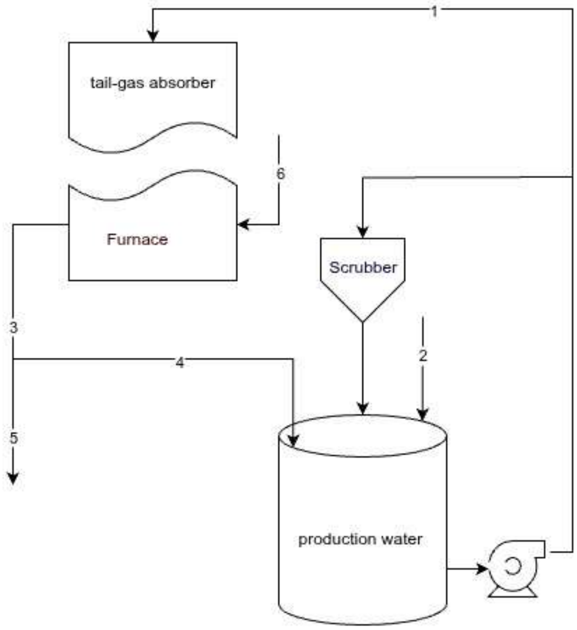
Calculating HCl Recycle Flow



$$Furnace_{Cl2.load} := [550, 600..800] \frac{m^3}{hr} = \begin{bmatrix} 550 \\ 600 \\ 650 \\ 700 \\ 750 \\ 800 \end{bmatrix} \frac{m^3}{hr}$$

$$\rho_{Cl2} := 3.15 \frac{kg}{m^3} \qquad \rho_{H2O} := 1 \frac{tonne}{m^3}$$

$$HCl_{gas.prod} := \frac{36.5}{35.5} \cdot \rho_{Cl2} \cdot Furnace_{Cl2.load} = \begin{bmatrix} 1.7813 \\ 1.9432 \\ 2.1052 \\ 2.2671 \\ 2.429 \\ 2.591 \end{bmatrix} \frac{tonne}{hr}$$

$$HCl_{aq.3} := \frac{HCl_{gas.prod}}{0.31} = \begin{bmatrix} 5.7461 \\ 6.2685 \\ 6.7909 \\ 7.3133 \\ 7.8356 \\ 8.358 \end{bmatrix} \frac{tonne}{hr}$$

from DCS observations in comparison with Water.ideal.1

$$Leakage_{H2O.6} := 1.6 \frac{tonne}{hr}$$

$$Water_{ideal.1} := \left| \begin{array}{l} \text{for } n \in [1..\text{length}(HCl_{gas.prod})] \\ \quad a_n := \text{solve}\left(\dfrac{HCl_{gas.prod\ n}}{HCl_{gas.prod\ n} + x \frac{tonne}{hr}} = 0.31, x \right) \\ a \frac{tonne}{hr} \end{array} \right. = \begin{bmatrix} 3.9648 \\ 4.3253 \\ 4.6857 \\ 5.0462 \\ 5.4066 \\ 5.767 \end{bmatrix} \frac{tonne}{hr}$$

w.t% diluted acid maintained in tank because of scrubber & recycle 4. This enters tail-gas absorber

$$DiluteAcid_{real.1} := [0, 0.02..0.14] = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \end{bmatrix} \%$$

⊞— Basic Scheme

$$DiluteAcidFeed_{real.1} := \left| \begin{array}{l} \text{for } m \in \left[1..\text{length}\left(DiluteAcid_{real.1}\right)\right] \\ \quad \left| \begin{array}{l} \Sigma H2O_{feed_m} := Leakage_{H2O.6} + x\,\frac{\text{tonne}}{\text{hr}} \cdot \left(1 - DiluteAcid_{real.1_m}\right) \\ \text{for } n \in \left[1..\text{length}\left(HCl_{gas.prod}\right)\right] \\ \quad \left| \begin{array}{l} \Sigma HCl_{feed_n} := HCl_{gas.prod_n} + x\,\frac{\text{tonne}}{\text{hr}} \cdot DiluteAcid_{real.1_m} \\ a_{m\,n} := \text{solve}\left(\frac{\Sigma HCl_{feed_n}}{\Sigma HCl_{feed_n} + \Sigma H2O_{feed_m}} = 0.31,\ x\right) \end{array} \right. \end{array} \right. \\ a\,\frac{\text{tonne}}{\text{hr}} \end{array} \right.$$

⊞— deNest Function

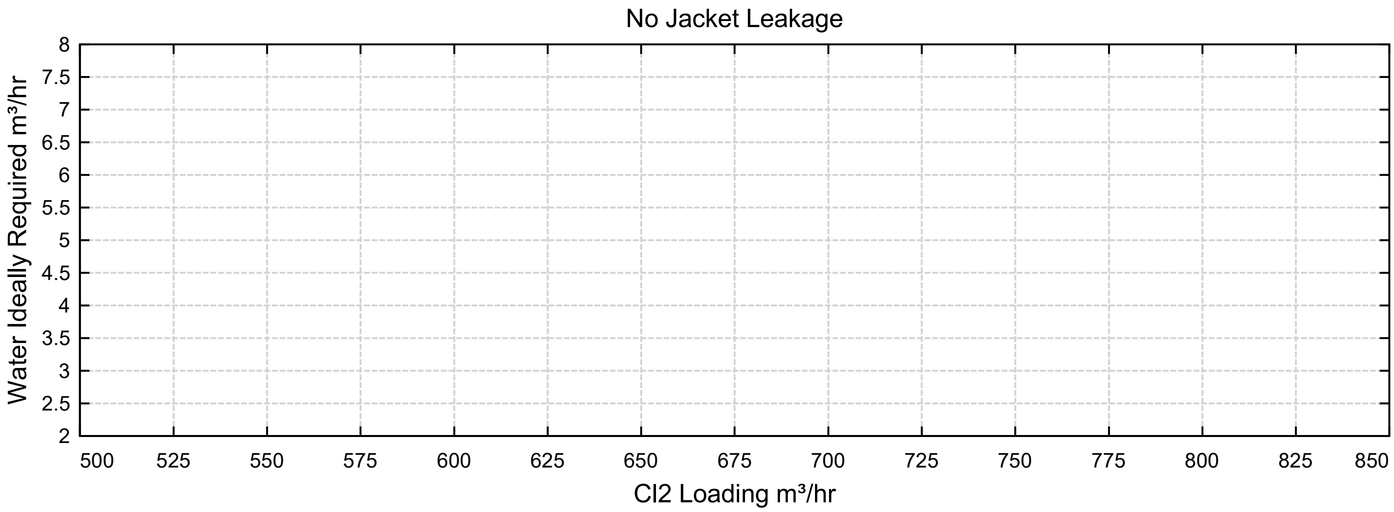
$$Table := \left| \begin{array}{l} horizontal := \text{stack}\left(\text{"Diluted Feed\% ↓ | Cl2 Load m³/h →"},\ DiluteAcid_{real.1} \cdot 100\right) \\ vertical := \text{stack}\left(Furnace_{Cl2.load}^{\ \mathrm{T}} \cdot \frac{3600}{1}\,\frac{\text{s}}{\text{m}^3},\ DiluteAcidFeed_{real.1} \cdot \frac{3600}{1000}\,\frac{\text{s}}{\text{kg}}\right) \\ \text{augment}\left(horizontal,\ vertical\right) \end{array} \right.$$

Table =

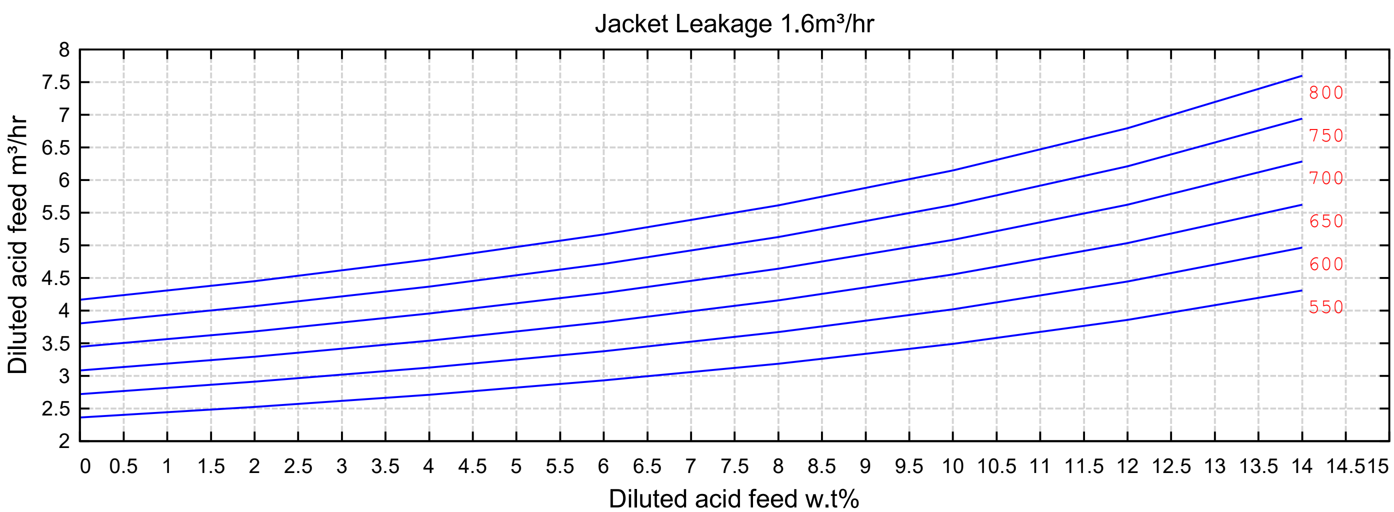
"Diluted Feed% ↓ | Cl2 Load m³/h →"	550	600	650	700	750	800
0	2.36	2.73	3.09	3.45	3.81	4.17
2	2.53	2.91	3.3	3.68	4.07	4.45
4	2.72	3.13	3.54	3.96	4.37	4.78
6	2.93	3.38	3.83	4.27	4.72	5.17
8	3.19	3.67	4.16	4.64	5.13	5.62
10	3.49	4.02	4.56	5.09	5.62	6.15
12	3.86	4.45	5.03	5.62	6.21	6.8
14	4.31	4.97	5.63	6.28	6.94	7.6

Plotting curves for various furnace Cl2 loading

$$\left| \begin{array}{l} \text{for } n \in \left[1..\text{cols}\left(DiluteAcidFeed_{real.1}\right)\right] \\ \quad \left| \begin{array}{l} y_n := \text{col}\left(DiluteAcidFeed_{real.1} \cdot \frac{3600}{1000}\,\frac{\text{s}}{\text{kg}},\ n\right) \\ plot_n := \text{augment}\left(DiluteAcid_{real.1} \cdot 100,\ y_n\right) \\ label_n := \text{augment}\left(14,\ y_{n_8},\ \text{var2str}\left(Furnace_{Cl2.load_n} \cdot 3600\,\frac{\text{s}}{\text{m}^3}\right),\ 8\right) \end{array} \right. \end{array} \right.$$

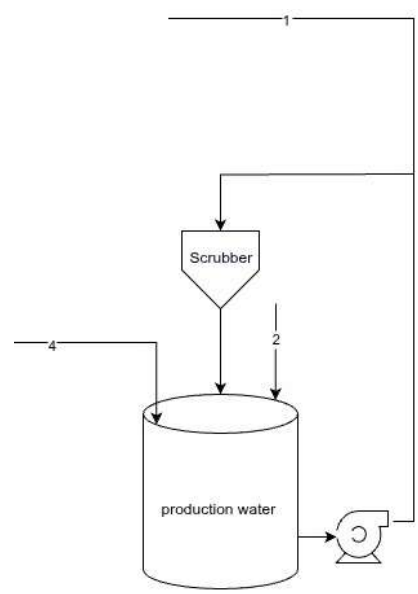


$$\left\{ \text{augment}\left(\text{Furnace}_{Cl2.load} \cdot \frac{3600}{1}\,\frac{s}{m^3},\ \text{Water}_{ideal.1} \cdot \frac{3600}{1000}\,\frac{s}{kg} \right) \right.$$



$$\left\{ \begin{array}{l} \text{plot} \\ \text{deNest}(\text{label}) \end{array} \right.$$

Balance around production water tank



$$DiluteAcid_{Feedvol.1} := [3..7]\ \frac{tonne}{hr} = \begin{bmatrix} 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{bmatrix} \frac{tonne}{hr}$$

$$DiluteAcid_{FeedConc.1} := [0.02, 0.04..0.10] = \begin{bmatrix} 2 \\ 4 \\ 6 \\ 8 \\ 10 \end{bmatrix} \%$$

$$PureWater_{Feedvol.2} := a\ \frac{tonne}{hr}$$

$$Acid_{Feedvol.4} := b\ \frac{tonne}{hr}$$

$$Acid_{FeedConc.4} := 0.31$$

Basic Scheme

$$var := \text{for } m \in [1..\text{length}(DiluteAcid_{Feedvol.1})]$$
$$\quad \text{for } n \in [1..\text{length}(DiluteAcid_{FeedConc.1})]$$
$$\quad\quad WB_{m\,n} := Acid_{Feedvol.4} \cdot (1 - Acid_{FeedConc.4}) + PureWater_{Feedvol.2} - DiluteAcid_{Feedvol.1\,m} \cdot (1 - DiluteAcid_{FeedConc.1\,n})$$
$$\quad\quad AB_{m\,n} := Acid_{Feedvol.4} \cdot Acid_{FeedConc.4} - DiluteAcid_{Feedvol.1\,m} \cdot DiluteAcid_{FeedConc.1\,n}$$
$$\quad\quad \begin{bmatrix} j_{m\,n} \\ k_{m\,n} \end{bmatrix} := \text{roots}\left(\begin{bmatrix} WB_{m\,n} \\ AB_{m\,n} \end{bmatrix}, \begin{bmatrix} a \\ b \end{bmatrix}\right)$$
$$\quad \begin{bmatrix} j \\ k \end{bmatrix}$$

$$\begin{bmatrix} PureWater_{Feedvol.2} \\ Acid_{Feedvol.4} \end{bmatrix} := \begin{bmatrix} var_1 \frac{\text{tonne}}{\text{hr}} \\ var_2 \frac{\text{tonne}}{\text{hr}} \end{bmatrix} = \blacksquare \frac{\text{tonne}}{\text{hr}}$$

$$RecycleAcid_{31\%} := \text{horizontal} := \text{augment}\left(\text{"Feed flow tonne/hr ↓ | Feed HCl% →"}, DiluteAcid_{FeedConc.1}^{T} \cdot 100\right)$$
$$\quad \text{vertical} := \text{augment}\left(DiluteAcid_{Feedvol.1} \frac{\text{hr}}{\text{tonne}}, Acid_{Feedvol.4} \frac{\text{hr}}{\text{tonne}}\right)$$
$$\quad \text{stack}(\text{horizontal}, \text{vertical})$$

$$PureWater_{Feed} := \text{horizontal} := \text{augment}\left(\text{"Feed flow tonne/hr ↓ | Feed HCl% →"}, DiluteAcid_{FeedConc.1}^{T} \cdot 100\right)$$
$$\quad \text{vertical} := \text{augment}\left(DiluteAcid_{Feedvol.1} \frac{\text{hr}}{\text{tonne}}, PureWater_{Feedvol.2} \frac{\text{hr}}{\text{tonne}}\right)$$
$$\quad \text{stack}(\text{horizontal}, \text{vertical})$$

$$RecycleAcid_{31\%} = \blacksquare$$

$$PureWater_{Feed} = \blacksquare$$