Improvement of the MonoChlorobenzene Separation Process through Heat Integration

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Background & Description:

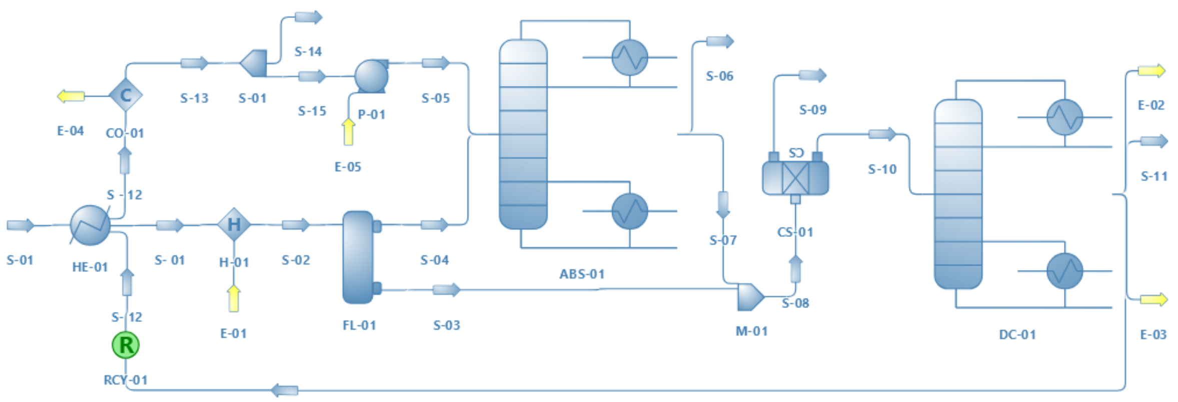
MonoChlorobenzene is an important intermediate in the production of waxes, rubbers, and, pharmaceutical products, among others. Its production occurs mostly from the chlorination of benzene, which produces a stream of benzene (BEN), monochlorobenzene (MCB) and chloridric acid (HCl). A secondary plant to separate these components was simulated and presented in the "Flowsheet" section, based on data from Seider *et al.* [1]. Wilson's Fluid Package was used to describe the equilibrium and thermodynamic relationships. According to Seider, this stream consists of 10% HCl, 40% BEN and 50% MCB, with a flow rate of 100 lbmol/hr, 80 °F and 37 psia. At the end of the process, the overhead outlet stream from the distillation column must have a MCB flow rate of 0.1 lbmol/hr and the bottom outlet stream must have a MCB mole fraction equals to 1.0.

In the original process, a heater was used to raise the feed temperature from 80 °F to 270 °F. After that, the stream passes through a flash vessel. Then, the flash's top stream is sent to an absorber column with 3 theoretical stages and 32 psia. The absorber column and the flash vessel bottom products are mixed and treated for total HCl removal. The S-10 stream components (MCB and BEN) can be separated by a distillation column with 20 theoretical stages and a pressure of 25 psia. The bottom stream from DC-01, constituted mostly of MCB, is divided, and part of it is pressurized and recycled to the absorber column.

It can be seen that the bottom stream (S-12) from the distillation column has a high temperature (306 °F), which requires its cooling to 120 °F by the condenser (CO-01). As the initial stream (S-01) must be heated, it is possible to perform a heat integration, taking advantage of the S-12 temperature, through a shell and tube heat exchanger.

Therefore, the flowsheet presented refers to an MCB separation plant with heat integration between streams S-01 and S-12. The heat exchanger (HE-01) has a minimum approach of 50 °C to obtain a f_t correction factor over 0.8 [2].

Flowsheet:



Heat Integration of MonoChloroBenzene Separation Process Flowsheet

Results:

Stream	S-01	S-05	S-06	S-10	S-11	S-12	S-14
Temperature [°F]	80	120	137	256	209	307	120
Pressure [psia]	37	32	32	32	25	25	25
Molar Flow [lbmol/hr]	100	99.2	9.81	188.9	40.1	148.8	49.5
Molar Composition							
HCl	0.10	0.00	0.96	0.00	0.00	0.00	0.00
BEN	0.40	0.00	0.00	0.21	0.99	0.00	0.00
MCB	0.50	1.00	0.04	0.79	0.01	1.00	1.00

Table 1. Main Streams Results

Object	E-01	E-03	E-05	E-02	E-04
Energy Flow [kW]					
Conventional Process	342.5	1112.3	0.084	1036.9	334.5
Integrated Process	172.5	1112.3	0.084	1036.9	164.3
(%) reduction	50%	-	-	-	51%
Utility Source	Steam (mps)*	Steam (mps)*	Electrical	Cooling water	Cooling water

*medium pressure steam

Table 2. Energy Results

Conclusion & Recommendations:

The simulated MCB separation process on DWSIM software (v6.7.1), with heat integration, presented results similar to the reference [1]. It can be observed that both S-11 and S-14 streams have purity of 99% of BEN and MCB, respectively.

This process presents a total energy consumption (electrical and steam) of 1284.9 kW and requires the removal of 1201.2 kW (cooling water) from the condensers. These results show the benefits related to heat integration as the energy demands from the heater (H-01) and from the condenser (CO-01) were decreased in at least 50%, reducing environmental impacts.

References:

[1] Seider, W. D., Lewin, D. R., Seader, J. D., Widagdo, S., Gani, R, Ming Ng, K., (2016), *Product and Process Design Principles: Synthesis, Analysis and Evaluation*, 4° ed., John Wiley & Sons, West Sessex.

[2] Perry, R. H., (1997) *Perry's Chemical Engineers' Handbook*, 7th ed., McGraw-Hill, New York.