CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The MINLP model is another method to generate water network with minimum amount of fresh water. Our calculation is easy to do water network synthesis with optimum freshwater flowrate under a set of freshwater data (FW_j^{MAX}). The first calculation by NLP model is to calculate the initial point of flowrate (Flowin_j) of the network which is used for the second calculation by MINLP model to get the optimal results as shown in Table 4.30. The optimal water network and water/wastewater network results are close to the results from literature (Koopal et al., 2003).

The MINLP model with NLP model as initial calculation step is used for simultaneous design of both networks; in water using process and wastewater treating. Grassroots design gives better results in term of TAC and saving cost than the retrofit design of water network only. However in the industrial process, they can choose one of these designs to improve their water network. If they do not want to pay more fixed cost they can use retrofit design of water network only. On the other hand, if they want to reduce more TAC they can use simultaneous grassroots design of water/wastewater network.

NOMENCLATURE

Model 1: Water Network with fixed flow rate

FS, Maximum Water flow rate of source SA_i Concentration of A in sources SB. Concentration of B in sources Water flow rate of sinks FD_{i} Concentration of A in sinks DA_i DB_{i} Concentration of B in sinks Max-concentration of A in sinks DMA_i DMB, Max-concentration of B in sinks Flow rate splitting fraction from i to j $X_{i,j}$ Flow rate splitting from i to j $F_{i,i}$ Fresh water usage for each sink FW_i WW, Waste of each source OFW Overall fresh water flow rate Overall waste water flow rate OWW Binary variable for splitting units $y_{i,j}$ Binary variable for fresh water Z_j feeding units

Model 2: Water Network with fixed contaminant load

LoadA_{i,j} Fixed load of contaminant A

LoadB_{i,j} Fixed load of contaminant B

Flowin_j Flow rate of each process

DeltaCA_{i,j} Outlet concentration A– Inlet

concentration A

DeltaCB_{i,j} Outlet concentration B– Inlet

concentration B

SA_i Concentration of A in sourcesSB_i Concentration of B in sources

Maximum fresh water flow rate

 FS_i^{max}

 DA_{i} Concentration of A in sinks DB_{i} Concentration of B in sinks Maximum concentration of A in DMA_i sinks DMB_i Maximum concentration of B in sinks $X_{i,i}$ Flow rate splitting fraction from i to j Flow rate splitting from i to j $F_{i,j}$ FW, Fresh water usage for each sink **OFW** Overall fresh water flow rate Water flow rate of source FS_i FD_i Water flow rate of sinks WW, Waste of each source OWW Overall waste water flow rate Binary variable for splitting units $y_{i,j}$ Binary variable for water feeding $\mathbf{z}_{\mathbf{i}}$ units HY Working time (h/yr) CostFW Cost of fresh water (\$/t) CostnX Cost of splitting units (\$/unit) CostnF Cost of water feeding units (\$/unit) FWCost Total cost of fresh water (\$/yr) nXCost Total cost of splitting units (\$)

Model 3: Water/wastewater

nFCost Total cost of water feeding units (\$)

Network with Treating Units

LoadA_{i,j} Fixed load of contaminant A

LoadB_{i,j} Fixed load of contaminant B

Flowin_j Flow rate of each process

DeltaCA_{i,j} Outlet concentration A– Inlet

concentration A

DeltaCB_{i,j} Outlet concentration B– Inlet

concentration B

FS_i^{max} Maximum fresh water flow rate

SA_i Concentration of A in sources

SB_i Concentration of B in sources

DA_i Concentration of A in sinks

 DB_i Concentration of B in sinks CWA_w Maximum concentration of contaminant A in sinks waste DMA_i Maximum concentration of A in CWB_w Maximum concentration of sinks DMB_i Maximum concentration of B in contaminant B in sinks waste CWC_w Maximum concentration of sinks Flow rate splitting fraction from i to j contaminant C in sinks waste $X_{i,j}$ $F_{i,i}$ Flow rate splitting from i to j Flow rate splitting fraction from i to $W_{i,w}$ Fresh water usage for each sink FW_i w **OFW** Overall fresh water flow rate $wF_{i,w}$ Flow rate splitting from i to w Water flow rate of source FS_i Water flow rate of source FS_{i} WW. Water flow rate of sinks Water flow rate of sinks waste FD, WW, Waste of each source OWW Overall waste water flow rate Model 5: Grassroots Design for OWD Overall waste water disposal Water/Wastewater Network Binary variable for splitting units $y_{i,j}$ LoadAi, Fixed load of contaminant A Binary variable for water feeding $\mathbf{Z}_{\mathbf{J}}$ LoadB_{i,j} Fixed load of contaminant B units Flowin, Flow rate of each process HY Working time (h/yr) DeltaCA Outlet concentration A- Inlet CostFW Cost of fresh water (\$/t) concentration A Cost of treatment water (\$/t) DeltaCBi Outlet concentration B- Inlet CostnX Cost of splitting units (\$/unit) concentration B CostnF Cost of water feeding units (\$/unit) FS_i max Maximum fresh water flow rate FWCost Total cost of fresh water (\$/yr) SA, Concentration of A in sources TCost Total cost of treatment water (\$/yr) SB. Concentration of B in sources nXCost Total cost of splitting units (\$) DA_i Concentration of A in sinks nFCost Total cost of water feeding units (\$) DB_i Concentration of B in sinks **TAC** Total annual cost (\$/yr) DMA, Maximum concentration of A in sinks Model 4: Retrofit Design of Water DMB, Maximum concentration of B in **Network with Treating Units** sinks Concentration A in sources SA_i Flow rate splitting fraction from i to j $X_{i,1}$ SB_i Concentration B in sources $F_{i,j}$ Flow rate splitting from i to j SC_i Concentration C in sources FW_i Fresh water usage for each sink WA. Concentration A in sinks waste OFW Overall fresh water flow rate WB_w Concentration B in sinks waste FS_i Water flow rate of source WC_w Concentration C in sinks waste Water flow rate of sinks FD_i

 WW_i

Waste of each source

0

OWW Overall waste water flow rate

OWD Overall waste water disposal

 $y_{i,j}$ Binary variable for splitting units

z_j Binary variable for water feeding

units

0

HY Working time (h/yr)

CostFW Cost of fresh water (\$/t)

CostT Cost of treatment water (\$/t)

CostnX Cost of splitting units (\$/unit)

CostnF Cost of water feeding units (\$/unit)

FWCost Total cost of fresh water (\$/yr)

TCost Total cost of treatment water (\$/yr)

nXCost Total cost of splitting units (\$)

nFCost Total cost of water feeding units (\$)

TAC Total annual cost (\$/yr)