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The Determination of Maximum Flow Rate in Well X Layer Y Field Z

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ABSTRACT: The field development target which usually in field X are mostly carried out in gas reservoirs over time, in several candidate wells gas reserves have started to run low so that the remaining oil reserves and pressure in the reservoir naturally decrease or natural depletion. This is due to continuous production of gas reserves. One of the wells that has the biggest potential for oil reserves in field X is well A9. In this study, the maximum flow rate was determined in the A9 layer A well in field X with a skin value of 10 using manual calculations. From manual calculations on the condition of well X with skin 10 Qmax Well X from the IPR plot results with manual calculations is 25.87 bbl/day with a PI value obtained 0.009371 stb/d/psi meanwhile in well condition X without skin the Qmax value obtained is 40.12 bbl/day with a skinless J value of 0.01457 stb/d/psi. From the determination of IPR on ECRIN, the Qmax value in well X without skin is 43.08 bbl/day, meanwhile in the condition of well X with skin 10 the Qmax value obtained is 25.84 bbl/day

KEYWORDS: production, reservoir, oil, reserves.

1. INTRODUCTION

The production process has an important role in recovering oil from reservoirs. This production process is carried out to find out the best or optimal scenario for producing fluid from inside the reservoir to the surface. Generally, fluid can flow to the surface without any obstacles. However, the production phase will decrease as time goes by. When there is a drastic decline in the production process, it indicates that there is a problem in the well. One of the problems that causes a decrease in production is skin. If this skin is not treated, over time it will cause the well to die due to blockages in the rock pores.

In this research, before carrying out deeper field development, a comparison will be made of the maximum flow rate on the skin equal to zero and the skin equal to 10 according to the data obtained. Determination of the maximum flow rate is done by determining the inflow performance relationship (IPR) curve using manual calculations and using ECRIN.

2. METHODOLOGY

The method used in this research uses the Vogel equation to determine the Q value with a skin of 10, as well as assuming a Pwf value starting with reservoir pressure followed by a decrease of 200 psi until the bottom well pressure value, or Pwf, is equal to zero.
According to Brown & Lea (1985), nodal analysis is defined as a system for obtaining optimal results in oil and gas wells, used comprehensively by evaluating each component of the production system. Every component production system can be optimized to obtain objective flow rates according to economic value.

All components from the base point of the well to the separator are analyzed to obtain optimal results. According to Awal & Heinze (2009), nodal analysis can help improve well completion and appropriate economic performance for the field, while Musnal & Melisa state that nodal is a meeting point between two different flow performances in production wells.

A node is a meeting point between two components, where at the meeting point physically there will be a mass balance or pressure balance. This means that the mass of fluid coming out of one component will be the same as the mass of fluid entering the next interconnected component or the pressure at the end of one component will be the same as the pressure at the end of another connected component. (Herawan, Production Engineering Module II)

Nodal system analysis of a well is required for:
1. Examine the fluid flow and reservoir in each component of the well system to determine the influence of each component on the

well system as a whole

2. Combining the fluid flow behavior throughout the components so that the well production rate can be estimated.

To analyze the influence of a component on the well system as a whole, the node node closest to the component is selected. For example, if the size of the choke on the production rate were figured out, then choose the nodal point at the wellhead. Otherwise, if the effect of the number of perforations was figured out, then choose the nodal point at the bottom of the well. (Herawan, 2018).

In this research, nodal analysis was carried out using PROSPER software which consists of PVT data matching, Gradient Matching, Inflow Performance Relationship data input, and system sensitivity analysis for each layer in the well to be analyzed.

Inflow Performance Relationship (IPR) Curve

The inflow Performance Relationship (IPR) in a well is the relationship between the production flow and the flowing well bottomhole pressure. In oil wells, it is often assumed that the fluid flow rate is proportional to the difference between reservoir pressure and wellbore pressure. This assumption leads to a straight-line relationship derived from Darcy's law for the steady state flow of an incompressible single-phase fluid and is called the Productivity Index (PI). However, this assumption only applies when above the bubble point pressure.

Based on the multiphase flow equation, shows that there is a relationship between flow rate and pressure when two-phase flow occurs in a reservoir (saturated oil). (Evinger & Muscat, 1942), based on multi-phase flow equations showed that there is a curved relationship between flow rate and pressure when two-phase flow occurs in a reservoir (i.e. saturated oil). Meanwhile, according (Vogel, 1968) presented the relationship between the performance of empirical fluid flow for reservoirs and the drive mechanism solution gas, based on simulation results and various properties of rocks and fluids. The well-known dimensionless IPR was developed to drain saturated oil from a reservoir with a drive mechanism for the gas solution to a well that has no effect. After Vogel, several empirical relationships have been developed to predict the performance of oil wells in saturated reservoirs. However, this IPR is empirical and has been developed for homogeneous gas-solution-driven reservoirs and may not apply to other cases.

Basically, the ability of a well to produce fluid can be known based on data obtained such as reservoir data and production data. Through this data, the ability of a well to flow fluid can be seen by reading the inflow performance relationship or IPR curve. Through reading the IPR curve, the maximum flow rate that can be obtained from a well can also be determined. The results of reading the IPR curve are also the first step in the process of optimizing fluid production. (Marpaung, 2015).

There are two types of IPR curves, namely single-phase IPR curves and two-phase IPR curves where the single-phase IPR curve shows when the reservoir pressure is greater than the bubble point pressure and there is only one liquid phase so that the IPR curve is in the form of a straight linear line as in Figure 1 while The two-phase IPR curve shows that when the reservoir pressure is less than the bubble point pressure and there are two phases, namely liquid, and gas, the IPR curve is curved as in Figure 2. In the one-phase curve, fluid flow in porous media was stated by Darcy (1856).) which was further developed for radial flow conditions with an equation of the form:

$$qo = 0{,}007082 \frac{ko\ h(Pe - Pwf)}{\mu o\ Bo\ In(\frac{re}{rw})}$$

The requirements needed to be able to use this equation are that the fluid must be in one phase, the flow is in a stable state, the formation is horizontal and the fluid is incompressible. Meanwhile, for the IPR curve where the fluid has two phases, Vogel develops simple regression results, with the following equation:

$$\frac{q}{q\ max} = 1 - 0{,}2\ (\frac{Pwf}{Pr}) - 0{,}8\ (\frac{Pwf}{Pr})^2$$

The conditions that must be met are that the fluid is two-phase, the type of driving force is solution gas, and the reservoir pressure is smaller than the bubble point pressure.

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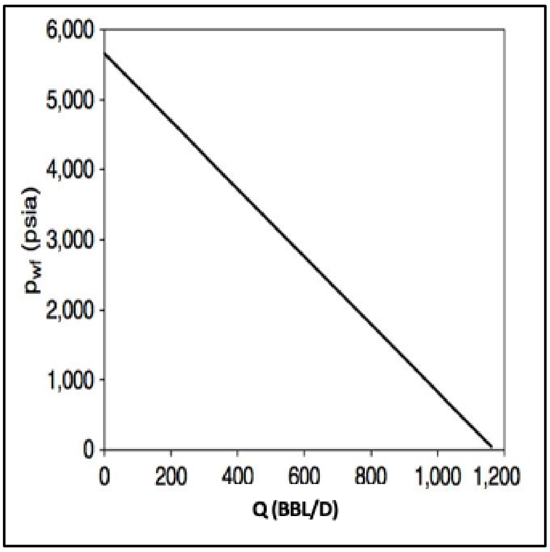

Figure 1. IPR Curve single phase

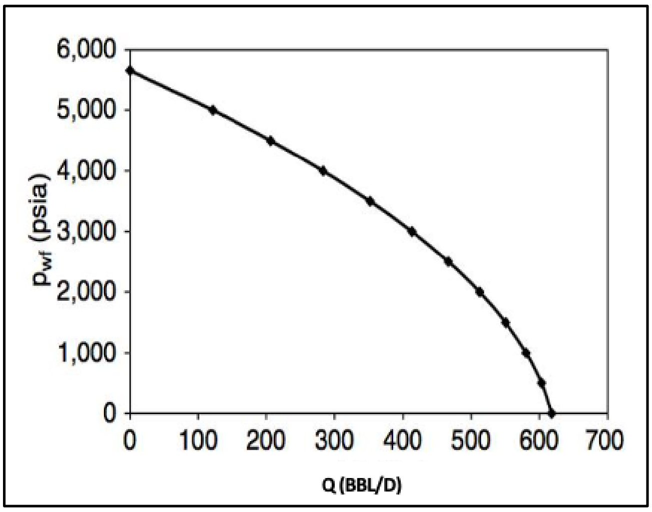

Figure 2. IPR Curve two phase

In this research, the productivity index (PI) was also calculated which is used to express the capacity of a formation to produce at a certain pressure difference. The PI equation is written as follows:

$$PI = J = \frac{q}{Ps-Pwf} \text{ STB/Day/Psi}$$

The J value can also be calculated using the equation below where in this equation the J value is influenced by the skin value.

$$J = \frac{0.00708 \, x \, k \, x \, h}{\mu B_o\left[ln\frac{re}{rw}\right]-0.75+s} \text{STB/Day/Psi}$$

3. RESULT AND DISCUSSION

Determination of the IPR curve was done manually using available data and using the two-phase IPR curve equation. The data used in this calculation is as follows:

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Table 1. Parameters of IPR Data

Parameter	Value	Unit
rw	8.5	in
	0.243	ft
por	0.116	fraction
h	4.2	ft
μo	0.95	cp
Bo	1.1214	bbl/STB
Pr	3591	psia
Pwf	1350	psia
Pb	4783.34	psia
Area	95115	m^2
Re	572.17	ft

At this stage, the first step taken is to find the J value using the skin equation where the skin value in well X is 10. The J value obtained in this calculation is 0.009371, therefore from here the maximum flow rate value with skin 10 can be calculated, namely 25.87 bbl/day. From the results of this calculation, an IPR curve was created with Pwf assuming starting from the reservoir pressure with a decreasing interval of 200 psi to Q with a skin of 10 as in Table 2.

Table 2. IPR Curve Data of X Well with Skin

Pwf Ass	Q(skin 10)
3591	0
3391	2,53
3191	4,93
2991	7,20
2791	9,35
2591	11,36
2391	13,25
2191	15,01
1991	16,64
1791	18,14
1591	19,52
1350	21,00
1191	21,88
950	23,05
791	23,73
550	24,59
391	25,06
150	25,62
0	25,87

From the results obtained from Table 2, the IPR curve can be determined, where a curve is obtained as shown in the image below:

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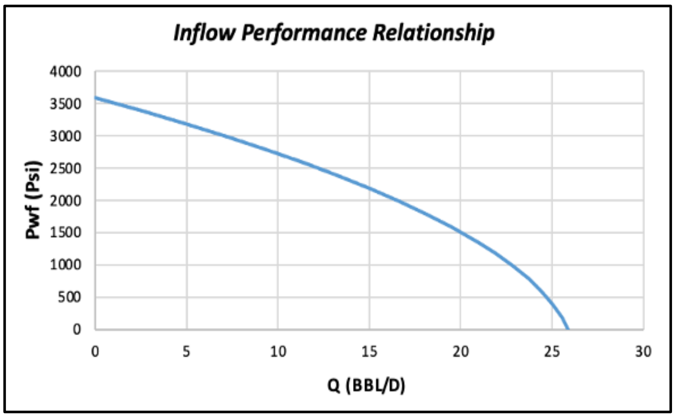

Figure 3. IPR Curve of X Well with Skin

Furthermore, manual calculations have also been carried out if well X does not have skin. From this calculation, the J value without skin is 0.01457 stb/d/psi, therefore from here the maximum flow rate value without skin can be determined 40.12 bbl/day. From this calculation, an IPR curve was also made with Pwf assuming starting from reservoir pressure with an interval of 200 to Q without skin (S=0) as in Table 3.

Table 3. IPR Curve Data of X Well without Skin

Pwf Ass	Q without s
3591	0
3391	3.92
3191	7.65
2991	11.17
2791	14.50
2591	17.62
2391	20.55
2191	23.28
1991	25.81
1791	28.14
1591	30.27
1350	32.57
1191	33.93
991	35.75
791	36.80
591	38.14
391	38.87
191	39.73
0	40.12

From the results obtained from Table 3, the IPR curve can be determined, where a curve is obtained as shown in the image below:

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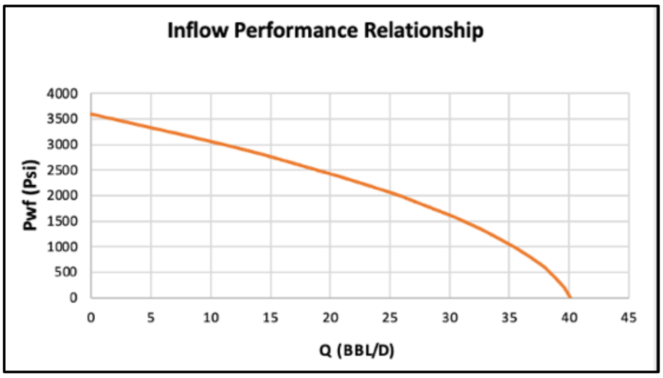

Figure 4. IPR Curve of X Well without Skin

In the next stage, the IPR curve without skin and with a skin value of 10 was determined using ECRIN as a comparison. The data parameters used are the data in Table 1. The results obtained from ECRIN are as follows:

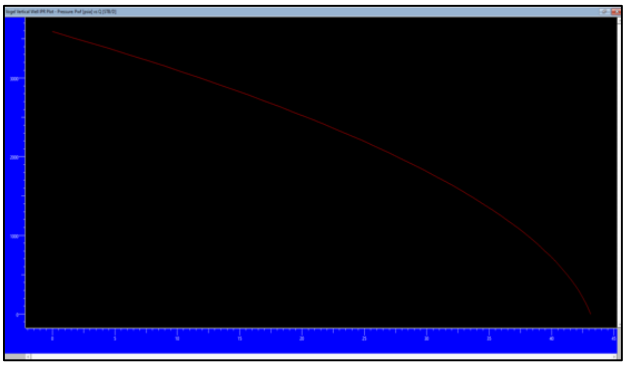

Figure 5. IPR Curve of X Well without Skin using ECRIN

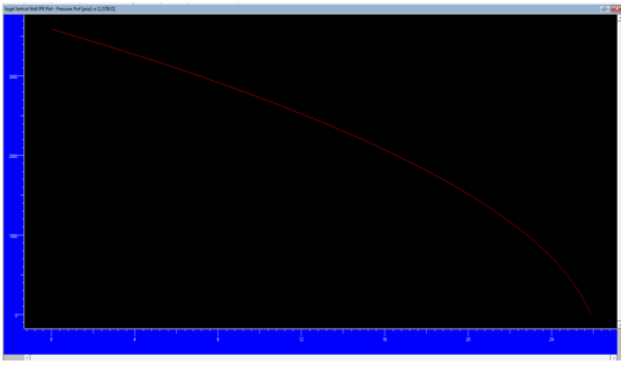

Figure 6. IPR Curve of X Well with Skin using ECRIN

From the curve in Figure 5, it can be seen that the Qmax value in well X without skin or S=0 is 43.08 bbl/day. Meanwhile, in Figure 6 it can be seen that the Qmax value in well X with skin 10 is 25.84 bbl/day.

4. CONCLUSION

From manual calculations for well X under the condition of skin value 10, the calculated Qmax (maximum flow rate) of well X, obtained from the IPR (Inflow Performance Relationship) plot through manual calculations, is 25.87 bbl/day, with a corresponding PI (Productivity Index) value of 0.009371 stb/d/psi. Meanwhile, under the condition of well X without skin, the obtained Qmax is 40.12 bbl/day, and the J value (flow efficiency index) without skin is 0.01457 stb/d/psi. From the IPR determination in ECRIN, the

Qmax value for well X without skin was 43.08 bbl/day. Meanwhile, in well X conditions with skin 10, the Qmax value obtained was 25.84 bbl/day.

As for suggestions that the author can provide for the continuation of this research in the future for the company, it is recommended to conduct a pressure build-up test to determine the skin value in field Z. The determination of the optimum flow rate can be made if there is production history data, followed by the establishment of a production forecast for layer Y. Subsequently, an analysis of artificial lift technologies, such as gas lift or ESP, can be conducted to increase oil production. Consideration can be given to studying water injection to maintain reservoir pressure and implementing enhanced oil recovery (EOR) to increase the recovery factor (Rf). Additionally, an economic estimation can be carried out for future field development plans.

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