Optimization of Oil and Gas Multi Stage Separators Pressure to Increase Stock Tank Oil

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ABSTRACT

A computer simulator is written to optimize the conditions of oil and gas separators using Hysys and Matlab software. Off gases in some wellhead equipment of south of Iran are burnt in flare. In the present paper, the separators of one of these wellheads are simulated. By changing different variables such as the plus fraction splitting methods and the temperature of separators the condition with the least difference with empirical data of crude oil separator test was selected based on which the optimal pressure of separators which minimize total GOR function was calculated. The results show thatusing oftheCavett-Edmister method leads to the lowest value of error andtemperature changes have little effect of the separators conditions.

Key words: Separation, Multi stage separators, Optimization, Gas oil ratio, Crud oil.

INTRODUCTION

While industrial countries such as USA, USSR, Japan, and Germany are developing methods to generate more substitute natural gas(SNG), middle Asian countries like Iran are still flaringhuge amounts of separators natural gasses on the wellheads[1].

Modeling for optimization of the conditions (pressure) of separators in multistage separators reduces the amount of gases produced with oil to a minimum.

For this purpose National Iranian South Oil Company is implementing a project to model all separators, and apply optimized conditions to them. Various works have been carried out worldwide in this field. The criteria used by Sanchez-Olea were "Maximum Recovery of Fluids" and "Minimum Requirements of Compression"[2]. Devon Energy Corp. optimization goal was to increase profits for the facility by putting more gas into the sales pipeline and to reduce emissions of methane with minimal costs to the facility[3]. But none of them has considered the effect of plus fraction characteristic determining. Designing the process by software will be very effective in case the properties of the fluid and its

composition are exactly specified. In well fluids, or gas reservoirs we face a range of compositions that the quantity and characteristic of all of them is not known to us.Therefore, the optimized conditions of separators have to be specified by a combination of laboratory method and modeling.

Theory

Stage separation of oil and gas is carried out by a series of separators whose pressures gradually decrease. The fluid is discharged from a high pressure separator to the next low pressure separator. The purpose of stage separation is to get the highest amount of hydrocarbon liquid from the well fluid, and provide the highest stability of the two streams of liquid and gas[4].

An ideal separation of gas and oil in term of the highest liquid recovery is carried out when the pressure of the well fluid from the wellhead in the separator vessel inlet is reduced to the atmospheric pressure in the separator outlet or near that, and gas or vapor is continuously removed from separator as soon as it is separated from the liquid. This special usage of differential separation is not practical and is never used[5].

Some of the advantages of an ideal separator may be realized by using multistage separation.When the pressure of the separator is increased, the gas/oil ratio of the separator is decreased. Increasing the pressure of the separator causes more light molecules enter the stock tank liquid. When the pressure is reduced to the atmospheric pressure, these molecules

leave the liquid phase, and this increases the gas/oil ratio in the stock tank. Therefore, the separator and stock tank gases pass a minimum together. The pressure of this minimum point is referred to as the optimized pressure of the separator[6].

MATERIAL AND METHODS

In the laboratory the well fluid is subjected to pressure reduction in several stages and the volume of the produced gas and oil is specified for different conditions.(Separator test). In order to achieve laboratory results, different methods of describing and splitting of the plus fraction are studied and used.

Here, in order to solve the problem, a four-unit set including three separation units and one atmospheric storage tank are considered. Well fluid from various oil wells enters the first stage in a simple stream with a given temperature, pressure and flow rate. Temperature and pressure of the entering stream are usually greater than the first stage. The drop in pressure cause flash vaporization. Crude oil from the first stage flows to the second stage. This process continued until the final stage which is a stock tank. Since there is a pressure-reducing valve at the input of each separator vessel, according to the input pressure, there will be three variables for the value of pressure fall in valves and this amount is a dependent value for the fourth valve. The general schema of the considered unit which was simulated by hysys is seen in Figure 1.
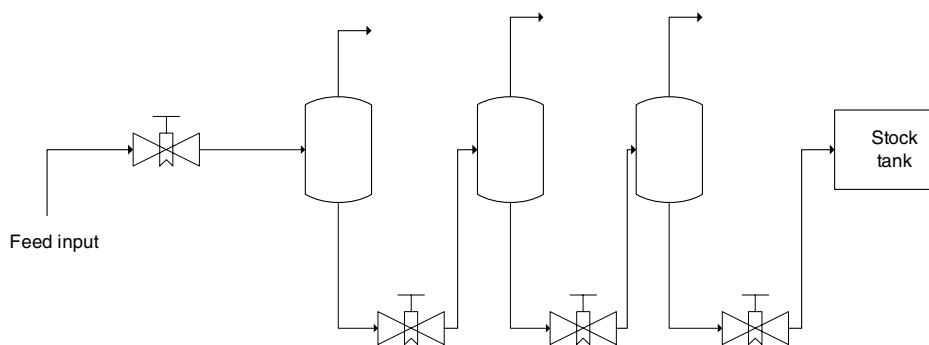

Fig. 1: Proposed Schema for calculations

There wasn't any LPG unit on the sight under study, so it is not considered here. However if there is a LPG plant separators conditions affect the amount of LPG produced[7]. Optimization in this condition is beyond the scope of this paper, however the producer applied here would be helpful in optimizing of any supposed function.

Thus the problem under studied can be formulated as follow: it is desired to find optimal pressures of stages which minimize total GOR as an objective function.

An important point for optimization of this collection is to develop a mathematical model that is accurate enough to be able to simulate the function of these units properly. Based on this fact, the Peng-Robbinson equation of state is used, for flash calculations which can describe oil mixtureswell[8].

Also different methods for plus fraction description such as Riazi-Daubert-Edmister, Cavett- Edmister ,Lee-Kesler, Bergman andits splitting such as Katz and Ahmed have been studied and employed[6]. The best method which has the lowest difference with experimental data is chosen and used in determination ofoptimum pressure fall in valves.In this paper, the Simplex method in MATLAB software is used to find the optimum point of GOR function[9].

The composition of applied oil for performing simulation is shown in Table 1.

Separator test results for this oil sample are shown in table 2. In this test the oil has encountered pressure fall from bubble point (6100 psia, 209 F[0]) in four stages.Also another oil sample has been used which its composition is shown in table 3.

Table 1: Composition of oil number1 applied in simulation

Mole percent	Component	Mole percent	Component
1.73	C_6	0.0	H_2S
2.21	C_7	0.21	N_2
2.58	C_8	0.09	CO_2
2.22	C_9	62.04	C_1
1.84	C_{10}	5.67	C_2
1.44	C_{11}	3.11	C_3
12.46	C_{12+}	0.84	$i\text{-}C_4$
100	total	1.71	$n\text{-}C_4$
$Mw(C_{12+})$	275	0.95	$i\text{-}C_5$
Specific gravity 0.8846		0.91	$n\text{-}C_5$

Table 2: Separator test results for oil number 1

Gas / Oil Ratio	Separators		
SCF/Bbl	Temp. F	Pressure	psig
1479.05	110	390	
87.1	110	100	
24.34	110	30	
35.2	110	atmospheric	
Total GOR : 1625.69	API@60 F[0]:35.98		

Separator test results for this oil sample are shown in table 4 and table 5. In these tests the oil has encountered pressure fall from bubble point (4024psia, 215 F^0) in four stages in two different temperatures

RESULTS

Error values obtained from comparison of simulation results with experimental data for oil number 1 and 2 are given in table 6, 7 and 8.

Table 3: Composition of oil number2 applied in simulation

Mole percent	Component	Mole percent	Component
4.48	C_6	0.0	H_2S
2.11	C_7	0.32	N_2
3.10	C_8	0.25	CO_2
2.32	C_9	47.88	C_1
1.84	C_{10}	7.32	C_2
1.69	C_{11}	4.45	C_3
19.55	C_{12+}	0.89	$i\text{-}C_4$
100	total	2.17	$n\text{-}C_4$
Mw(C_{12+}) 295		0.76	$i\text{-}C_5$
Specific gravity 0.9084		0.86	$n\text{-}C_5$

Table 4: Separator test results for oil number2-120F°

Gas / Oil Ratio	Separators		
SCF/Bbl	Temp.	F	Pressure psig
600	120		746.52
90	120		149.78
20	120		28.16
atmospheric	120		38.84
Total GOR : 963.31	API@60 F°:32.99		

Table 5: Separator test results for oil number2-95F°

Gas / Oil Ratio	Separators		
SCF/Bbl	Temp.	F	Pressure psig
600	95		682.77
90	95		154.43
20	95		29.62
atmospheric	95		46.07
Total GOR : 912.89	API@60 F°:32.3		

Table 6: Errors obtained with comparison of total GOR calculated by program with empirical data for oil number1

Plus Fraction properties determination methods	Spliting method	Error of total GOR
Riazi-Daubert-Edmister	-	3.6%
Cavett- Edmister	-	3.16%
Lee-Kesler	-	4.14%
Bergman	-	3.2%
Riazi-Daubert-Edmister	Katz	4.68%
Riazi-Daubert-Edmister	Ahmed	6.55%

**Table 7: Errors obtained with comparison of total GOR calculated
by program with empirical data for oil number 2-120F°**

Plus Fraction properties determination methods	Spliting method	Error of total GOR
Riazi-Daubert-Edmister	-	7.46%
Cavett- Edmister	-	6.4%
Lee-Kesler	-	8.09%
Bergman	-	6.99%
Riazi-Daubert-Edmister	Katz	8.52%
Riazi-Daubert-Edmister	Ahmed	6.08%

**Table 8: Errors obtained with comparison of total GOR calculated
by program with empirical data for oil number 2-95F°**

Plus Fraction properties determination methods	Spliting method	Error of total GOR
Riazi-Daubert-Edmister	-	4.96%
Cavett- Edmister	-	3.57% L e e -
Kesler	-	5.62%
Bergman	-	3.91%
Riazi-Daubert-Edmister	Katz	6.04%
Riazi-Daubert-Edmister	Ahmed	4.46%

Table 9: Optimum pressures for oil number 1

Stages	Optimum pressure (psia)	Gas/oil Ratio SCF/Bbl
First stage	619.4	1341.01
Second stage	109.2	137.25
Third stage	28.27	34.03
Forth stage	Atmospheric	15.4
Total GOR : 1527.88API@60 F^0:44.35		

**Table 10: Optimum pressures
for oil number2-120F°**

Stages	Optimum pressure (psia)	Gas/oil Ratio SCF/Bbl
First stage	466.4	721.58
Second stage	86.41	102.98
Third stage	25.78	29.55
Forth stage	Atmospheric	14.65
Total GOR : 868.78API@60 F^0:39.85		

**Table 11: Optimum pressures
for oil number2-95F°**

Stages	Optimum pressure (psia)	Gas/oil Ratio SCF/Bbl
First stage	499.2	705.4
Second stage	86.37	105.08
Third stage	25.98	30.36
Forth stage	Atmospheric	14.94
Total GOR : 856.08API@60 F^0:40.22		

The method which has the lowest error is Cavett-Edmister without splitting of plus fraction.Obtained optimum pressures of four stages using this method in program are given in table 9, 10 and 11.

DISCUSSION

First for relaying on simulation results and finding the best way for plus fraction description,

the results of simulation are compared with crude oil separator test data. So how to describe oil compositions properties is important in following calculations.

What is very important here is the method of oil describing which affects the amounts of error. Splitting the plus fraction of oil does not necessarily lead to better results. When the plus fraction of oil is not split, the method used to describe the plus fraction is important.

After comparison of the results from each method with empirical data, the best method of describing oil is selected and used in the optimization program and determination of the optimized pressures.

The method with the lowest amount of error in total gas/oil ratio is the Cavett-Edmister without splitting of plus fraction. The separator tests carried out on the oil number 2, and the results from the program show the slight effect of changes in temperature on the conditions of separators. A change of %20.83 in temperature results in a change of %1.46 in the total gas/oil ratio.

Oils under studied in this survey contain light and medium crude oils, so the procedure mentioned here for finding optimum pressures could be applied for a wide range of oils. Since the deterministic optimization methods are generally sensitivetoward initial guess for finding the answer, the selection of application method for optimization is of great importance.

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