

Water Management in Process Plants

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Executive Summary

In the interests of improving water use optimization model accuracy, physical models of several common processes commonly used in refineries for wastewater regeneration were developed. Specifically, the water regeneration processes modeled were:

- API separation
- Activated carbon adsorption
- Reverse osmosis
- Chevron wastewater treatment

Once physical models for each of these processes were developed, the physical models were used to generate performance data for iterations of each of the processes as the process design variables were altered. Non-linear regression was then used to develop relations between the design variables and the performance of the water regeneration process. Specifically, relations for the following performance aspects were developed.

- Process outlet concentration
- Process equipment cost
- Process operating cost

For each of the processes modeled, the results were as follows:

- API separation
 - % Contaminant Removed = $-35.26e^h + 53.05\ln(L) + \frac{84.82}{1+1.58 \cdot 10^4 e^{-210.31\Delta SG}} + 47.45\ln(D_p) - 120.20\frac{F}{A} - 7.6031$
 - $EC = (\$1.35 \cdot 10^4 F + \$7600\ln(\%QS) - \$1400e^{\Delta SG} - \$1100\ln(D_p) + \$700\ln(h) + \$6700)\frac{PST}{\$833}$
 - $OC = (\$1.14 \cdot 10^5 F)\frac{PE}{\$0.07}$
- Activated carbon adsorption
 - $C_{OUT} = \frac{KC_{IN}^2}{2KC_{IN}+1}$
 - $EC = (\$110F + \$100C_{IN} + \$2.29 \cdot 10^4 D + \$610H - \$1.26 \cdot 10^4)\left(\frac{0.31PST}{\$833} + \frac{0.69PAC}{\$2300}\right)$
 - $OC = (\$8800F + \$2.23 \cdot 10^5 C_{IN})\left(\frac{0.11PE}{\$0.07} + \frac{0.89PACR}{\$1840}\right)$
- Reverse osmosis
 - $C_{OUT} = [1 - ((1 - RP)^N)]C_{IN}$
 - $EC = (\$1600F + \$400C_{IN})\left(\frac{PM}{\$90}\right)$
 - $ECs = (\$1600F + \$400C_{IN})\left(\frac{PM}{\$90}\right)[(1 + BR)^{N-1} + 1]$
 - $OC = (\$1100F)\left(\frac{PE}{\$0.07}\right)$
 - $OCs = (\$1100F)\left(\frac{PE}{\$0.07}\right)[(1 + BR)^{N-1} + 1]$
- Chevron wastewater treatment
 - $X_{OUT} = -0.0048\ln(TN) + 0.061X_{IN} + 0.0011e^{RBR} - 0.0035\ln(\eta) + 0.011$
 - $X_{OUT} = -0.0049\ln(TN) + 0.057X_{IN} + 0.0016e^{RBR} - 0.011e^{RFR} - 0.0012\ln(\eta) + 0.035$
 - $EC = (\$14F + \$2900TN + \$2.1 \cdot 10^4 D - \$4000)\frac{PSS}{\$1400}$
 - $OC = (\$1.76 \cdot 10^5 F + \$600)\frac{PH}{\$7.33}$