CHAPTER III
EXPERIMENTAL

3.1 Equipment

3.1.1 Computer

A. Lenovo Y450 Intel® Core 2 Duo P7450 (2.13 GHz)

B. Acer Intel® Core 2 Quad Processor Q6600 (2.4 GHz)

3.1.2 Software

A. Mathematical programming software: Generic Algebraic Modeling System (GAMS).

B. Commercial process engineering simulation software (PRO/II).

C. Microsoft Visio.

D. Microsoft Excel Spreadsheet.

3.2 Methodology

3.2.1 Formulation of Stage-wise Superstructure Model for Single Period

3.2.1.1 Model

Firstly, a single period model is formulated based on stage-wise superstructure of Yee and Grossmann (1990) using GAMS as the optimization program. This single period model will be the starting point of following modified models.

3.2.1.2 Case Study

A simple case study of three hot streams and four cold streams is used to verify the model. The data is adapted from a literature of Verheyen and Zhang (2006). As their case study is a multiperiod problem of vacuum gas oil (VGO) hydrotreating unit in oil refinery. Therefore, the selected stream data is chosen from one of those three periods.

3.2.2 Sequential Approach for Multiperiod HEN Synthesis

3.2.2.1 Algorithm

Several algorithms of multiperiod heat exchanger network synthesis will be proposed. The methodology is based on the utilization of only MINLP single period model from section 3.2.1. Some modifications on the model may be needed in accordance with each algorithm.

3.2.2.2 Case Study

A case study is applied with the proposed algorithms. As mentioned before, the problem is adapted from the literature of Verheyen and Zhang (2006). It composes of three operational periods of VGO hydrotreating unit. Those different conditions of each period result from deactivation of catalyst used in the process. After applying each algorithm, the multiperiod HENs will be compared by considering total annualized cost (TAC).

3.2.3 Simultaneous Approach for Multiperiod HEN Synthesis

3.2.3.1 Model

For simultaneous approach, the MINLP single period model will be modified to obtain an MINLP multiperiod model where it can solve the problem as all-at-once step by taking into account all stream data of every period concurrently. Therefore, there is no need to assemble the solution of each period.

3.2.3.2 Case Study

The case study is similar to the one that is used in sequential approach. The best final solutions of sequential and simultaneous approaches will be compared.

3.2.4 Application to the Industrial Case: CDU Process

There are some differences between case study and real case. Basically, the real case problem is larger and more complex which means that there are more streams involved in HEN. This makes the model non-convex and difficult to solve. For example, it may require much more computational time to solve or the solution may fall to a local optimum because the search space is very large.

For real industrial case study, firstly, simulation of the real process has to be done by using PRO/II, and then essential data will be extracted from the program to be applied with the model. The procedures are shown as follows:

A. Simulating the refinery process using PRO/II as a real case study.
B. Extracting the required data from PRO/II which are needed for GAMS
C. Applying the MINLP multiperiod model with the real case data.
D. Validating the results from GAMS on PRO/II in order to test its feasibility.

The validation step is important because some assumptions are used in mathematical model for simplification such as constant heat capacity flowrates. But, in fact, heat capacity is a function of temperature. Therefore, as the temperature changes, heat capacity changes. Because of this issue, validation of final HEN has to be done to see its feasibility in real simulation.

3.2.5 Model Improvement

During developing models, some ideas of model improvement may arise to reduce the computational time. This is because solving by GAMS is very sensitive by nature of solver especially MINLP which cannot guarantee the global optimal solution.