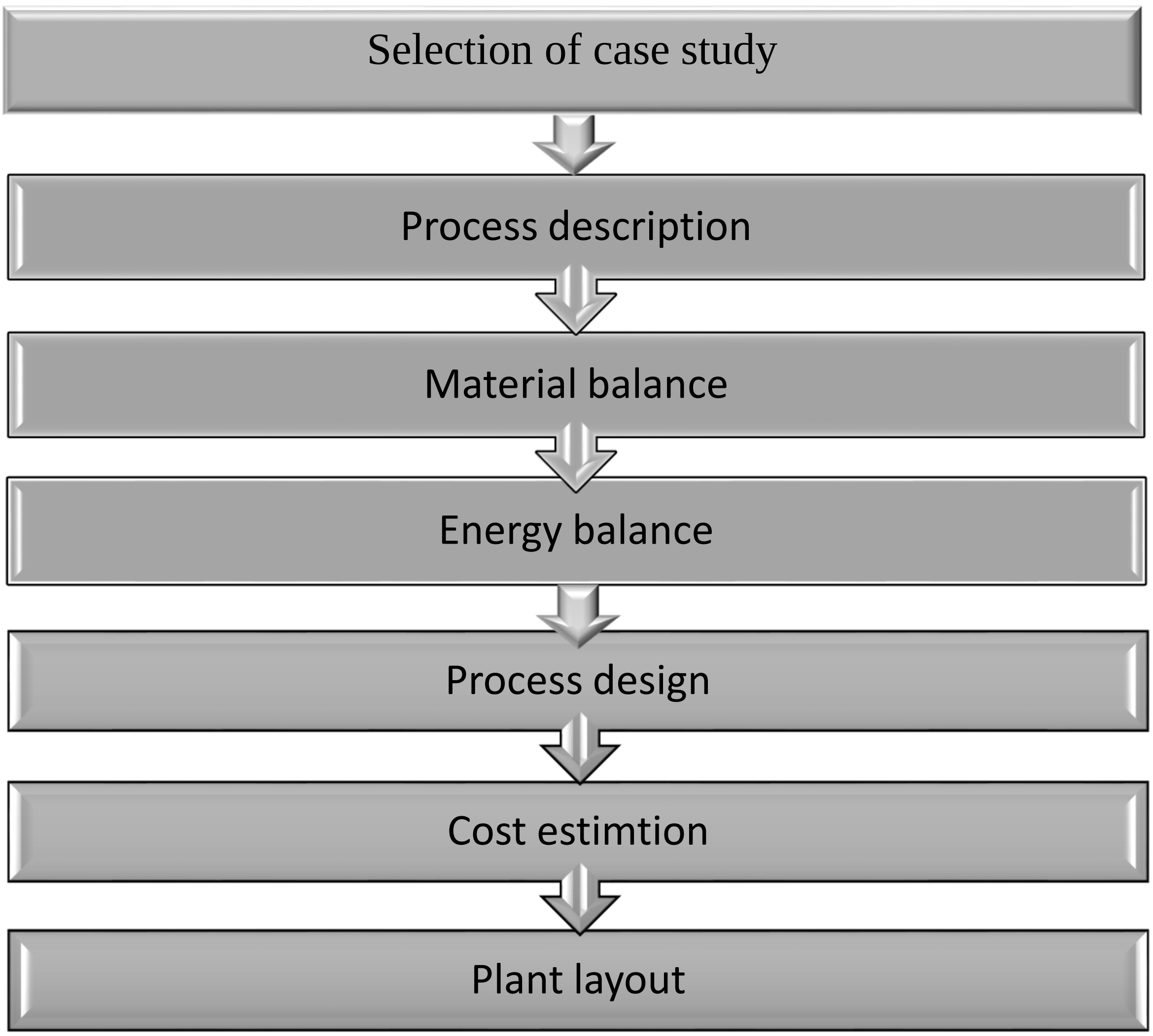
CHAPTER 3

METHODOLOGY

3.1. Project work:



3.1.1. Selection of case study:

Gasoline produced from Khartoum refinery is chosen as the subject for this project, the amount of gasoline production by Khartoum refinery is 3400ton/day.

3.1.2. Process description:

A simplified process flow diagram for the MTBE plant is shown in Figure 3.1. The methanol and mixed butenes feed are pumped and heated to reaction conditions. The reactor operates at 20 bar to ensure that the reaction occurs in the liquid phase. The reaction is operated at low temperatures to obtain favorable equilibrium behavior for MTBE production. The reactor effluent is distilled in Tower 901, with MTBE as the bottom product. Methanol is separated from the butenes with a methanol absorber. Essentially all of the butenes pass through the absorber while the methanol dissolves in the water phase. Methanol is separated from water by distillation in Tower 903 so that pure methanol reactant can be recycled.

3.1.2.1Process Equipment:

-Pump (P-901 A/B, includes spare pump):

The pump increases the pressure of the mixed feed to the reaction conditions. The liquid density may be estimated using a linear average of the pure component densities, weighted by their mass fractions in the mixture. The cost of electricity to

run the pump is a utility cost based on the required power for the pump. The required power is the work multiplied by the mass flow rate of Stream 4.

-Heat Exchanger (E-901):

This heat exchanger heats the feed to the reactor feed temperature. Each component must remain in the liquid phase at the chosen pressure. The cost of the heat source is a utility cost.

-Reactor (R-901):

This is where the reaction occurs. The reactor is adiabatic, and the reaction is exothermic. Therefore, the heat generated by the reaction raises the temperature of the exit stream. The exit temperature is a function of the conversion. The reaction must be run at a pressure and temperature to ensure that all components remain in the liquid phase in the reactor. Methanol must be present in the reactor feed at a minimum 200% excess to suppress undesired side reactions that produce undesired products. An operating pressure must be chosen. Temperature and conversion must be determined.

-Distillation Column (T-901):

This column runs at 19 atm. (The pressure is controlled by a valve, that is not shown on the PFD, in the product stream from R-901.) Separation of methanol and MTBE occurs in this column. Of the methanol in Stream 7, 98% enters Stream 9. Similarly, 99% of MTBE in Stream 7 enters Stream 8.

-Heat Exchanger (E-902):

In this heat exchanger, the some of the contents of the stream leaving the bottom of T-901 going to E-902 are vaporized and returned to the column. The amount returned to the column is equal to the amount in Stream 8. The temperature of these streams is the boiling point of MTBE at the column pressure. There is a cost for the amount of steam needed to provide energy to vaporize the stream; this is a utility cost. The steam temperature must always be higher than the temperature of the stream being vaporized.

-Heat Exchanger (E-903):

In this heat exchanger, the contents of the top of T-901 are partially condensed from saturated vapor to saturated liquid at the column pressure. 99% of the MTBE and water condense and 99% of all other components remain in the vapor phase. The remaining 1% of all other components condense with the MTBE. It may be assumed that this stream condenses at the boiling point of methanol at the column pressure.

There is a cost for the amount of cooling water needed; this is a utility cost. The cooling water leaving E-903 must always be at a lower temperature than that of the stream being condensed.

-Absorber (T-902):

The absorber runs at 5 atm and 90°C (outlet streams and Stream 11). In the absorber, 99% of the methanol in Stream 9 is absorbed into the water. All other components enter Stream 12. The cost of Stream 9 is a raw material cost. Process water sent to scrubber is controlled so that 5.0 kmol of water are used for every 1.0 kmol of methanol.

-Distillation Column (T-903):

This column runs at 5 atm. (The pressure is controlled by a valve in the product stream from T-903, which is not shown on the PFD.) Separation of methanol and water occurs in this column. Of the methanol in Stream 14, 99% enters Stream 15. Similarly, 99% of water in Stream 14 enters Stream 16.

-Heat Exchanger (E-904):

In this heat exchanger, the some of the contents of the stream leaving the bottom of T-903 going to E-904 are vaporized and returned to the column. The amount returned to the column is equal to the amount in Stream 16. The temperature of these streams is the boiling point of water at the column pressure. There is a cost for the amount of steam needed to provide energy to vaporize the stream; this is a utility cost. The steam temperature must always be higher than the temperature of the stream being vaporized.

-Heat Exchanger (E-905):

In this heat exchanger, the contents of the top of T-903 are completely condensed from saturated vapor to saturated liquid at the column pressure. It may be assumed that this stream condenses at the boiling point of methanol at the column pressure.

The flowrate of the stream from T-902 to E-905 is three times the flowrate of Stream 15. There is a cost for the amount of cooling water needed; this is a utility cost. The cooling water leaving E-905 must always be at a lower temperature than that of the stream being condensed.

3.1.2.2. The flow sheet:

As showing in figure (3.1)below:

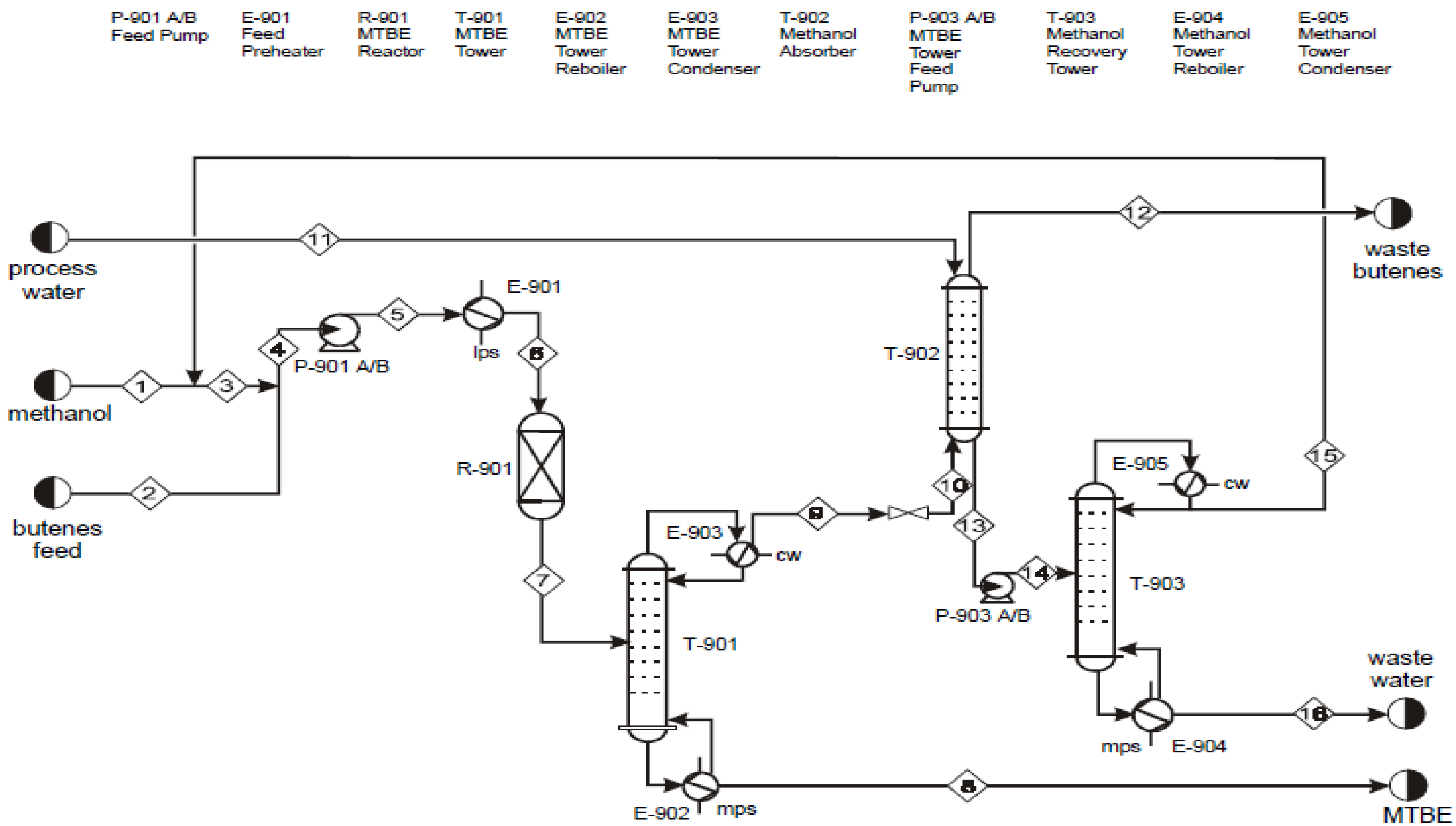


Figure 3.1.Unit 900 - MTBE Production Facility.

3.1.3. Material balance:

-Over all material balance.

-Material balance around reactor(R-901).

-Material balance around distillation column (T-901).

-Material balance around methanol absorber (T-902).

-Material balance around tower (T-903).

Calculations are made by using Excel sheet.

3.1.4. Energy balance:

-Energy balance around summing point

-Energy balance around heat exchanger (E901).

-Energy balance around reactor (R901).

-Energy balance around distillation column (T901).

-Energy balance around methanol absorber (T902).

-Energy balance around distillation column (T903).

Calculations are made by using Excel sheet.

3.1.5 Process design:

3.1.5.1. Distillation design:

-Design procedure:

1-Collect the data of fluid to be distillated and distillated fluids.

2-Determination of the type of trays required.

3-Specification of the light and heavy key components.

4-Determination of the minimum reflux ratio required (R_{min})

5-Determination of the actual reflux ratio(R)

6-Calculation of the minimum number of theoretical stages(N_{min})

7-Calculation of the number of theoretical stages (N)

8-Calculation of the column efficiency (E_0)

9-Calculation of the number of actual stage (N_a)

10-Determination of the tray spacing.

11-Determination of the feed plate location.

12-Calculation of the column height.

13-Calculation of the tower diameter.

14-Determination of the fractional entrainment.

15-Calculation of the pressure drop (head).

16-Calculation of the down comer residence time (t_d).

17-Calculation of the down comer residence time (t_d).

18-Checking of flooding.

19-Determination of the tower and the closure thickness (mechanical design).

20-Summary of the design and specification of distillation.

3.1.5.2 Reactor design.

3.1.6. Cost estimation:

-Estimation of MTBE plant cost

-Estimation of purchased equipment cost

-Estimation of total capital investment (T.C.I).

-Estimation of working capital.

-Estimation of total production cost (T.P.C).

-Estimation of total income.

-Estimation of payback period (PBP).

-Net present value (NPV).

-Breakeven point.

-Internal rate of return (IRR).

Most of chemical plant use an initial working capital about 10-20% of total capital investment.

3.1.7. Plant layout:

- Plant location.

-Plant layout.

Proposed location for MTBE plant is Khartoum refinery.