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 ($Flowin_i$) 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_i Maximum Water flow rate of source
SA_i Concentration of A in sources
SB_i Concentration of B in sources
FD_j Water flow rate of sinks
DA_i Concentration of A in sinks
DB_j Concentration of B in sinks
DMA_j Max-concentration of A in sinks
DMB_j Max-concentration of B in sinks
$x_{i,j}$ Flow rate splitting fraction from i to j
$F_{i,j}$ Flow rate splitting from i to j
FW_j Fresh water usage for each sink
WW_i Waste of each source
OFW Overall fresh water flow rate
OWW Overall waste water flow rate
$y_{i,j}$ Binary variable for splitting units
z_j Binary variable for fresh water 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
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_j Concentration of B in sinks
DMA_j Maximum concentration of A in sinks
DMB_j Maximum concentration of B in sinks
$x_{i,j}$ Flow rate splitting fraction from i to j
$F_{i,j}$ Flow rate splitting from i to j
FW_j Fresh water usage for each sink
OFW Overall fresh water flow rate
FS_i Water flow rate of source
FD_j Water flow rate of sinks
WW_i Waste of each source
OWW Overall waste water flow rate
$y_{i,j}$ Binary variable for splitting units
z_j Binary variable for water feeding 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 ($)
nFCost Total cost of water feeding units ($)

Model 3: Water/wastewater 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_j Concentration of B in sinks

DMA_j Maximum concentration of A in sinks

DMB_j Maximum concentration of B in sinks

$x_{i,j}$ Flow rate splitting fraction from i to j

$F_{i,j}$ Flow rate splitting from i to j

FW_j Fresh water usage for each sink

OFW Overall fresh water flow rate

FS_i Water flow rate of source

FD_j Water flow rate of sinks

WW_i Waste of each source

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

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)

Model 4: Retrofit Design of Water Network with Treating Units

SA_i Concentration A in sources

SB_i Concentration B in sources

SC_i Concentration C in sources

WA_w Concentration A in sinks waste

WB_w Concentration B in sinks waste

WC_w Concentration C in sinks waste

CWA_w Maximum concentration of contaminant A in sinks waste

CWB_w Maximum concentration of contaminant B in sinks waste

CWC_w Maximum concentration of contaminant C in sinks waste

$w_{i,w}$ Flow rate splitting fraction from i to w

$wF_{i,w}$ Flow rate splitting from i to w

FS_i Water flow rate of source

WW_w Water flow rate of sinks waste

Model 5: Grassroots Design for Water/Wastewater Network

$LoadA_{i,j}$ 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_j Concentration of B in sinks

DMA_j Maximum concentration of A in sinks

DMB_j Maximum concentration of B in sinks

$x_{i,j}$ Flow rate splitting fraction from i to j

$F_{i,j}$ Flow rate splitting from i to j

FW_j Fresh water usage for each sink

OFW Overall fresh water flow rate

FS_i Water flow rate of source

FD_j Water flow rate of sinks

WW_i Waste of each source

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

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)