CHAPTER III

EXPERIMENTAL

3.1 Methods and Tools

3.1.1 Equipment:

1. Desktop computer (Dell, Vostro 3450 Intel(R) Core i3-2330, 2.20 GHz RAM 8 GB, Microsoft Office 2007)

3.1.2 Software:

1. PRO/II version 9.1
2. SustainPro program
3. SimaPro version 7.0
4. ECON

3.2 Experimental Procedures

3.2.1 Literature survey

The objective here is to define the sustainable design problem, taking into account, the available knowledge of the process.

a. Study and review the background of bioethanol production including their environmental impact through the LCA and sustainability techniques.
b. Study the feasibility of the potential of raw materials (cellulosic materials) in Thailand and select the best material for the process.
c. Focus on the selected raw material (in this work, it is cassava rhizome), getting all the necessary information.

3.2.2 Location of the Bioethanol Production from Cassava Rhizome Plant

The reasonable location for the plant should be placed close to the available raw material sources and also not too far from ethanol distributors or refineries. In this report, the cassava production was used directly for indicating cassava rhizome quantity which means the higher cassava production, the more cassava rhizome. According to Office of Agricultural Economics, Ministry of

Agriculture and Cooperatives (2010), Most of cassava production in Thailand are concentrated in five provinces, namely Nakhonratchasima, Kampaeng Phet, Sakaew, Chaiyapoom and Kanchanaburi. In term of the distance from plant to refinery area (in this case assume to be Rayong province) and the distance from raw material sources to plant. Nakhonratchasima province has the highest cassava production in Thailand, not too far from ethanol distributors or refineries. Moreover,it also near other province that has high cassava production in Thailand. According to the previous information, the most appropriate location for bioethanol production from cassava rhizome plant is Nakhonratchasima province.

3.2.3 Capacity of the Bioethanol Production from Cassava Rhizome Plant

Thailand has available unused of cassava rhizome about 2.55 million tons per year. This is based on theoretical ethanol production yield from cassava rhizome is about 0.34 L/kg dry (NREL, 2002). According to the total demand of ethanol in Thailand (2011) which is about 11.50 million liters per day (February 2012), plant operation of 330 days/year, price of cassava rhizome about 500 Baht/ton (16.67 $/ton), price of ethanol about 20.7 Baht/L (0.69$/L) and exchange rate at 30 Baht/1 USD, the capacity for ethanol production from cassava rhizome is about 150,000 liters/day (average from operating plants in Thailand). This is about 1.30 % of total demand of ethanol in Thailand. The plant requires the quantity of cassava rhizome about 940 tons/day or 310,000 tons/year (330 operation days) which about 12.13 % of total available unused cassava in Thailand. This capacity should provide acceptable profit and adequate for collecting of cassava rhizome around the agricultural area.

3.2.4 Process Simulation

The objective here is to obtain steady state mass and energy balance information for the process so that analysis related to cost, sustainability, LCA, etc., can be performed.

a. Simulate the process at the established base case design for the process flow-diagram and the selected materials, using the selected process simulator.

b. Verify that the necessary assumptions for the steady state simulation models to be used in process simulation are compatible with the actual process-operation scenario.
c. Verify if the available data satisfy the data neeeded by the simulator.
d. Generate the missing data through through suitable model-based tools, for example, ICAStools (for missing property data, operation design, solvents, etc.).

3.2.5 Sustainability analysis

The objective here is to perform the sustainability analysis in order to indicate area for base case design improvement.

a. Collect of mass and energy balance data from simulation results.
b. Identify all the mass and energy flow-paths in the process by decomposing the flow-diagram into open- and close-paths for each compound in the process.
c. Determine the parameters (indicators) for the sensitivity analysis.
d. Generate alternative designs based on operability, energy consumption, waste reduction, environmental impact, safety and cost. Verify the new designs through process simulation.

3.2.6 Life cycle assessment (LCA)

The objective here is to perform the LCA in order to compare the process alternative.

a. Define the functional unit for bioethanol production.
b. Perform inventory analysis and collect data related to environmental and essential quantities for all relevant data and within the defined system boundary.
c. Generate the life cycle impact assessment (LCIA) data with the selected software.

d. Analyze and compare the impacts on human health and the environment burdens associated with raw material and energy inputs and environmental releases quantified by the inventory.

3.2.7 Economic evaluation

The objective here is to perform economic analysis in order to compare the generated sustainable design alternatives

a. Select location of the bioethanol production plant.
b. Collect stream and operational data of materials, unit operations and utilities from process simulation.
c. Determine the indicators for the economic analysis with the selected software.
d. Analyze and compare the cost requirements of each part of the process based on materials, equipment and utilities.