Collins Helium Liquefaction Cycle

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Background & Description:

The Collins cycle also known as modified Claude cycle is mainly used for helium liquefaction. This liquefier consists of five or six heat exchangers and two reciprocating expander. Collins cycle uses a joule Thomson valve or a turboexpander for cooling down the compressed gas by throttling its flow which results in rapid expansion.

The below mentioned flowsheet is of liquefaction of helium using the Collins cycle with a turbo expander in place of Joule Thompson valve.

Helium gas enter the cycle at -190^{0}C and 1 bar with a molar flow rate of 1000 kmol/h. the feed and the recycled product coming all the way through the exchanger mixes and enters in a compressor which increases the pressure to 15 bar. Then the compressed gas is cooled by using various coolers and five different heat exchangers to get liquified helium as shown in fig 1. After getting cooled the compressed gas is to be passed through a Joule Thompson valve so instead of the valve I have used a turbo expander and a cooler to decrease the pressure to 1 bar and temperature -269^{0}C (boiling point of helium). Hence helium is obtained in liquid state at -269^{0}C. 50% of the product is collected and rest 50% is heated and sent as a recycle in the Collins cycle.

The liquified helium obtained is at 1 bar and -269^{0}C with molar flow rate of 950.5 kmol/hr.

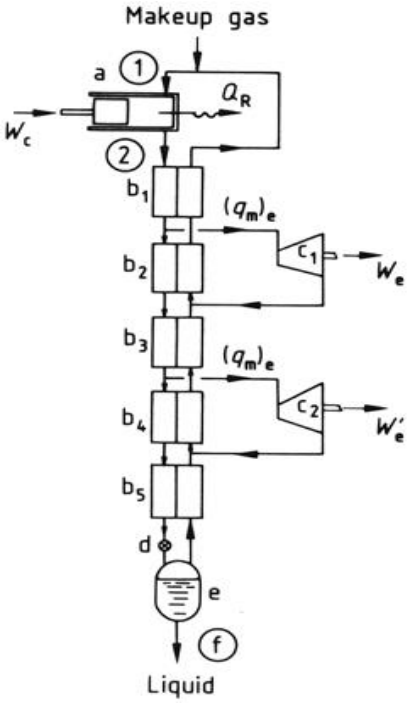
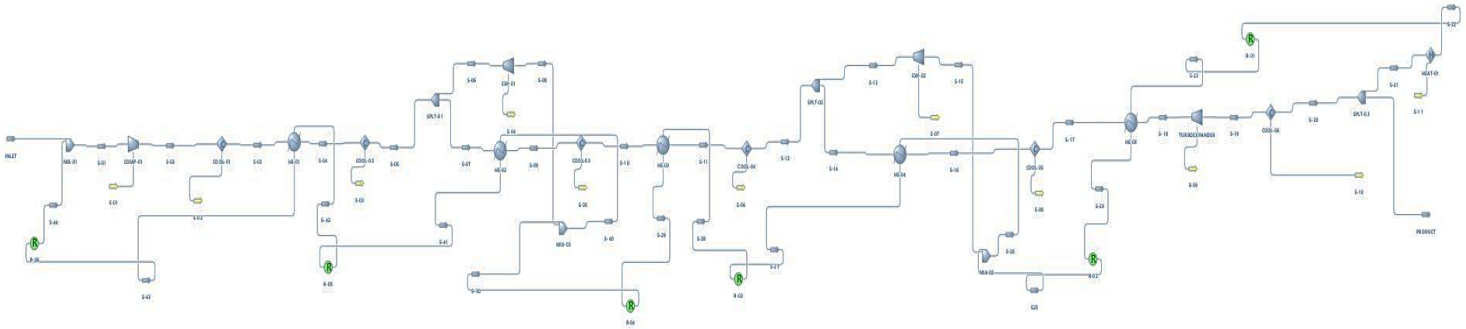


Figure 1. Collins helium liquefaction system a) Compressor; b) Heat exchangers; c) Expanders; d) J–T valve; e) Liquid receiver

Flowsheet:



Results:

Material Stream									
Object	INLET	PRODUCT	S-01	S-02	S-18	S-19	S-22	S-44	
Temperature	-190	-269	-186.709	38.6948	-192.401	-232.65	-220	-185.846	C
Pressure	1	1	1	15	15	1	1	1	bar
Molar Flow	1000	950.581	5143.84	5143.84	1901.16	1901.16	950.581	4129.72	kmol/h
Phases	Vapor Only	Liquid Only	Vapor Only	Vapor Only	Vapor Only	Vapor Only	Vapor Only	Vapor Only	

Expander				
Object	EXP-01	EXP-02	TURBOEXPANDER	
Pressure Drop	14	14	14	bar
Delta-T	-103.318	-58.7357	-40.2488	C.

Heat Exchangers						
Object	HE-01	HE-02	HE-03	HE-04	HE-05	
Cold fluid outlet temperature	-185.846	-193.165	-206.023	-211.291	-215.156	C
Hot fluid outlet temperature	-20.7763	-70.141	-109.073	-160.028	-192.401	C
Logarithmic mean temperature difference LMTD	171.554	128.258	101.616	55.1918	26.3587	C.

Coolers							
Object	COOL-01	COOL-02	COOL-03	COOL-04	COOL-05	COOL-06	
Outlet Temperature	-15	-65	-105	-155	-190	-269	C
Heat Removed	1594.73	1313.44	869.66	1145.78	329.007	442.158	kW
Delta-T	-53.6948	-44.2237	-34.859	-45.9269	-29.9721	-36.3499	C.

Reference:

I. Atrey, M.D., *Thermodynamic analysis of Collins helium liquefaction cycle* ,Cryogenics 38 (1998)

II. Ullmann's Encyclopedia Of Industrial Chemistry: Cryogenic Technology. (Page 15-16)