Propylene-Propane separation using mechanical vapor recompression

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Background

Propylene is one of the most important petrochemicals produced globally today. Propylene is an essential raw material in the manufacture of a variety of propylene derivatives like polypropylene, acrylonitrile, cumene and acrylic acid.
About 85% of the global propylene demand is met via conventional methods such as thermal cracking and fluid catalytic cracking. Multiple hydrocarbon products including light alkanes, alkenes and aromatics are generated through thermal cracking. According to the U.S. Department of Energy, the separation of a propylene-propane mixture by distillation is one of the most energy-intensive commercial distillation processes. Separation of propylene-propane via distillation occurs either at high pressures (>20 bar) or at low pressures, requiring cryogenic conditions.
Mechanical heat pumps (MHPs), which use electrical or mechanical energy to move heat from a heat source at a lower temperature to a heat sink at a higher temperature, have been successfully integrated with distillation columns, providing substantial energy savings without the need for major modifications to the existing process.
MHPs can be further broken down into three basic configurations – mechanical vapor recompression (MVR), external vapor recompression and bottom flashing.
In this flowsheet, we develop MVR for Propylene-propane separation and compare it with conventional stripper column.

Description of Flow-Sheet

A C3-splitter receives a 85:15 mole % liquid propylene-propane feed at 47 C° and 19 bar from the upstream C_3H_4 hydrogenation unit.
A pressure drop of 0.7 kPa is assumed for each stage in the C3-splitter. Pressure drops across the condenser, reboiler, flash drums, and heat exchangers are all assumed to be zero.
Conventional stripper column and MVR arrangement are simulated as per selected reference.[1]
Refer 1a, 1b for conventioanl stripper arrangment and 2a,2b from MVR arrangement.

Result

In case of MVR, in re-boiler liquid is vaporised with heat of compressed gas. So there is no direct reboiler duty but energy required by the compressor can be consider as indirect reboiler duty.
After cooling down of compressed gas, it is further cool down with the Joule Thompson effect. And then remained gas is condensed in cooler. This cooler is condenser for MVR column.
So, for MVR;

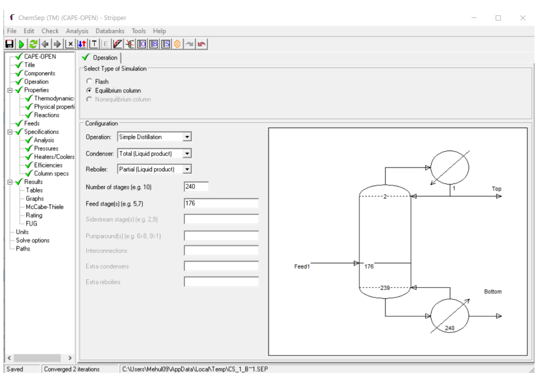
Reboiler duty is 7638 kW &
Condenser duty is 5487 kW.

In case of convention stripper column there is no heat integration so,

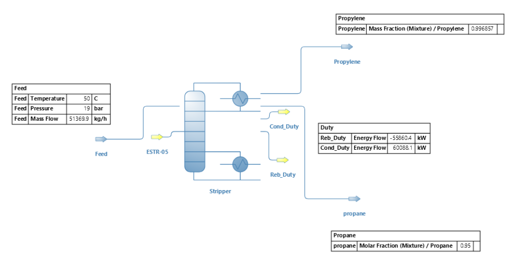
Reboiler duty is 55860 kW &
Condenser duty is 60088 kW.

Tray in conventional column is 240 and for MVR column, it is only 147. But in MVR arrangement one compressor, two heat exchangers and one separator are required which increase CAPEx.

Flowsheet of conventional stripper

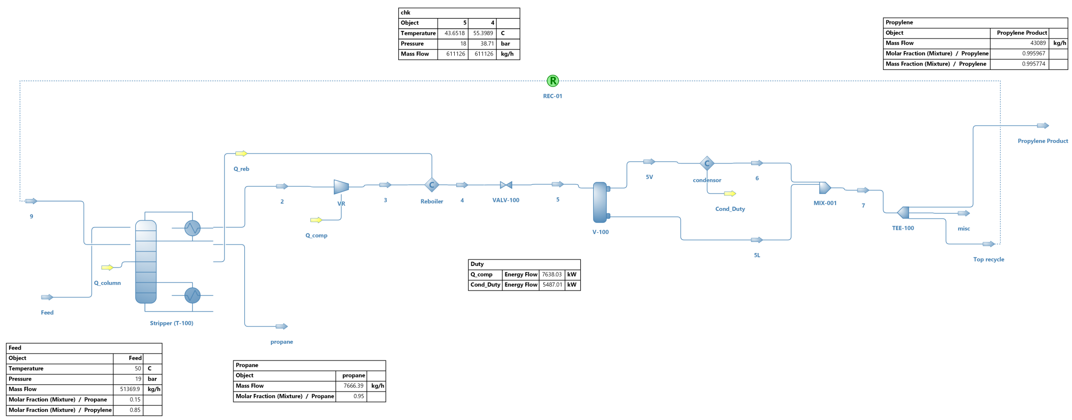


(a) Stripper Column.

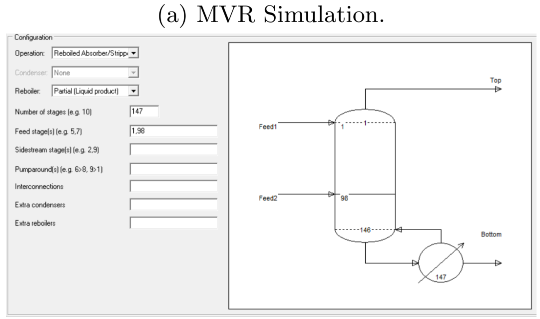


(b) Conventional Stripper Simulation

Flowsheet of Mechanical Vapor Recompression



(a) MVR Simulation.



(b) MVR Column

References

[1] Chang Chu En Christopher, Arnab Dutta, Shamsuzzaman Farooq, and Iftekhar A Karimi;"Process synthesis and optimization of propylene-propane separation using vapor recompression and self-heat recuperation", Ind. Eng. Chem. Res. 2017, 56, 49, 14557–14564.(refer support material for clarity on simulation)

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