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Simulation of Gas Condensate Stabilization Unit Aiming at Selecting the Right Technique and Assessing the Optimized Operational Parameters

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Abstract. Gas condensate or natural gasoline is a valuable liquid hydrocarbon mixture which could be utilized as fuel or converted to different petroleum products like gasoline, light oil, jet fuel etc. It should be processed so that its water, salt, and acid contents meets the required standards for storage and transportation. Its vapor pressure, determined as Reid Vapor Pressure (RVP), must be in a range that light components don't evolve as a separate gas phase in transport pipelines or storage tanks. The optimum value is usually 10 psia in summer and 12 psia in winter. In the present study, we investigated condensate stabilization using two methods of multistage flash vaporization and distillation (fractionation) within two case studies. The results show that depending on the properties of feed to be stabilized, one or both of the two methods could be practical. Generally, the fractionation method is preferred over the multistage flashing.

Keywords: Gas Condensate, Stabilization, Simulation, Optimization, HYSYS.

1. Introduction

The process of increasing the quantity of intermediate (C_3 to C_5) and heavy (C_{6+}) components in gas condensate is called condensate stabilization. The main purpose of this process is to reduce the vapor pressure of the condensate liquids to prevent production of vapor phase upon flashing the liquid to atmospheric storage tanks. On the other hand, the scope of this process is to separate very light hydrocarbon gases, methane and ethane in particular, from the heavier hydrocarbon components (C_{3+}). Stabilized liquid, however, has a vapor pressure specification, as the product will be injected into a pipeline or transport pressure vessel, which has definite pressure limitations [1]. It is usually 10 psia in summer and 12 psia in winter case. It should be noted that acidic contents (i.e. H_2S, CO_2, mercaptanes etc), glycol, free water, and possible salts must be also removed to have a gas condensate suitable for end-use applications. There are two methods for stabilizing gas condensates: flash vaporization and fractionation (distillation). Fractionation is more efficient and provides better control over vapor pressure for tanker shipment [2]. Non-refluxed distillation column is simpler but less efficient than refluxed one. Since it doesn't require any external cooling source is particularly applicable to remote locations [2]. Benoy and Kale [3] investigated gas condensate stabilization through three stage flashing, non-refluxed and refluxed distillation with and without hydrocarbon recovery from the flashed gas by compression. They found that heat duty in multistage flashing is much higher than distillation while liquid recovery is less. Nevertheless, liquid recovery is independent of the technique applied when intermediate hydrocarbons are recovered from the flashed gas.

2. Process Description

NGL-3100 gas plant is under construction near the oil production unit of Cheshmeh-khosh located at the southwest of Iran for optimal recovery of C_{2+} product from the associated gases of North Dezful oil fields.

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It's planned to produce 46,000 bbl.d^{-1} C_{2+}, 1180 bbl.d^{-1} Stabilized Sour Condensate, 6.12 MSCMD Sweet Gas, and 0.62 MSCMD Sour Gas.

Shahid Hashemi-nejad (Khangiran) Gas Refinery is located at the northeast of Iran. The feed to the refinery comes from sweet gas reservoirs of Khangiran and sour gas reservoirs of Mozdoran. The treatment of 41.5 MSCMD of sour gas, dehydration of 7.4 MSCMD of sweet gas, distillation of 360000 L.d^{-1} of gas condensates, and recovery of 2400 ton.d^{-1} sulfur are the most important operations undergone in this plant.

The feed to the stabilization units of Khangiran and NGL 3100 plants are mixtures of filter separators, slug catcher, and regeneration gas separators of which the main specifications are listed in tables 1 and 2. Peng Robinson equation of state was applied for thermodynamic calculations of both gas and liquid phases. Since there was no data available on the boiling point curves (including ASTM and TBP distillation curves), the assessment of C_{10+} and C_{6+} oil cuts specifications was carried out by using their respective specific gravities (sp. grs.) and molecular weights (MWs) [4]. The final temperature and pressure of stabilized condensate is governed by the storage conditions which is 35.3°C (95.5°F) and 2 bar in NGL3100 and 37.8°C (100°F) and 0.96 bar in Khangiran case.

Table 1: Feed properties of Khangiran gas processing plant stabilization unit

component	H_2O	N_2	CO_2	H_2S	COS	C_1	C_2	C_3	i-C_4	n-C_4	i-C_5
(mol%)	0	0.02	7.47	11.20	0	11.43	0.97	0.59	0.91	1.27	1.12
component	n-C_5	C_6	C_7	C_8	C_9	C_{10+}					
(mol%)	1.12	1.83	10.41	6.90	6.90	37.86					

Temp. (°F)	Press. (psia)	Molar Flow (lbmole.hr^{-1})	M.W.	RVP (psia)	GCR [1]
74	139	146.7	119.44	155.7	179

Table 2: Feed properties of NGL 3100 gas processing plant stabilization unit

component	H_2O	N_2	CO_2	H_2S	COS	C_1	C_2	C_3	i-C_4	n-C_4	i-C_5
(mol%)	0.00	0.05	2.07	5.31	0	9.07	13.76	20.5	5.67	15.84	6.49
component	n-C_5	C_{6+}	CS_2	Mercaptanes							
(mol%)	6.23	14.92	0.0006	0.0452							

Temp. (°F)	Press. (psia)	Molar Flow (lbmole.hr^{-1})	M.W.	RVP (psia)	GCR
77	413	595.8	53.1	235.9	251

2.1. Multistage Flash Vaporization

Our main objectives were recovering as much as liquid condensate as possible while keeping its RVP at 10 psia for the summer case. However, heat duties of steam heaters and shell and tube heat exchangers (so as their surface areas) should be minimized to reduce the operating and capital costs to the least possible amount. The pressure ratio of flash tanks (separators) was considered equal. The pressure of the last stage (V-102 in Fig. 1) is the atmospheric pressure (0.96 bar) in Khangiran and 2 bar in NGL3100 case while the first one is adjusted in such a way that total heat duties are minimized. The liquid stream leaving the third separator (L3 in Fig. 1) is recycled to preheat the liquid stream leaving the second one so that the heat duty

[1] Gas To Condensate ratio, STD m^3.h^{-1} gas flow per STD m^3.h^{-1} liquid flow

of the following steam heater (E-102 in Fig. 1) is lowered. A pressure drop of 5 psi was designated to both shell and tube sides. The heat duty of the steam heater is adjusted aiming at bringing RVP of the final liquid product to 10 psia. In NGL3100 case an additional preheating and pressure reduction was considered before the feed enters the first separator to increase condensate recovery. The RVP, H_2S, and H_2O concentrations of stabilized condensate are listed in table 3.

It can be inferred that multistage flash vaporization is a practical method to stabilize the condensate in Khangiran case, as it is already utilized in the aforementioned gas processing plant. However, in NGL3100 case, it doesn't sound promising considering low condensate recovery and high total heat duty. H_2S content is high in both cases and must be reduced to standard values (e.g. less than 50 ppm).

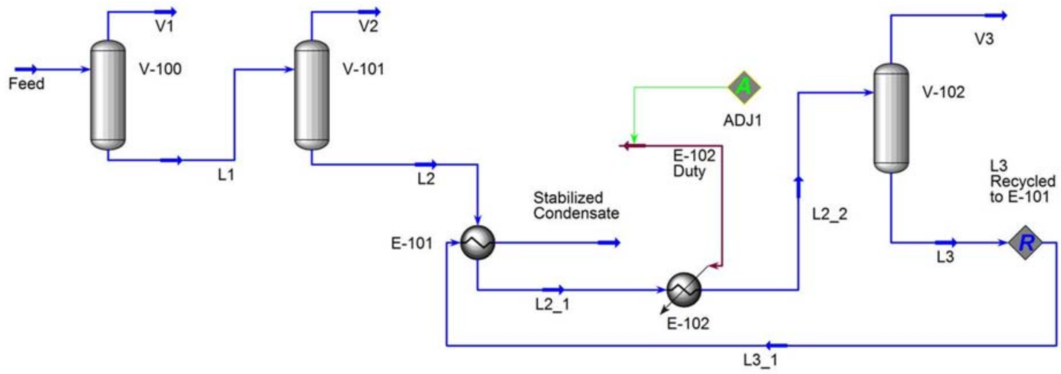

Fig. 1: Multistage flash vaporization scheme with the recycle of hot stabilized condensate

2.2. Fractionation

A distillation column with a reboiler and without any condenser (non-refluxed column) was used (Fig. 2 and 3). The column has 10 theoretical trays; the pressures of top tray and reboiler are 130 and 135 psia in Khangiran and 140 and 145 psia in NGL3100 case respectively. Boil-up ratio is adjusted aiming at having the bottom product RVP at 10 psia. The feed is preheated to an extent that the reboiler and cooler (E-104 in Fig. 2) heat duties are minimized. It is notable that stabilized condensate flow rate and heat duties variations have the same trend, so there's a trade-off between heat duties and the profit obtained from more condensate flow rate. Since the feed pressure of NGL3100 is high (413.4 psia) it passes through a Joule-Thomson valve (VLV-113 in Fig. 3) and reaches to 98.5°F and 159.6 psia. The RVP, H_2S, and H_2O concentrations of stabilized condensate are listed in table 3.

Capital costs of the process equipments aside, multistage flash vaporization is more suitable than the fractionation in terms of total heat duty and the flow rate of stabilized condensate (or condensate to feed ratio) in Khangiran case. However, in NGL3100 case, from table 2 it is clear that fractionation is far better than flashing since it provides more condensate recovery, less heat duty, and H_2S content within the standard range. It seems that RVP of the feed has a great effect on the performance of stabilization unit which, in these cases, were 155.7 psia and 235.9 psia. We should take this fact into account that distillation column is further capable of handling variations in the feed composition (which affects its RVP).

Choosing any of these schemes obviously requires performing cost estimations. The equipments capital cost estimation could be made using methods presented in Product and Process Design Principles [5] or Chemical Process Equipment selection and design [6] books.

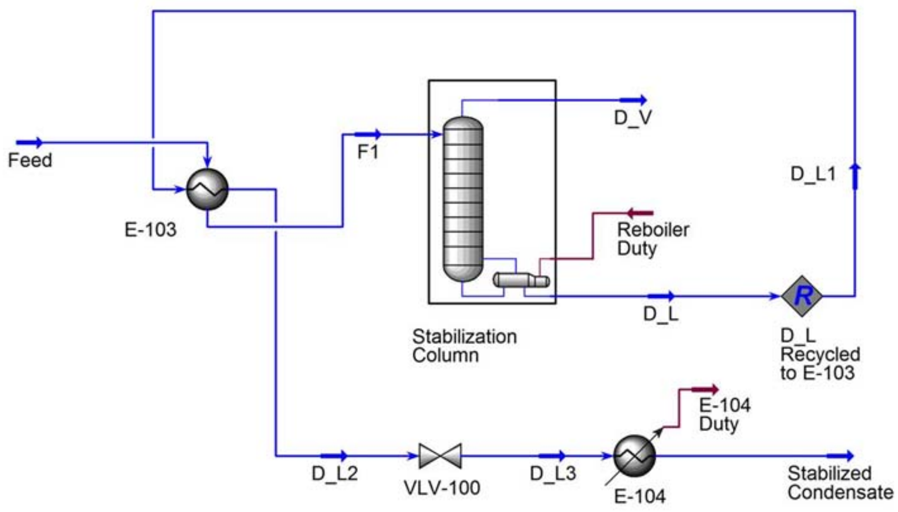

Fig. 2: Fractionation (Distillation) scheme with the recycle of hot stabilized condensate (bottom product) in Khangiran case

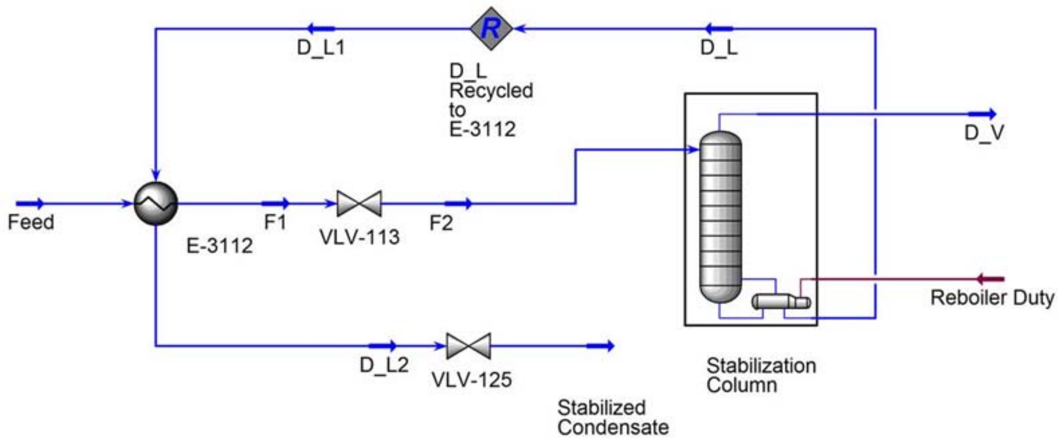

Fig. 3: Fractionation (Distillation) scheme with the recycle of hot stabilized condensate (bottom product) in NGL 3100 case

Table 3: Stabilized condensate specifications in Khangiran and NGL3100 cases

Khangiran	**RVP (psia)**	**H_2S (ppm)**	**H_2O (ppm)**	**Condensate To Feed Ratio (%)**	**Total Heat Duty ($btu.h^{-1}$)**
Fractionation	10	5017	<1	65	1.662×10^6
Flash Tanks	10	5222	<1	69	2.502×10^5
NGL3100	**RVP (psia)**	**H_2S (ppm)**	**H_2O (ppm)**	**Condensate To Feed Ratio (%)**	**Total Heat Duty ($btu.h^{-1}$)**
Fractionation	10	<1	<1	22	3.553×10^6
Flash Tanks	10	206	<1	3.5	5.438×10^6

3. Conclusions

In the present study, two methods of multistage flashing and non-refluxed fractionation were used to stabilize gas condensate by reducing its RVP to 10 psia in summer. Gas condensates of two gas processing plants were considered. Results show that depending on the feed properties (especially its RVP) one or both of the aforementioned techniques could be applied. In Khangiran case (RVP and GCR of the feed were 155.7 psia and 179 respectively), multistage flashing provides less total heat duty and more condensate recovery which makes it more interesting to choose. In NGL3100 case (RVP and GCR of the feed were 235.9 psia and 251 respectively), fractionation yields less total heat duty and much higher condensate recovery. It is also capable of lowering H_2S concentration to less than 1 ppm. Therefore, fractionation is highly preferred. Finally, cost benefit analysis should be performed to select one of these techniques.

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