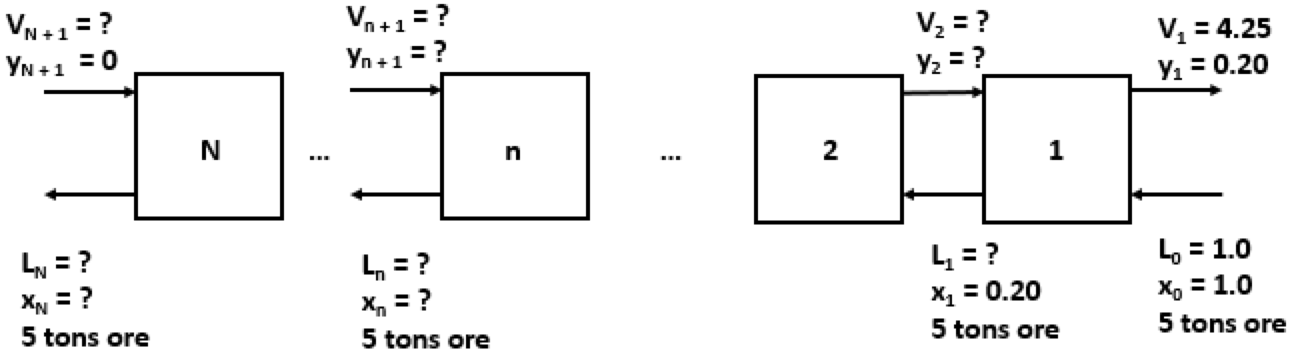
$$x_0 L_0 + y_1 V_2 = x_1 L_1 + y_1 V_1$$

$$1.0 + y_2 * 9.0 = 0.20 * 5.75 + 0.20 * 4.25$$

$$y_2 = 0.111$$

Now we have the point $(x_1, y_2) = (0.20, 0.111)$

Now we will do balances containing stages 1 to n.



We can choose an arbitrary value for x_n due to the fact that the stage n is an arbitrary location in the battery.

Choose $x_n = 0.12$ this leads to $1.0 \frac{tons\ solution}{ton\ raw\ ore}$ from the retention data.

Therefore $L_n = 1.0 * 5 = 5\ tons\ solution$

Solution Balance

$$L_0 + V_{n+1} = L_n + V_1$$

$$1 + V_{n+1} = 5 + 4.25$$

$$V_{n+1} = 8.25\ ton\ solution$$

NaCl Balance

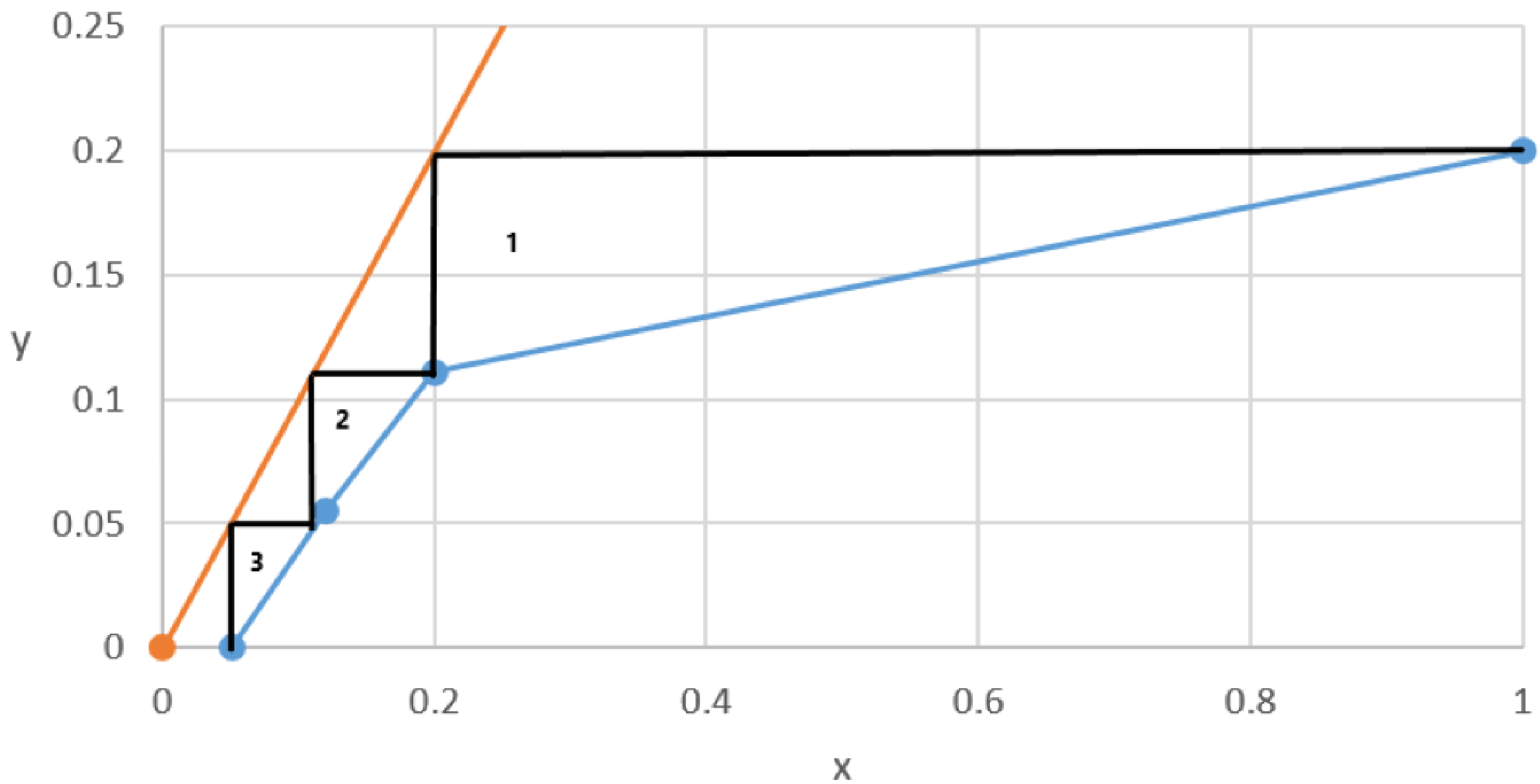
$$x_0 L_0 + y_{n+1} V_{n+1} = x_n L_n + y_1 V_1$$

$$1.0 + y_{n+1} * 8.25 = 0.12 * 5.0 + 0.20 * 4.25$$

$$y_{n+1} = 0.055$$

Now we have the point $(x_n, y_{n+1}) = (0.12, 0.055)$

We can now plot the operating and equilibrium lines. (Remember that equilibrium line is $x_n = y_n$)



b) There are 3 ideal stages required.