CHAPTER III
PROCEDURE

3.1 Grass-root Design for Heat Exchanger Network

The methodology used for heat exchanger network design is consisted of

3.1.1 Study and Test The MILP Model

Study the model to understand how it works and interpret the result of the optimal heat exchanger network. Generally, the MILP model is composed of two parts which are

3.1.1.1 Input or Set Parameters

Parameters such as heat transfer zone, number of temperature intervals, heat content in each interval, temperature upper and lower in each interval, flow rate, heat capacity and heat transfer coefficient for hot and cold process streams, logarithmic mean temperature difference, utility cost, price of heat exchanger, any assumptions for example non-isothermal mixing and constraints that indicated the allowed or forbidden matching between each pair of hot and cold streams are put into the first part of the model.

3.1.1.2 Set of Equations

This part is used to generate the optimum heat exchanger network that can be operated at minimum total cost while the transshipment model concept is applied. There are many equations and constraints presented into this zone and all explanations are mentioned in the previous chapter.

3.1.2 Modify Non-Automatic MILP Model

This step, non-automatic MILP model is modified to be an automatic model. Without manually input all parameters stated above in the input part, the model with automatic parameter calculation can be generated by adding more equations to produce the parameter values automatically. For example, the following equations used for LMTD calculation are equipped with the model, so the LMTD parameter is not necessary to set into the first part of the model at all.

$$LMTD = \frac{HHEAD_{im,jn} - CHEAD_{im,jn}}{LOG\left(HHEAD_{im,jn} / CHEAD_{im,jn}\right)} \tag{3.1}$$

when, $HHEAD_{im,jn} > 0, CHEAD_{im,jn} > 0, HHEAD_{im,jn} > CHEAD_{im,jn}$

or

$$LMTD = \frac{HHEAD_{im,jn} + CHEAD_{im,jn}}{2} \tag{3.2}$$

when,

$$HHEAD_{im,jn} > 0, CHEAD_{im,jn} > 0, HHEAD_{im,jn} < CHEAD_{im,jn}, or HHEAD_{im,jn} = CHEAD_{im,jn}$$

while,

$$HHEAD_{im,jn} = \sum_{\substack{m \in M_i^z \\ n \in N_j^z}} \left(T_m^U - T_n^U\right) \quad \text{and} \quad CHEAD_{im,jn} = \sum_{\substack{m \in M_i^z \\ n \in N_j^z}} \left(T_m^L - T_n^L\right) \tag{3.3}$$

$HHEAD_{im,jn}$ = Temperature difference between interval m of hot stream i and interval n of cold stream j at hot end

$CHEAD_{im,jn}$ = Temperature difference between interval m of hot stream i and interval n of cold stream j at cold end

T_m^U = Upper temperature of interval m

T_m^L = Lower temperature of interval m

T_n^U = Upper temperature of interval n

T_n^L = Lower temperature of interval n

In convenient, automatically dividing the temperature interval for each stream process is considered. Some sets of equations are attached in order to specify and calculate all parameters.

Temperature difference in each interval m for hot stream i

$$DT_H = \frac{\sum_{\substack{i \in H^z \\ z \in Z}} \left(Tin_{i,z} - Tout_{i,z}\right)}{\sum_{m \in M_i^z} m} \tag{3.4}$$

Temperature difference in each interval n for cold stream j

$$DT_C = \frac{\sum_{\substack{j \in C^z \\ z \in Z}} \left(Tin_{j,z} - Tout_{j,z}\right)}{\sum_{n \in N_j^z} n} \tag{3.5}$$

Instead of putting many parameters stated above, only few parameters are required, for example heat content, upper and lower temperature in each interval and logarithmic mean temperature difference can not be contained into this part because the model can automatically generate them all.

3.1.3 <u>Apply The Automatic MILP Model</u>

The variables studied in this work are the temperature intervals and heat transfer zone. The target that is necessary to concern also be the total cost for the heat exchange process. The simulations are proposed to test with four examples and the number of intervals are varied to find the stable heat exchanger network.

3.1.4 <u>Analyze The Objective Value Stability</u>

These included any other costs which are utility, fixed and area cost, and the heat exchanger network structure when changing the variable such as temperature interval.

3.2 Retrofit Design for Heat Exchanger Network

3.2.1 Adjust Grass-root Design Model to be Retrofit Configuration

For retrofit model, additional equations are required to specify the existing heat exchanger or indicate the existing matches between hot and cold streams. All of constraint equations are mentioned in Chapter II.

3.2.2 Comparison MILP Approach to any Other Methods

The network structure produced by MILP model are compared with solutions generated by Ciric et al. (1989) and Kin-Lung Ma et al. (2000).