Optimization of separator pressures in Marun oilfield with genetic algorithm

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Abstract

In the oil production industry one of the most important targets is to produce maximum oil volume. Because of the oil pressure drop in the production plants, remarkable volume of oil reduced due to the dissolved gas extraction from liquid. To reduce this volume reduction of oil, some separators with optimum pressures are needed. So the main objective of this paper is to determine these desired pressures. For approaching this idea a MATLAB program has been written that using the modified Peng Robinson equation of state for phase calculation and optimize the pressures by GA (Genetic Algorithm). This program was validated by experimental data of separator test and then used PVT data of one of the Iranian Oilfield (MARUN) to optimize its separators pressures. For accurate simulation and data analysis, the PR EOS parameters were tuned by PVTi software and the modified parameters were used in program. The results show that the recovery has improved by pressure optimization. Also the effect of temperature was investigated, that shows the recovery increases by lowering temparature.As a result the tecovery improving to about 0.4% that introduced 2000 bbl/day more recovery of oil in stock tank. It has 200000 dollars per day more income.

Key words:EOS, GA, pressure optimization, PVT

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1. Introduction

Oil and gas production usually requires surface separation before they are transported to market. The pressure vessel used for separating well fluids produced from oil and gas wells into vapor and liquid components is called a separator. The vessel is engineered to separate production fluids into their constituent components of oil, gas, and water.

The surface separation system is a combination of separator/ separators and the stock tank. Different numbers of stages are applied for different reservoir fluids. For the same fluid stream, more liquid yield is usually preferred because of its higher commercial value. Theoretically, the more stages of consecutive separation exist, the higher the liquid production. However, in practice, the real number of separations is often limited by available space and operational cost[1].

The four-stage separation is designed for high-API-gravity oils, high GOR, and high flowing pressures. Four-stage separation is also used where highpressure gas is needed for market or for pressure maintenance. The pressure of the separator is controlled with a backpressure valve through which the separated gas flows to the gas pipeline.

The temperatures of the separator and the stock tank are determined by the temperature of the feed and ambience. Vaporization and expansion also affect the vessel temperature. Separator temperature can be adjusted by cooling and heating. The fact that the percentage of liquid recovery from surface separation is controlled by separator pressures and temperatures and stock-tank pressure and temperature for given wellstream composition is well known. There are optimum operating conditions for a certain system to separate a specific wellstream. During the production, there is a small room for the temperature adjustment.[2]

1.1. 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.

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.

Some of the advantages of an ideal separator may be realized by using multistage separation. When the pressure of the separator some of the advantages of an ideal separator may be realized by using multistage separation. 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 decreases the API. The pressure of this maximum API and minimum GOR and maximum Formation volume factor is referred to as the optimized pressure of the separator.[3]

1.2 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. [3]

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 then outlet of second stage comes to the third stage and the outlet of third stage will being inlet of stock tank. Thus the problem under studied can be formulated as follow: it is desired to find optimal pressures of stages which maximize total API 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 modified Peng-Robbinson equation of state is used. Splitting method of modified (quadrature) whitson and for critical properties and acentric properties Kesler-Lee is used.

2. Data and Simulation

We used the MARUN oil field data, compositions and real tests to tuning the EOS parameters then is used as a feed for our MATLAB program and set the equation to GA to optimize the pressure with maximize the API minimum GOR and maximum formation volume factor.

The composition ofthe MARUN oilfield that was applied for performing simulation is shown in Table 1, the separator test that has done for simulation is shown in table 2 and Gas composition of separator test is shown in tables 3. In these tests the oil has encountered pressure fall from bubble point (3867 psia, 215 F°) in four stages.

Table1:Composition of the reservoir of marun oilfield

Components	Mol%	Components	Mol%
H_2S	0.00	nC_5	0.87
N_2	0.25	C_6	3.82
CO_2	0.29	C_7	2.76
C_1	49.24	C_8	3.21
C_2	7.64	C_9	1.87
C_3	4.61	C_{10}	2.12
iC_4	0.91	C_{11}	1.96
nC_4	2.23	C_{12+}	17.45
iC_5	0.00		

Table2: Separator Test

Separator pressure (psig)	Gas/Oil ratio (SCF/STB)	API @ 60°F
600	702.23	
90	146.28	
20	28.12	
0.0	54.15	**33.06**
Total GOR :	**930.78**	

Table 3: Gas composition of separator test @ 110 F

	Separator			
Component	**1st Stage 600 psig Gas (mol %)**	**2nd Stage 90 psig Gas (mol %)**	**3rd Stage 20 psig Gas (mol %)**	**4th Stage 0 psig Gas (mol %)**
H_2S	0.000	0.000	0.000	0.000
N_2	0.332	0.402	0.213	4.180
CO_2	0.413	0.569	0.551	0.725
C_1	85.731	64.106	39.326	9.625
C_2	8.600	18.837	26.935	20.618
C_3	3.041	9.738	19.446	28.797
iC_4	0.403	1.409	3.110	6.130
nC_4	0.779	2.788	6.230	14.700
iC_5	0.190	0.645	1.403	4.212
nC_5	0.196	0.648	1.362	4.589
C_6	0.176	0.504	0.898	3.955
C_7	0.087	0.244	0.371	1.818
C_8	0.043	0.100	0.132	0.606
C_{9+}	0.008	0.010	0.025	0.046
Total	100.000	100.000	100.000	100.000
GOR (SCF/STB)	**702.23**	**146.28**	**28.12**	**54.15**
Mw	**19.21**	**24.77**	**31.99**	**46.31**
Gas Gravity	**0.6631**	**0.8551**	**1.1042**	**1.5986**

At first the MARUN oilfield data are simulated for tuning the parameters of EOS. Then tuned EOSis used as input of MATLAB programfor phase calculation and then GA is usedto optimize the pressures. The tuning accuracy is good and sees the results of the tests in the following figures:

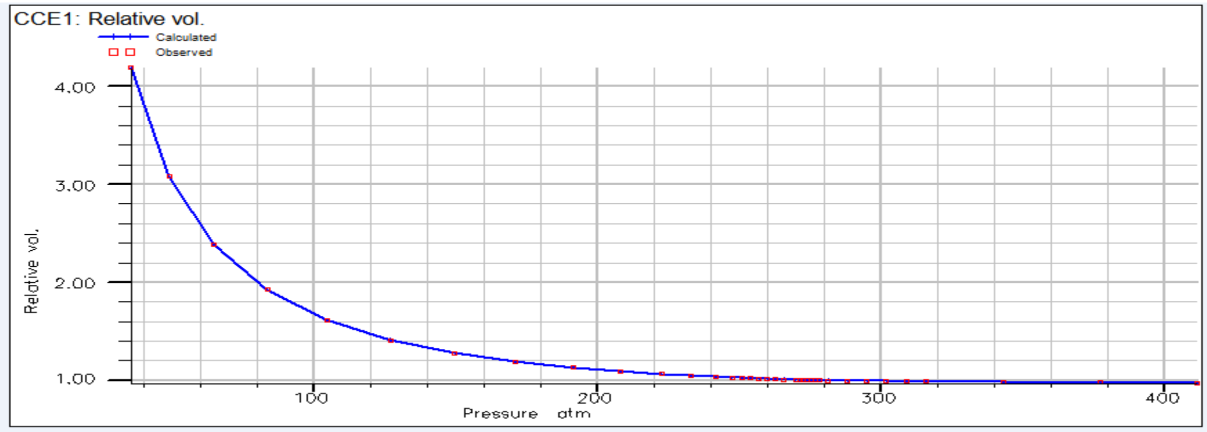

Figure 1: CCE test; Relative volume

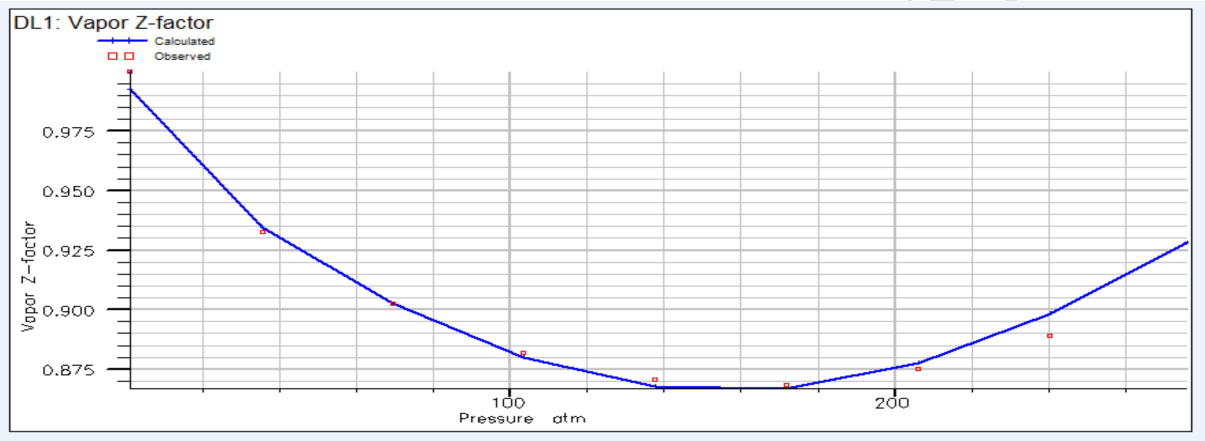

Figure 2: DL test; vapor Z-factor

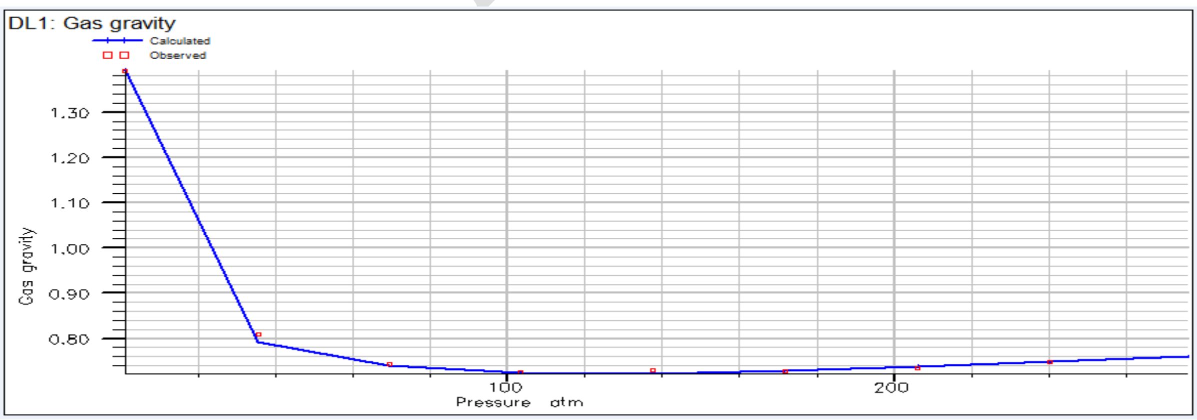

Figure 3: DL test; gas gravity

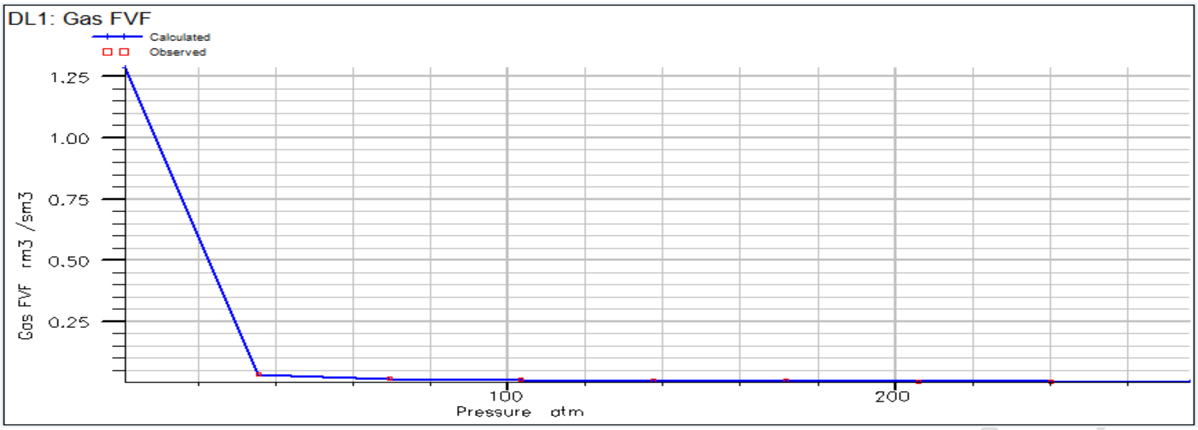

Figure 4: DL test; Gas FVF

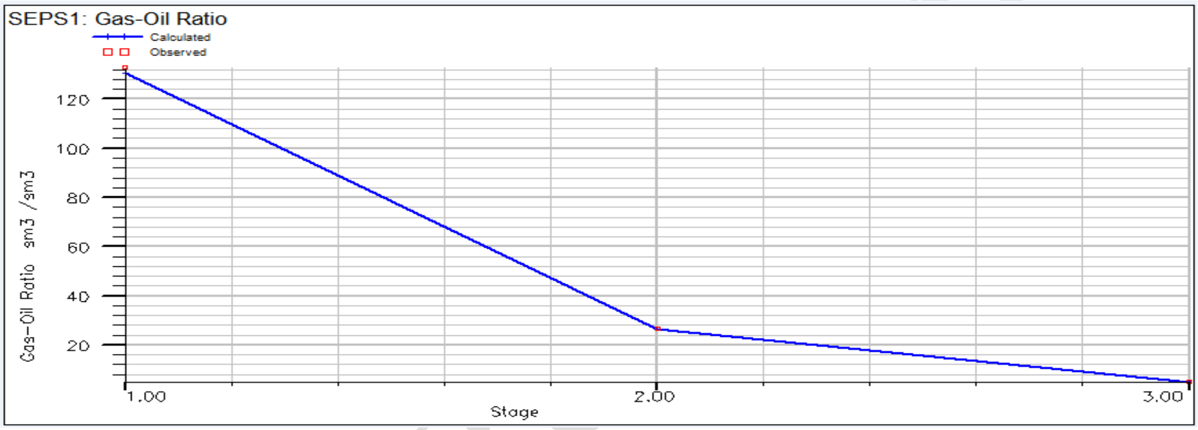

Figure 5: separator test; Gas-oil Ratio

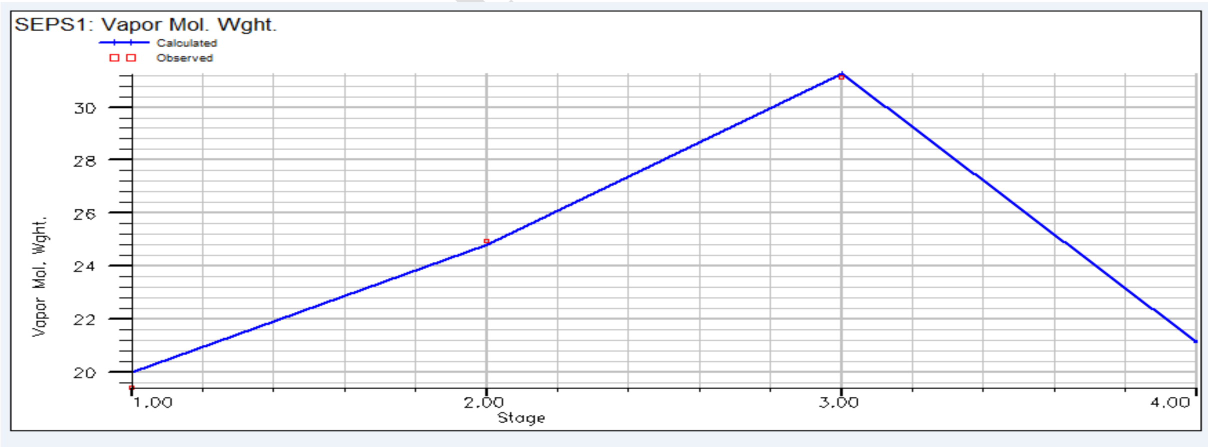

Figure 6: separator test; vapor mol. weight

The simulations are done for 2 conditions of pressure and temperature.

3. Results

There is one case for winter with present and optimized pressures and one case for summer with present and optimized pressures as following; in winter and present pressures these conditions are available:

We have separator's pressures of 600, 100, 30 and 0 psig with temperatures of 90, 85, 80 and 75F° respectively at present with the following specifications;

API gravity	TotalGOR(SCF/STB)	Recovery (bbl/lbmole-feed)
34.05	874.8	0.27

But the optimized separator's pressures are 446.57, 99.52, 19.37and 0 psig with90, 85, 80 and 75 F° respectively. the results of the alternating present pressures, with optimized pressures, are:

API gravity	Total GOR(SCF/STB)	Recovery (bbl/lbmole-feed)
34.12	872.33	0.2704

It is concluded the condition with optimized pressures has more recovery than present pressures at same temperatures; and now we consider only effect of pressure on recovery:

In summer case with separator's temperature of 120, 113, 106 and 99F° and winter case separator's conditions of 90, 85, 80, 75 and 70°F respectively,the results of the alternating summer temperatures, with winter temperatures, are:

Summer case with present pressure:

API gravity	Total GOR(SCF/STB)	Recovery (bbl/lbmole-feed)
34.98	893.41	0.2693

Winter case with present pressures:

API gravity	Total GOR(SCF/STB)	Recovery (bbl/lbmole-feed)
34.05	874.8	0.27

It isconcluded the condition with lower temperature has more recovery than higher at same pressures;

The optimized pressures of summer case are 496.75, 109.31, 20.82, and 0 psig with temperatures of 120, 113, 106 and 99°F, and the results of optimized pressure in summer temperatures are as follow:

API gravity	Total GOR(SCF/STB)	Recovery (bbl/lbmole-feed)
35.05	891.3	0.2696

4. Conclusion

It is concluded that good results are achieved and optimization improved the recovery. achieving better results when we have optimized pressures with cooler temperature. it can give us better recovery to about 0.4% that introduced 2000 bbl/day more recovery of oil in stock tank. it has 200000 dollars per day more income.

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