Gas Condensate Stabilization Methods: Optimum Operating Conditions

Ahmed Samir, Nadia Ali, Said Ali

Abstract*: Gas condensate is a hydrocarbon mixture. It could be converted to petroleum products like jet fuels and gasoline or used as a fuel. Processing of the condensate should be done to meet the storage and transportation standards. Reid Vapor Pressure (RVP) is used to determine the condensate vapor pressure and it must be in the range that doesn't allow the light components to separate as a gas phase in the storage tanks or transport pipelines. The optimum value of Reid Vapor Pressure in winter is usually 12 psia and in the summer is 10 psia. In our case study, we tried to find the optimum operating conditions for a current condensate stabilization unit as the Reid Vapor Pressure of the produced condensate is high and the plant is suffered from high gases emissions from the storage tank besides the problems which faced during condensate shipping. The current technique of condensate stabilization which is already used is flash vaporization technique. This study will show if this method is practical in the current conditions or applying the other method of fractionation (distillation) will be more practical or economic. That will help how to choose the practical method for your case. It is shown from the results that one of the methods or both of them could be practical. That is depending on the properties of feed that need to be stabilized. In general, the distillation method is preferred more than the flash vaporization method.

Keyword: stabilization, simulation, optimization, HYSYS, gas condensate.

I. INTRODUCTION

Natural gas is the gas which produced or extracted from the natural underground reservoir. Methane occupies the largest quantity in the natural gas with small quantities of heavier hydrocarbons like ethane, propane, normal butane, iso-butane, etc. Some of non-hydrocarbons are often present in raw gas with a considerable amount like, carbon dioxide, nitrogen, hydrogen sulfide, helium and various mercaptans. It is generally saturated with water [1]. Natural gas condensate is the liquid which formed by gas condensation, specifically; when the gas is transmitted to surface separators from the reservoir, the hydrocarbon liquid separates from natural gas because of the changes in pressure and temperature. Such condensate keeps a liquid at atmospheric temperature and pressure [2]. Condensate stabilization is a process to increase the intermediate components (C3 to C5) and heavy components (C6+) in condensate. Condensate stabilization is applied by two methods: Multi Stages Flash Vaporization and Fractionation [3]. The stabilization is done to decrease the vapor pressure of condensate to avoid forming vapor phase inside the atmospheric storage tanks by flashing the liquid. Besides, Stabilized liquid is transported by pipeline or transport pressure vessels as they have definite limitations of pressure [3]. The present work studies the different condensate stabilization methods for controlling the RVP of the sweet condensate in the storage tanks. The case study is South Umbaraka Gas Plant (Khalda Petroleum Company-EGYPT) and the study is to get the optimum operating conditions for the current CSU (flash vaporization unit) in terms of getting on-specification product and applying distillation (fractionation) technique to make comparison between the results using the simulation software packages Aspen HYSYS®. There are two main methods for the stabilization of condensate: multi-stage flash vaporization and fractionation (distillation). Flash method is simple stabilization process using two or three flash vessels. It depends on the difference in density between vapor and liquid phases. Fractionation method is common in the gas industry as it is more accurate and gives good results.

Refluxed fractionation column is more efficient and complicated than Non-refluxed one, as it is not applicable to remote location and requires cooling source [4].

II. PROCESS DESCRIPTION

The South Umbarka gas plant is a portion of the Western Desert Gas Project was designed to allow the export of gas to the new Salam treatment facilities, without exotic stainless steel metallurgy and condensate produced to be stabilized and injected into existing crude facilities. It is designed to receive the raw gas/condensate from Khepri and Sethos fields to separate the condensate from the gas in the inlet separator.

The composition and conditions of the inlet feed to the plant have been changed as the current streams which feed the plant are: Gas from first stage separator of West Kalabsha Gas plant (Ptah wells), Gas from the compression station at Kalabsha fields and Gas from Apris separator which get its feed from Apris well. All these gases lines are collected in underground 8" lines directed to plant manifold. The Plant is designed to produce 33 MMscfd gas and 2000 SBPD condensate.

Manuscript published on 30 September 2019
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It utilities stage separation of condensate as well as glycol dehydration of the gas stream. The feed to the stabilization unit is the oil stream from the inlet separator which has specifications listed in table I. The simulation package software Aspen HYSYS version V 8.3 was used in this work to model the plant. For thermodynamic calculations of both liquid and gas phases, Peng Robinson equation of state was applied.

Table- I: Conditions and Composition of CSU Inlet Feed

Comp.	H2O	N2	CO2	Methane	Ethane	Propane	i-Butane
Mole %	0.01	0.14	1.91	8.96	8.01	16.07	7.47
Comp.	n-Butane	i-Pentane	n-Pentane	n-Hexane	n-Heptane	n-Octane	n-Nonane
Mole %	16.52	8.48	8.69	12.09	8.54	1.68	0.31
Comp.	n-Decane	Benzene	Toluene	p-Xylene	m- Xylene	o- Xylene	
Mole %	0.32	0.33	0.48	0.00	0.00	0.00	
Temperature (°C)	Pressure (bar-g)	Molar flow (Kgmole/hr)	Std gas flow (MMSCFD)	RVP (psia)			
30	9	42.23	0.8479	162			

The current stabilization unit consists of the 2nd and 3rd stage separators and an electric heater (153 kw) was installed inside the 3rd stage separator to supply with heat for stabilization. The main object was to find the optimum operating conditions which recover more liquid condensate and keeping its Reid vapor pressure at 10 psia. However, it should minimize the heat duty of the electric heater to decrease the costs. The second stage separator pressure (the first stage separator for CSU) is set to the flow line pressure 9 bar-g (147 psia). The pressure of the storage tank is 1 atm (13.9 psia). The 3rd stage separator pressure would almost equal 2 barg (45 psia) according to the rule of thumb (the pressure between the stages should have the same ratio) Campbell (2004).

Fig. 1 shows process simulation of the current gas plant condensate stabilization unit using Aspen HYSYS version V 8.3.

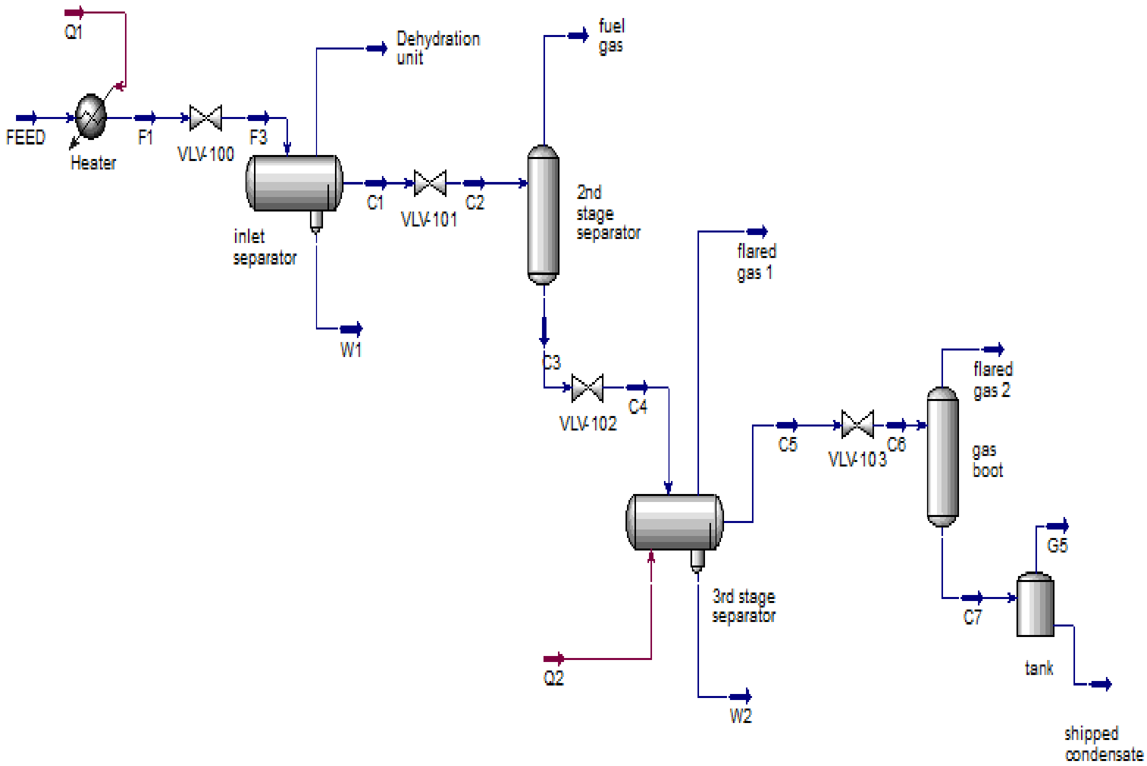

Fig. 1.Process Simulation of the Current Gas Plant CSU

Retrieval Number: C4430098319/19©BEIESP
DOI:10.35940/ijrte.C4430.098319

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According to data obtained by HYSYS simulation to the unit in Table II, despite the high heat duty applied in the 3rd stage separator by the electric heater Q2, the stabilized condensate recovery was very low.

Table- II: Effect of 3rd Stage Separator Pressure on the Heat Duty Q2 and the Quantity of the Recovered Condensate at RVP 10 psia for C5 Stream

Pressure of 3rd stage separator Bar-g	Heat duty of Q2 MMBtu/d	Recovered Condensate in tank bbl/d
1.5	23.41	17.93
2	24.90	0.5318
2.5	25.4	0

Also from HYSYS simulation of the unit, Table III shows that although the RVP of C5 stream is more than 10 psia, the presence of gas boot as a part of CSU helped to achieve on-specification condensate inside the tank (C7 stream) with lower heat duty of Q2 than in the previous case (Table II). The flashing that happened in the gas boot decreases the RVP to be 10 psia inside the tank. So, the presence of gas boot as a part of the unit leads to achieve good results for RVP inside the tank (10 psia) and recover more condensate than the previous case which was depend on achieving the on-specification condensate for C5 stream before entering the gas boot.

Table- III: Effect of 3rd Stage Separator Pressure on the Heat Duty Q2 and the Quantity of the Recovered Condensate at RVP 10 psia Inside the Tank (C7 stream)

Pressure of 3rd stage separator Bar-g	Heat duty required of Q2 MMBtu/d	Flared gas FG1+FG2 MMScf/d	Condensate recovered in the tank bbl/d	RVP Of C5 psia
1	16.29	0.5665	140	14.39
1.5	16.32	0.5590	147	16.02
2	16.40	0.5546	151.4	17.46
2.5	16.49	0.5516	154.2	18.78
3	16.59	0.5497	155.9	20.00
3.5	16.68	0.5485	157.2	21.16
4	16.77	0.5477	157.8	22.27
4.5	16.86	0.5474	158.1	23.33
5	16.94	0.5474	158.2	24.35
5.5	17.01	0.5474	158.1	25.63

III. APPLYING FRACTIONATION METHOD

In this case, a non-refluxed distillation column (with a reboiler and without condenser) and a heat exchanger are installed instead of the 3rd stage separator using simulation by HYSYS as shown in Fig. 2. The liquid stream leaving the distillation column (C5 stream) is recycled to preheat the stream of liquid leaving the 2nd stage separator (C3 stream) aiming at lowering the heat duty of the reboiler Q2. The pressure drop for the tube and shell sides was designated 1 KPa. The heat duty (Q2) and Boil-up ratio is adjusted for getting the RVP 10 psia for the final liquid product.

Table IV shows the conditions and composition of the distillation tower feed stream C4 obtained from simulation.

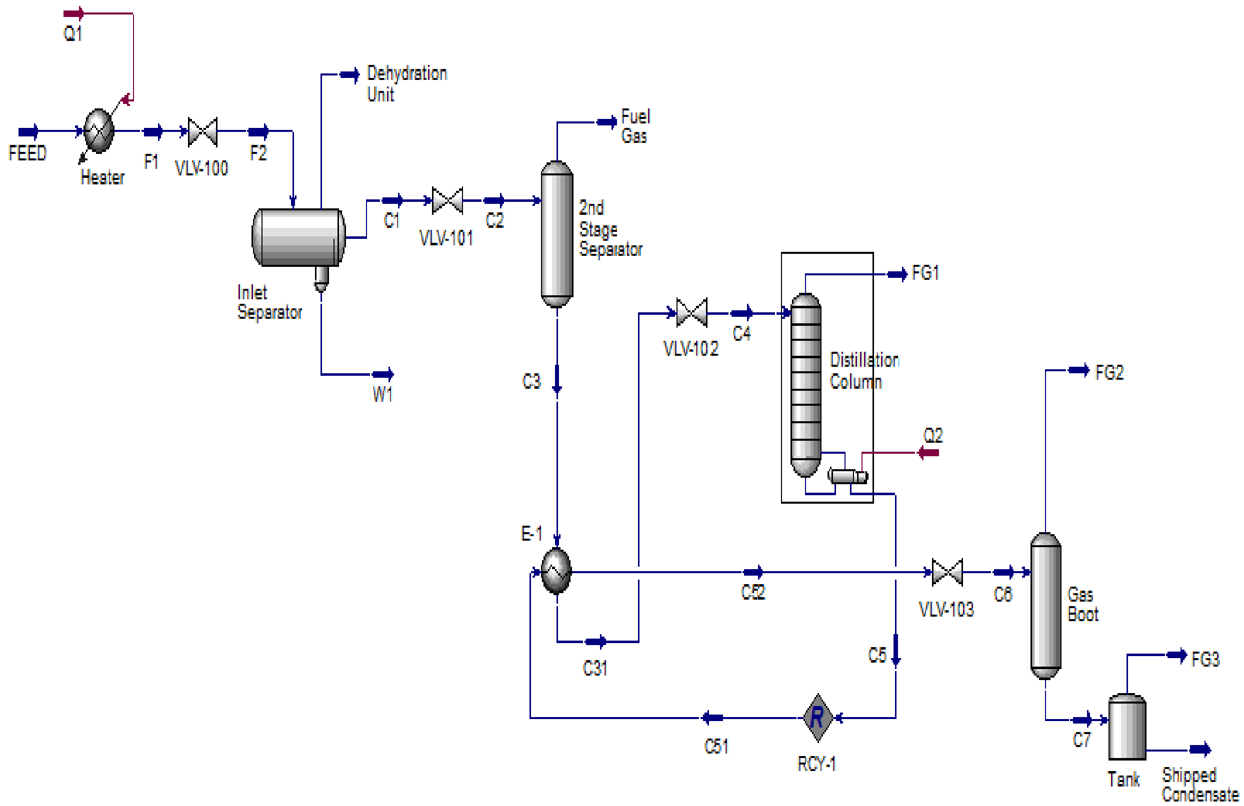

Fig. 2.Process Simulation of CSU after adding Distillation Column with a Reboiler instead of the 3rd Stage Separator

Table- IV: Conditions and Composition of the Distillation Tower Feed Stream C4

Comp.	H_2O	N_2	CO_2	Methane	Ethane	Propane	i-Butane
Mole %	0.00	0.01	0.88	2.36	5.61	15.85	8.22
Comp.	n-Butane	i-Pentane	n-Pentane	n-Hexane	n-Heptane	n-Octane	n-Nonane
Mole %	18.60	9.90	10.21	14.41	10.22	2.02	0.37
Comp.	n-Decane	Benzene	Toluene	p-Xylene	m- Xylene	o- Xylene	
Mole %	0.38	0.39	0.57	0.00	0.00	0.00	
Temperature (°C)	Pressure (psig)	Molar flow (Kgmole/hr)	Std gas flow (MMSCFD)				
59.83	100	35.17	0.7062				

The reboiler pressure and the top tray pressure are primarily considered as 102 and 98 psig respectively. From simulation process obtained data that shows the effect of stages number on the reboiler heat duty and the recovered condensate quantity at RVP 10 psia for the liquid product as shown table V.

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DOI:10.35940/ijrte.C4430.098319

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Table- V: effect of number of stages of the tower on the reboiler heat duty and the recovered condensate

Number of stages	Reboiler heat duty (MMBtu/d)	Recovered Condensate (bbl/d)
4	13.24	243.5
6	12.70	254.0
8	12.49	258.3
10	12.46	260.1
12	12.42	261.2
14	12.39	261.2
16	12.39	261.6
18	12.39	261.6

From table V it can make charts showing the effect of number of stages of the column on the reboiler heat duty and the recovered condensate as shown in Fig. 3& Fig. 4.
Fig. 3 shows that as the number of stages increases, the heat duty of the reboiler decreases. However, the increasing in number of stages results in increasing the height of column and therefore high capital costs. At the same time, the amount of stabilized condensate increases by increasing the number of stages as shown in Fig. 4. It is clear that adding more stages than 10 has small effect on condensate flow rate and the duty of the reboiler. So 10 is the optimized number.

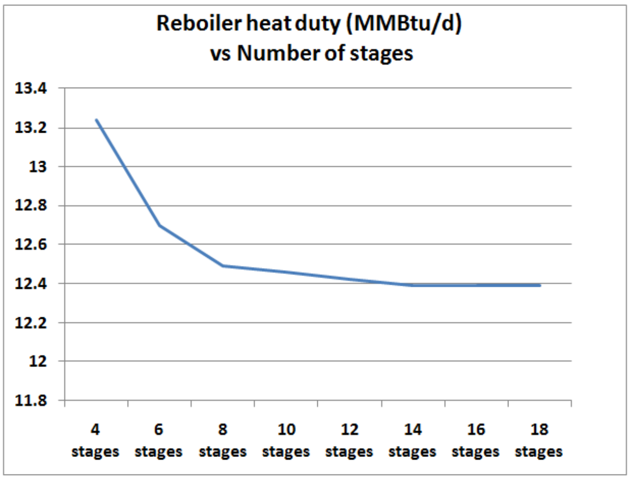

Fig. 3. Effect of Number of Stages on the Heat Duty of the Reboiler Q2

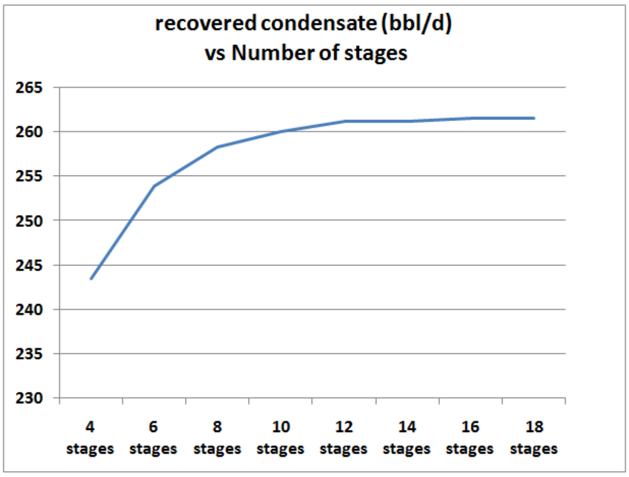

Fig. 4. Effect of Number of Stages on the Quantity of Recovered Condensate

IV. PROCESS SELECTION

Table V shows that the fractionation (distillation) is better than vaporization as it provides more recovery of condensate and less heat duty. Also the cost estimation of modification gave very good payback.

The fractionation is more practical and suitable for this case and also the fractionation column is able to handle the variations in the feed composition.

V. CONCLUSION

In the present study, we worked on finding the optimum operating conditions for the current condensate stabilization unit which uses the multi-stage flash vaporization technique and applied the other technique of fractionation (distillation) using HYSYS simulation to make comparison between the results. The results showed that

1- When we tried to achieve the required RVP (10 psia) for the unit outlet stream C5, the results were not practical and also not economic as it needed high heat duty from the electric heater that led to vaporize all the liquid and no condensate recovered as shown in table VI. Besides, the power of the current electric heater is 153 kw that can give maximum heat duty 12.5 MMBtu/D, that mean in this case we need to change it with another high power one and that is not economic.

2- When we put the gas boot in the consideration and made simulation for achieving the required RVP for the gas boot condensate outlet stream C7, the results were practical but not economic as the amount of the recovered condensate was good but also needed another electric heater with high power to supply the required heat duty (more than 16 MMBtu/D) as shown in table VII.

3- Using fractionation method gave better results, more condensate recovery and less heat duty as shown in table VIII as the number of stages for the column was 10 and we used almost the same heat duty of the current electric heater (12.5 MMBtu/D) for the reboiler and achieved the required RVP with a recovered condensate 260 bbl/d.

4- The conclusion is that the performance of stabilization unit is affected greatly by the Reid vapor pressure of the feed as one or both of methods is/are applicable and/or economic depending on the feed properties (especially its RVP) and in our case the changing in the feed sources of the plant led to a change in the RVP of the feed of condensate stabilization unit as it became high 162 psia and the current flash vaporization technique became not applicable as it didn't give the desirable results as before and the fractionation method is applicable and economic for our case.

VI. ACKNOWLEDGMENT

The author would like to appreciate Eng. Mohamed Abdel-Wahab Kaoud and Eng. Mohamed Ahmed Mustafa Soliman from Khalda Petroleum Company for their support and the technical information that they provided.

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