Cascade Propane Refrigeration Cycle

Kedar H Joshi

Chemical Engineering Department

VVP ENGINEERING COLLEGE, RAJKOT - 360005

Email: kedarhitenj@gmail.coom

BACKGROUND

Efficient performance of refrigeration system depends upon maximum heat gained by evaporator and utilize it to convert its working fluid to vapor. But after expansion through valve it may consist vapor which will not give contribution to generate cooling effect. And Recycle of effective working fluid may increase size of evaporator and compressor. Also, it may increase compressor duty & reduce COP. By adding a gasliquid separator after expansion valve we can minimize this issue by decreasing flash gas flow.

FLOWSHEET DISCRIPTION

Flowsheet is similar to simple vapor compression refrigeration cycle (2 stage) and propane will work as working fluid but here the middle evaporator is replaced by Gas-Liquid separator (Flash unit). Outlet of VALV-02 (upper loop) is flash unit inlet. Liquid outlet of flash unit is fed to VALV-01 (lower loop) and vapor outlet of flash mixed with outlet of COMP-01 (lower loop). This mixed stream then fed to COMP-02 (upper loop). The design temperatures of -30.3728° C for the evaporation step (outlet) and +40.0701° C for the condensation step (outlet). The design mass flowrate in upper loop is set as 1 kg/s and rest is in accordance with this.

RESULTS

COP of this refrigeration system is 2.83 (for similar non-cascaded single loop system it would 2.43).

$$COP = \frac{\text{Cooling Effect}}{\text{Total Work Input}} = \frac{\text{Q Chilling}}{Total Compressor Duty}$$

Material Streams												
Object	Н	G	F (1)	F	E	D	C(1)	С	B(1)	В	А	
Temperature	-30.3729	-0.314341	-0.314341	40.0701	47.9819	4.49487	-0.314341	4,49487	6.49135	6.49135	-30.3728	С
Pressure	1.664	4.742	4.742	13.805	13.805	4.742	4.742	4.742	4.742	4.742	1.664	bar
Mass Flow	0.691406	0.691406	0.983583	0.983583	0.983583	0.99079	0.292177	0.99079	0.691406	0.691406	0.691406	kg/s
Molar Flow	56,4469	56.4469	80.3005	80.3005	80.3005	80,8889	23.8535	80.8889	56,4469	56.4469	56,4469	kmol/h
Volumetric Flow	0.0324348	0.00131057	0.0296424	0.00216666	0.0339658	0.09836	0.0283318	0.09836	0.0692965	0.0692965	0.180984	m3/s
Mixture Density	21.3168	527.56	33.1817	453.963	28.958	10.0731	10.3127	10.0731	9.97751	9.97751	3.82027	kg/m3
Vapor Phase Molar Fraction	0.173656	0	0.297053	0	1	1	1	1	1	1	1	

Energy Streams										
Object	Duty Evaporator (Q Chilling)	Condenser	Duty COMP-02	Duty COMP-01	Unit					
Energy Flow	235.62	381.795	50.1435	33.0672	kW					

REFERENCE

Lorens T. Biegler, E. Ignacio grossmann, Arthur W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall International.

 $\underline{https://mychemengmusings.wordpress.com/2014/03/01/ideal-two-stage-economizer-refrigeration-process-cycle for-propane/}$