Benzene Toluene Fractionation Unit

Background:

Benzene Toluene Fractionation to produce pure benzene via Benzene Distillation during the past decade, multivariable controllers for have been extensively applied in ethylene plants. These control applications have increased process efficiency and plant capacity.

By now, the technology is well understood and widely accepted. The only obstacle to further implementation and better maintenance is the cost and the majority of the cost lies in the model identification step.

The Benzene/Toluene fractionator is part of an aromatics extraction unit. The aromatics are extracted from an aromatics rich stream using liquid/liquid extraction. The benzene is separated from the aromatic extract in a distillation column. The light and heavy key components are benzene and toluene, respectively. The relative volatility for these compounds is approximately 2.5, making this a separation with a moderate reflux to feed ratio required. This means that incremental benefits of better control are moderate and justifying a major control project for such an application can be a challenge. But, the benefits of better control are not insignificant, especially with the high cost of energy, in recent years.

Description of flowsheet:

The equimolar mixture of benzene and toluene feed enters at 100kmol/h at 25 degree Celsius in to a preheater heat exchanger where it is heated up to 40.32 degree Celsius by the bottoms of the distillation column. The preheated feed then enters the 11th stage of the 24 staged distillation column which is operating with 1 atm condenser and boiler pressure at a reflux ratio of 10. The distillate obtained has 0.91 mole fraction of benzene at 55kmol/h and the bottoms is obtained at 45kmol/h at 110.4 degree Celsius temperature which is recycled to a heat exchanger and used to preheat the feed. The distillate is hence purified benzene which is obtained at 82 degree Celsius is the final product. The cooled bottoms at 83 degree Celsius is highly pure toluene with a mole fraction of 0.999 which is also of high importance to the industry. The Roult’s Law property package is used in the flowsheet.

Results:

1) Distillate obtained is benzene with mole fraction of 0.91.

2) The bottoms is highly pure toluene with mole fraction of 0.999.

3) The total power requirement for the process is 255kW which is readily calculated by DWSIM.

4) The condenser duty is 5259kW and the reboiler duty is -5514kW.

5) The feed is preheated from 25 degree Celsius to 40 degree Celsius by the bottoms which in turn cools from 110 degree Celsius to 83 degree Celsius.

Conclusions:

1) The distillate concentration can be varied by varying the reflux ratio in the distillation column. By increasing the reflux ratio, higher purity of benzene can be obtained.

2) The bottoms is at 110 degree Celsius and hence this heat can be effectively used to preheat the feed or elsewhere.

Reference:

Unit Operations of Chemical Engineering, by Warren L. McCabe, Julian C. Smith, Peter Harriott, Chapter 18, Problem no.4