

Pressure swing distillation column for separation of Ethanol-water mixture.

The aim of this work is to simulate a pressure-swing distillation column for the separation of ethanol from a ethanol-water binary system. The choice for this system is because of importance of ethanol-water system.

Introduction:

It is been observed that the separation of components forming an azeotrope is quite a challenging task because due to the formation of azeotrope it is not possible to the separation through a simple distillation process because their relative volatility becomes equal to unity. However, separation of such non-ideal mixtures is a very common process in chemical industries. There are three methods to separate such mixtures azeotropic distillation, extractive distillation and pressure swing distillation column.

Methodology:

In this simulation we used two components ethanol and water. The thermodynamic package used in this simulation is Raoult's law. In this simulation we use two distillation columns as the name suggest one with the low pressure and another one with the high pressure both with 22 stages. The LPC operates at 1 atm and the HPC operates at 11 atm. The feed with a flow rate of 100 kmol per hour and at a composition of (mole fraction 0.3 ethanol). The feed is introduced at 16 stage in LPC, there are actually two inputs to the LPC feed at 16 and recycled out at 5 stage respectively. After passing through the LPC we achieve our motive actually the distillate is pure ethanol while the bottom containing the mixture of ethanol and water is introduced as a feed to HPC at stage 7. The bottom gives us approximately with a water concentration of around 90% and the distillate of the HPC is sent for recycling.

Properties of HPC and LPC

1. Number of stages: LPC=22 and HPC=22
2. Pressure of the column: LPC= 1 atm and HPC= 11 atm
3. Conditions of the feed: LPC= 1 atm pressure and approx. 75-degree centigrade temperature and HPC= 1 atm pressure and 81-degree centigrade temperature.
4. Reflux ratio: LPC= 7 and HPC= 0.33.
5. Boiled up ratio: LPC= 0.33 and HPC= 10.
6. Stage efficiencies: LPC= 0.8 and HPC= 1.

Objects used:

1. Distillation column
2. Cooler
3. Valve (2 valve was used)
4. Recycle block

Energy stream ESTR-012 is liberated with a energy of 1937.68 KW after cooling the liquid from 157.205 to 75.3471.

Valve is used to reduce the pressure from 10.997 atm to 1 atm to be able to fed into the LPC.

Results:

| Streams | Temperature (Celsius) | Pressure(atm) | Mole fraction of Ethanol | Mole fraction of water |
|--------------|-----------------------|---------------|--------------------------|------------------------|
| Feed | 75 | 1 | 0.3 | 0.7 |
| Pure ethanol | 78.719 | 1 | 0.99548 | 0.004 |
| Pure water | 184.535 | 10.997 | 0.005 | 0.995 |
| Distillate 2 | 157.178 | 10.997 | 0.945 | 0.055 |
| Recycled out | 75.3471 | 1 | 0.945 | 0.055 |

Reference:

Pressure swing distillation of azeotropic mixture — A simulation study , Asma Iqbal, Syed Akhlaq Ahmad, <http://dx.doi.org/10.1016/j.pisc.2016.01.001>.