Cascade Propane Refrigeration Cycle

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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 gas-liquid 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). Out let of VALV-02 (upper loop) and outlet of COMP-01 (lower loop) is fed to flash unit. Liquid outlet of flash unit is fed to VALV-01 (lower loop) and gas out of flash is fed to COMP-02 (upper loop). The design temperatures of -30.3728^{o} C for the evaporation (outlet) step and +40.0701^{o} 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 2.82 (for similar non-cascaded single loop system it would 2.43).

Material Streams										
Object	H	G	F (1)	F	E	D	C	B	A	Unit
Temperature	-30.3729	-0.314341	-0.314341	40.0701	43.5089	-0.31434	-0.31434	6.49135	-30.3728	C
Pressure	1.664	4.742	4.742	13.805	13.805	4.742	4.742	4.742	1.664	bar
Mass Flow	0.682197	0.682197	1	1	1	1	1	0.682197	0.682197	kg/s
Molar Flow	15.4709	15.4709	22.678	22.678	22.678	22.678	22.678	15.4709	15.4709	mol/s
Volumetric Flow	0.0320027	0.00129312	0.0301371	0.002203	0.033561	0.096968	0.096968	0.068373	0.178573	m3/s
Mixture Density	21.3168	527.56	33.1817	453.963	29.7963	10.3127	10.3127	9.97751	3.82027	kg/m3
Vapor Phase Molar Fraction	0.173656	0	0.297053	0	1	1	1	1	1	-

Energy Streams					
Object	Duty Evaporator (Q Chilling)	Duty Condenser (Q Condensing)	Duty COMP-02	Duty COMP-01	Unit
Energy Flow	232.481	314.814	49.7064	32.6267	kW

REFERENCE

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

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