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Research Article

Investigating the Behavior of Low Permeable Lean and Rich Gas Condensate Reservoirs

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Abstract

The producing behavior of low permeable gas condensate reservoirs is dramatically different from that of conventional reservoirs and requires a new paradigm to understand and interpret it. As the reservoir pressure initiates to decline and reaches to dew point pressure of the fluid then the condensate is formed and causes the restriction in the flow in the reservoir rock which results, decrease in the well productivity near the wellbore vicinity which is known as condensate blockage. Henceforward, it is better to understand the behavior of the low permeable lean and rich gas condensate reservoirs by several perspectives through the compositional simulator. Besides this study involves the following perspectives; the increase in the number of wells and by varying the flowrate of the gas in six different cases for low permeable lean and rich gas condensate reservoirs. It was concluded that low permeable lean and rich gas condensate reservoirs have similar gas recovery factors. Whereas the CRF plays inverse behavior for both reservoirs as CRF is maximum for lean gas condensate at single producing well but for rich gas condensate reservoir the CRF increases as the number of wells escalates. Additionally, in second effect the varying gas flowrates lean gas condensate reservoir has maximum CRF at lesser flowrate but it is opposite for the low permeable rich gas condensate reservoir, for single or two producing wells the flowrate effect plays but when the number of wells is increasing there is not any significant change in CRF

Keywords: *Low permeable, Lean gas condensate reservoir, Rich gas condensate reservoir, Compositional Simulation, Gas recovery factor, Condensate recovery factor.*

1. Introduction

The behavior of low permeable gas condensate wells is distinctive in a sense; which cause the rapid loss of productivity of the well. The well productivity decreases due to the thermodynamic behavior and continuous phase change as the reservoir pressure fall below the dew point pressure. These both cause the development of liquid yield as gas condenses near the wellbore vicinity which is known as condensate blockage. That high condensate saturation or condensate yield formation causes the reduction in gas deliverability or productivity in the wellbore vicinity.

Furthermore, the mature fields worldwide are at the last stage of their field life, about to approaching dew-point pressure or has approached to yield the condensate drops out. Universally, the demand of the NGL has raised up and results to optimize the gas condensate reservoirs or intensely to start the production from the low permeable or tight gas reservoirs. [2014; BP ENERGY OUTLOOK]

Thus, it is necessary to forecast and recognize the behavior of the low permeable lean and rich gas condensate reservoirs. The research on this work isn't done broadly; the previous researchers have provided the following information such as through PVT lab experiments in CCE and CVD, it was investigated by taking five samples of the different fields that each fluid behaves differently as the compositions vary [2000; A.A. Shapiro *et al*] Additionally, in another research, it was identified through compositional simulation that creation of deep pressure drawdown cones in reservoirs and non-uniform drainage of individual reservoir zones causes the dropout of additional volume of retrograde condensate. Also, he studied the condensate recovery factor (CRF) vs Gas Recovery factor (GRF) by varying the permeability to 1md, 10md and, 100md, which results in the better recovery factor for 100md. [2012; Alexander Shandrygin, *et al*]

2. Methodology

In this study, the compositional model for the low permeable lean and rich gas condensate reservoirs has been constructed through Eclipse-300. The composition for both low permeable reservoirs i.e. Lean and Rich gas condensate reservoirs is shown in Table 1.

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Table 1 Composition of low permeable Lean and Rich gas condensate reservoirs

	Well Stream (mol %)	
Component	**Rich Gas Condensate**	**PVTP, Lean Gas Condensate**
CO_2	1.15	00
N_2	1.74	00
C1	66.2	67.35
C2	8.6	10.34
C3	5.38	5.38
iC4	2.72	2.72
nC4	2.61	2.61
iC5	1.91	1.91
nC5	1.38	1.38
C6	1.21	1.21
C7+	7.1	7.1
Total	100	100

Table 2 Grids Distribution

Dimension	Grids
X	20
Y	20
Z	9

Table 3 Well stream and reservoir parameters

API Gravity	52.3
S.P Gravity	0.7685
M.W of C7+	143
Separator gas gravity	0.742
Sep-gas/ Sep liquid ratio at 2000 psia and 72 F	4812 scf/bbl.
Depth	7500 ft.
Reservoir Pressure	3550 psia
Saturation Pressure	3428 psia
Reservoir Temperature	198 F
Oil density	0.341106 g/cc

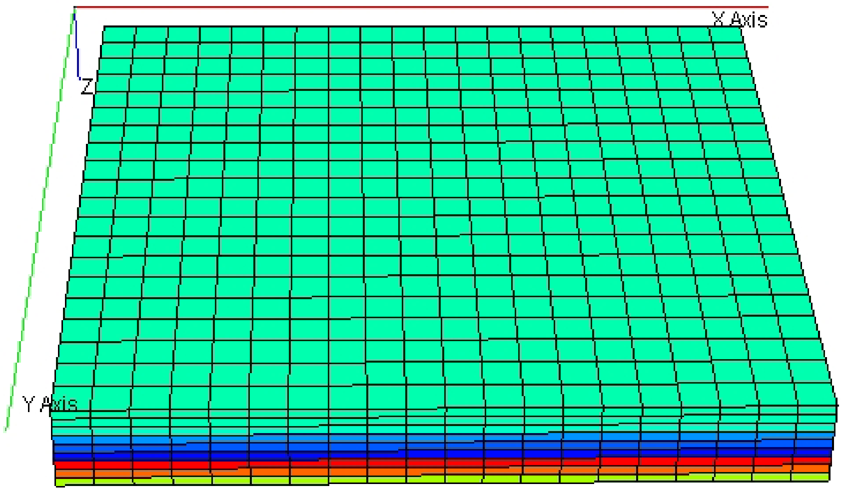

Figure 1 Grids distribution

In this study, the reservoir dimensions are 2600ft, 2600ft and 315ft. Furthermore, the single grid block in term of X and Y equals 130 ft. and the nine layers in the third dimension i.e. the Z dimension. Both reservoir models have identical dimensions and grids in terms of X, Y and Z direction as shown in Table 2. Also, the Girds distribution is shown in Figure 1 and the well stream and reservoir parameters are shown in Table 3.

The study involves two main models but on many perspectives, the model has been upgraded and results are generated. The first effect is studied by increasing number of wells where as, the second effect is studied by varying the flow rates.

The first effect is on the basis of the number of producing wells and arrangement are shown in Figure 2, consists of six cases for low permeable lean gas condensate reservoir and separately six cases for rich gas condensate reservoirs.

Whereas, the second effect is varying the flow rate for both reservoirs i.e. low permeable lean and rich gas condensate reservoirs with an increase in the number of wells.

3. Results and Discussion

3.1. Investigating effect of number of wells & arrangements

First of all, on the basis of well numbers, the recovery factor is analyzed separately from a single well to six producing wells and in each case, the behavior for low permeable lean and rich gas condensate reservoirs differs.

There were six different compositional models for lean and rich, separately. It means that in total twelve models. The following compositional models were constructed on the basis of well numbers and arrangements as listed below and likewise as shown in Figure 2.

a) Single well at the center of the reservoir
b) Single well at the corner of the reservoir
c) Two wells diagonally
d) Four wells
e) Five wells
f) Six wells

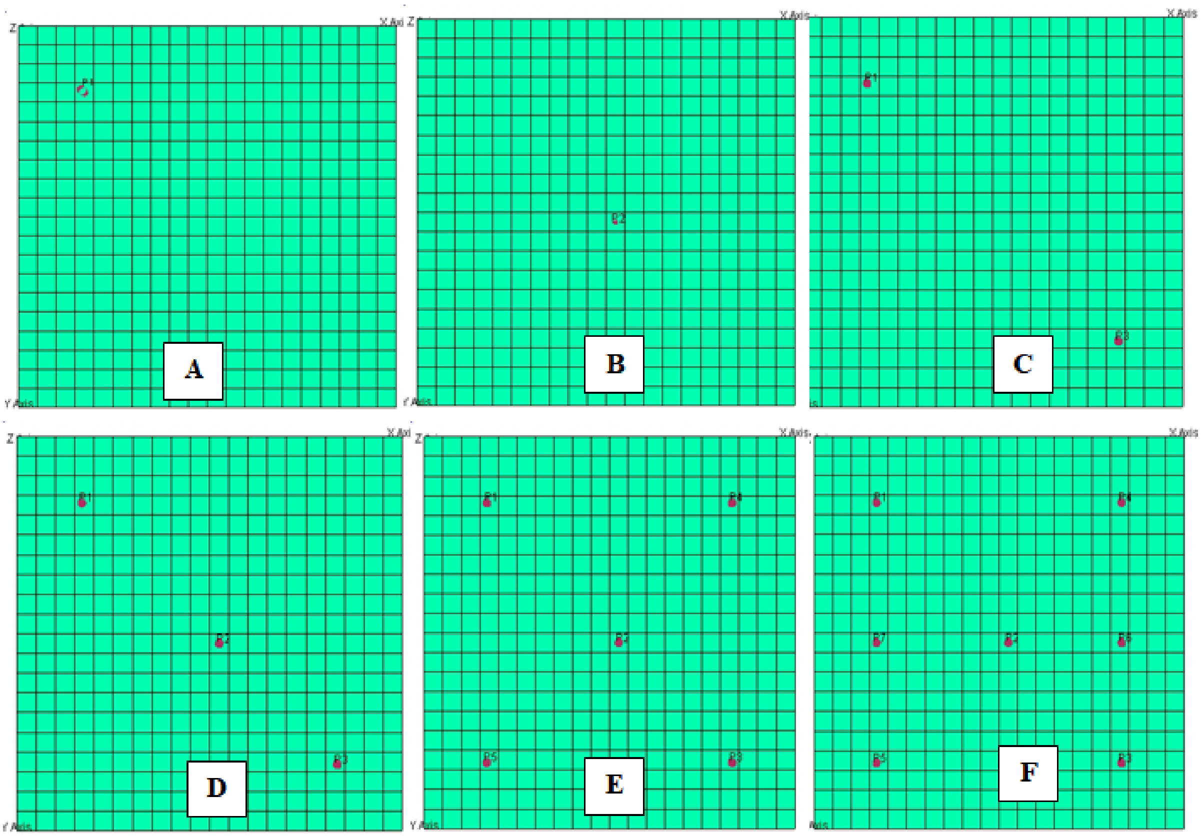

Figure 2 Distribution of the Number of wells in each case

3.1.1. For low permeable Lean gas condensate reservoir

The compositional simulation has developed for above all listed cases, separately and the recovery factor is calculated through the production data forecasted by the Eclipse-300. It resulted that the gas condensate recovery (GRF) in each case is identical whereas, the condensate recovery factor (CRF) varies in each case, the maximum condensate recovery was in second case i.e. when the producing well is at the corner of the reservoir as shown in Figure 2(A). Additionally, the condensate recovery factor declines as the number of producing wells are increasing.

3.1.2. For low permeable Rich gas condensate reservoir

Likewise, in an identical way, the six more compositional model is created for low permeable rich gas condensate reservoirs. The models bring it about that the rich gas condensate behaves similar for gas recovery factor in each rich gas condensate case but it behaves in an opposite way for the condensate recovery factor as the rich gas condensate reservoir has the maximum recovery at case f

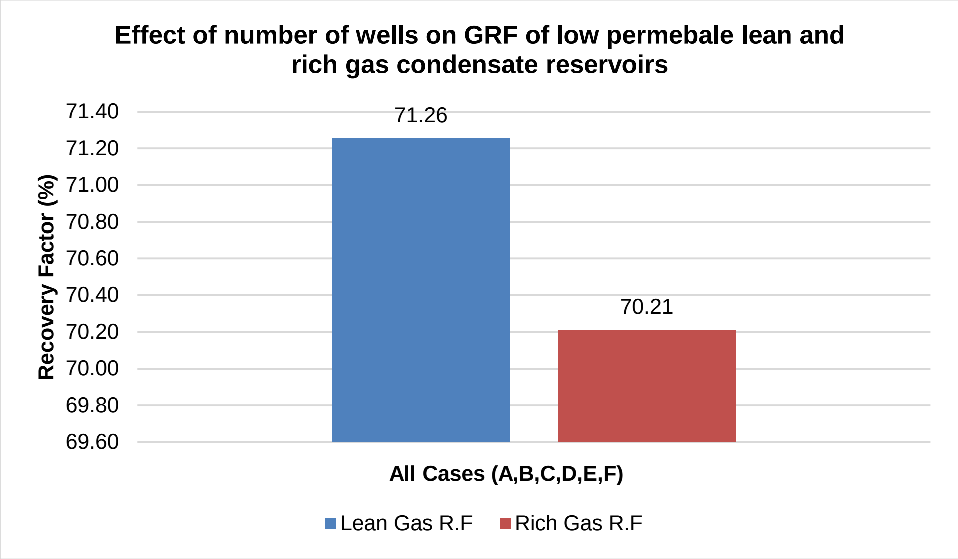

Figure 2 Effect of number of wells on gas recovery factor

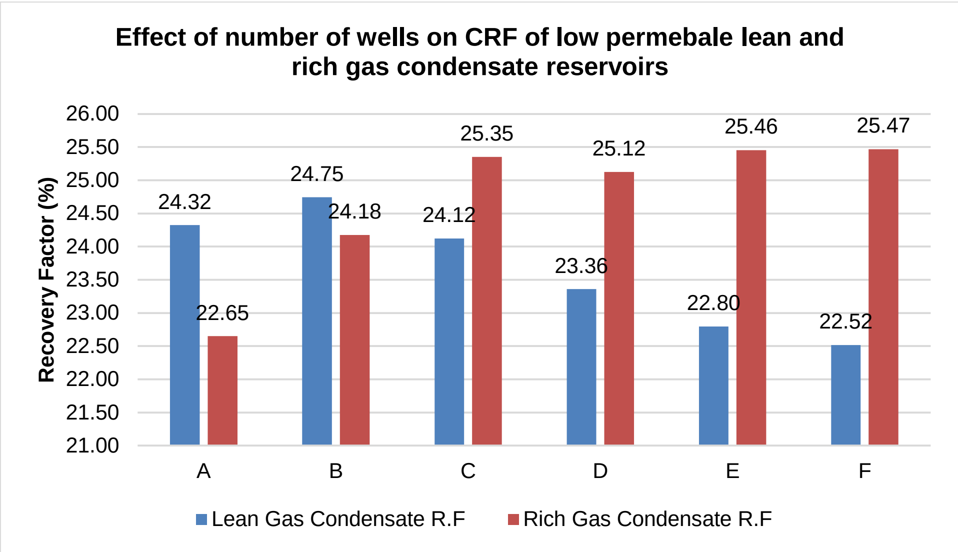

Figure 3 Effect of number of wells on condensate recovery factor

3.1.3. Comparison Results for number of wells

In this effect, it is noticed that for gas recovery factor there is not and major variation for either for lean or rich gas condensate reservoir among all six cases. As in all cases of lean, the GRF was 71.25% whereas for rich gas condensate reservoirs it was 70.21%. Through Figure 3 it can easily be visualized the results.

However, for condensate recovery factor, the behavior is totally different for low permeable lean and rich gas condensate reservoirs. The condensate recovery factor was highest with 24.74% for the case b (Figure 2(B)) of the lean gas condensate reservoir i.e. when the producing well is at the corner of the reservoir and the second result appears that by increase in the number of the wells the condensate recovery factor is decreases. For easy visualization the comparison can be seen in Figure 4.

While for the low permeable rich gas condensate reservoir the maximum recovery was achieving at the case f and we can say that at the case e too because there isn't much difference.

3.2. Investigating effect of varying flow rates

In second effect on the basis of different flow rates, all the six models of low permeable lean and rich gas condensate reservoirs are investigated by selecting these below flow rates.

a) 20000 Mscf/day
b) 17000 Mscf/day
c) 14000 Mscf/day

The gas and condensate recovery factor for low permeable lean and rich gas condensate reservoirs the results with above all three flow rates are listed in Table 4 & 5, respectively.

Table 4 GRF of low permeable lean and rich gas condensate reservoirs

	Gas Recovery factor of Low permeable gas condensate reservoirs					
		Lean			Rich	
Flowrates	14000 Mscf/day	17000 Mscf/day	20000 Mscf/day	14000 Mscf/day	17000 Mscf/day	20000 Mscf/day
A	71.26	71.26	71.26	70.21	70.21	70.21
B	71.26	71.26	71.26	70.21	70.21	70.21
C	71.26	71.26	71.26	70.21	70.21	70.21
D	71.26	71.26	71.26	70.21	70.21	70.21
E	71.26	71.26	71.26	70.21	70.21	70.21
F	71.26	71.26	71.26	70.21	70.21	70.21

Table 5 CRF of low permeable Lean and rich gas condensate reservoirs

	Condensate Recovery factor of Low permeable gas condensate reservoirs					
		Lean			Rich	
Flowrates	14000 Mscf/day	17000 Mscf/day	20000 Mscf/day	14000 Mscf/day	17000 Mscf/day	20000 Mscf/day
A	24.53	24.44	24.32	22.81	22.74	22.65
B	24.88	24.83	24.75	23.97	24.11	24.18
C	24.67	24.39	24.12	25.46	25.40	25.35
D	24.04	23.68	23.36	25.18	25.16	25.12
E	23.17	22.92	22.80	25.44	25.47	25.46
F	22.79	22.64	22.52	25.48	25.49	25.47

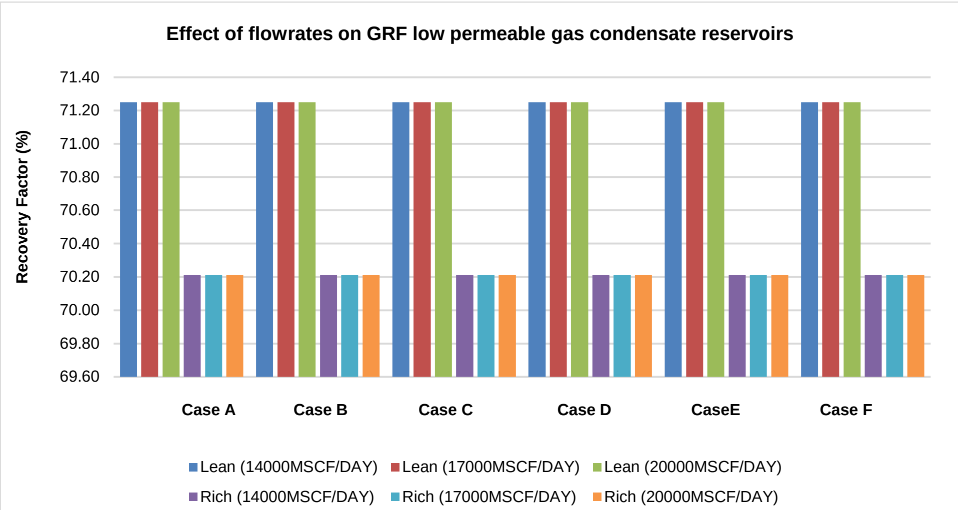

Figure 4 Effect of flow rates on Gas recovery factor

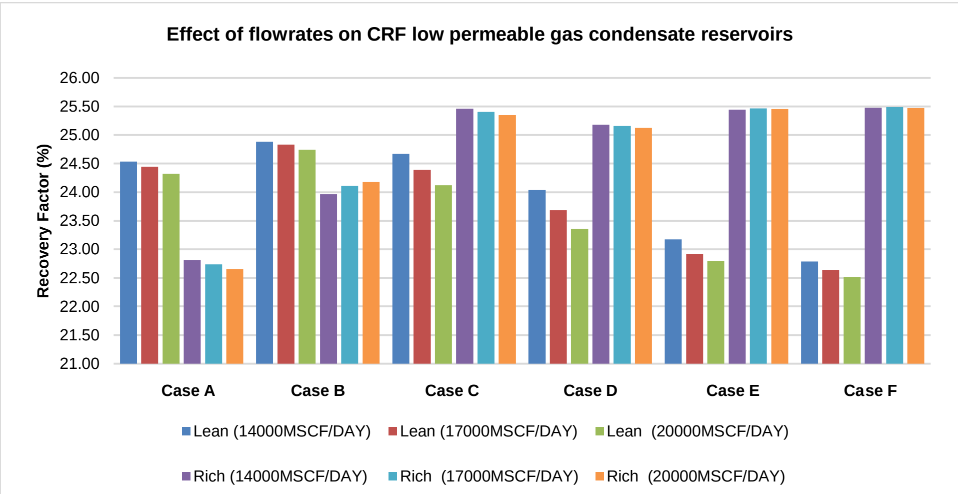

Figure 5 Effect of flow rates on Condensate recovery factor

3.2.1. Comparison Results for effect of different flow rates

From the Figure 3, it is clear that, for gas recovery factor at each flow rate as listed above, the GRF is identical i.e. 71.22% and 70.21% for low permeable lean gas and rich gas condensate reservoir. Likewise, it is also shown in Table 4.

Likewise, from all cases either its lean or rich the condensate recovery factor is given in the Table 5, which shows that for lean gas condensate reservoir has the maximum recovery factor of 24.74% at 14000 Mscf/day flow rate for first four cases but after fourth case, the recovery declines.

While, for low permeable gas condensate reservoir the maximum gas condensate recovery factor is achievable at the maximum number of wells i.e. in case e and f which was 25.45% and 25.47%, respectively.

Conclusions

After the compositional model analysis of all cases in sense of the number of producing wells and also effect of varying flow rates, the following conclusions are produced:

1. The first result is concluded that there is no any variation on GRF as the number of producing wells are increasing in the reservoir but the time period of achieving that recovery factor varies for each case i.e. single well reaches at the end of the 4th year whereas for six wells the maximum GRF is achieved at the end of 2nd year. Moreover, there is no any major difference between the GRF of low permeable lean and rich gas condensate reservoirs. In this study, the low permeable reservoir has 71.25% and 70.21% GRF for lean and rich gas condensate respectively.
2. While the CRF plays contrarily for low permeable lean and rich gas condensate reservoirs. In this study, it is noticed that for lean gas condensate reservoir the maximum CRF is achieved when the single producing well is at the corner of the reservoir having 24.7% but for rich gas condensate reservoir, the CRF is maximum i.e. 25.47% when the six producing wells are in the field.
3. The second effect of varying flow rates concluded that there is no any changing in the GRF in each flow rate and case selection but for CRF the low permeable gas condensate reservoir gives maximum recovery at lesser flow rate while the rich gas condensate gives maximum recovery by supreme flow rate.

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