Forecast gas well production performance with well test analysis for oil and gas industry

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Abstract. Well test pressure and deliverability analysis are carried out to determine permeability (k), skin formation damage factor, initial pressure (Pi), (ΔP skin), investigation radius (ri), the boundary of the reservoir. The results of this work are used to calculate the initial gas reserves by wells and predict production capacity in the wells studied (AOPF). Furthermore, an optimal production plan will be produced to produce the most economical value. The result of this work is the initial pressure value (Pi) which is equal to 862 psi. The skin values of the pressure derivative and Horner Plot methods are -0.214 and -0.232 respectively, the permeability value is 148 and 135 mD, the value of the investigation radius is 2110 ft. The resulting AOPF is 8214 Mscf/D. The calculation of the initial gas reserves by well uses the volumetric method which is equal to 458 MMscf. These results carried out forecasting production performance aims to determine the most optimal production planning. This production plan, the scenario plan are the 1st scenario with a gas rate of 2 MMscf and 2nd scenario uses a compression 50 psi with a gas injection rate of 1 MMScf. Furthermore, the best scenario of this research is the maximum production by using 50 psi injection rate of 1 MMScf.

1. Introduction
Well test analysis is often used in the oil and gas industry. Well test is used to determine the performance of the wellbore study. In this particular study, the well test is combined with the gas reserve calculation method (GIIP) and then subsequently generate the production forecast from the wells.

Development of oil and gas fields throughout the world always encounters problems and obstacles at the implementation stage. A specific common problem found is the decline in the production rate, that is due to several reasons, among others, is the formation damage occurred surrounding wells or formation layers.

The well test pressure can know damage from the formation. In addition to knowing the well damage, wellbore test can also to determine the value of the initial reservoir pressure, permeability, investigation radius, and boundary of the reservoir.

The most common analysis requires that the well produces at a constant rate, either from the start-up or long enough to establish a stabilized pressure distribution before shut-in. If possible, the flowing bottom-hole pressure prior to shut-in should also be recorded, which is essential if an estimate of skin is required [1].

Kamal and Pan published a multiphase analysis method in 2011, that produces values of absolute permeability as a result, which are consistent with the relative permeability relations. The procedure consists of a few steps [2].
In this research, the data used to obtain production-forecast uses data from the calculation of hydrocarbon reserves around the well, that is, from the value of the radius of the investigation, other parameters use the assumption that data is available. Next is production forecasting from the well under study.

2. Methods
The methods used in this research include well testing (type curve pressure derivative, modified isochronal test), the method to determine the ability of a layer or formation to produce. From the test results, there will be a lot of information to be obtained such as effective fluid permeability, formation damage or repair around the boreholes tested, reservoir pressure, the boundary of a reservoir, the shape of the drain radius, heterogeneity of a layer [3].

Introduced the Modified Isochronal test method. In the isochronal test method, the length of the closure time is generally not uniform and not short because it must achieve static equilibrium conditions, then in the Modified Isochronal Test the period of time the well closure is taken at the time of flow [4].

Development from this research is to combine well test methods and calculation of gas reserves with the volumetric method Gas Initial In Place (GIIP).

\[
GIIP = \frac{43560 \cdot A \cdot h \cdot \phi \cdot (1 - Swi)}{Bgl}, \text{Scf}
\]  

3. Results and discussion
The figure 1. below is a history data of pressure plots with flow rates.

![Figure 1. History data plot from wellbore (Exported from software analysis).](image)
The following result from the analysis data of the matching *Type Curve Pressure Derivative* method:

![Type Curve Pressure Derivative matching](image)

**Figure 2.** Type Curve Pressure Derivative matching (Exported from software analysis).

Calculations performed with this method can show in table 1 below:

| Parameter                  | Results |
|----------------------------|---------|
| Skin (s)                   | -0.214  |
| Permeability (k), mD       | 148     |
| $P_i$, Psi                 | 861.8   |
| $\Delta P_{\text{skin}, \Psi}$ | -4.23   |
| Radius Investigation, ft   | 2110    |

From table 1 can be concluded that the value of negative skin indicates no damage to the wellbore. Permeability values also show a good reservoir performance. From the results, the value of the radius of investigation will be used to calculate reserves around the wellbore ($GIIP$). Skin factors can also have done with the Horner Plot method. The result of this method is -0.232.

Analysis of the deliverability test can also be done using the Modified Isochronal Test method. This time the Modified Isochronal Test uses the extended period method, where the price of the straight line extension is stable, and the axes intersection will determine the value of $C$. This value of $C$ is to determine the maximum gas flow rate or what is commonly known as *Absolute Open Flow Potential (AOFP)*.
Table 2. Modified isochronal test data.

| $Q_g$ (mscf/d) | $P_{wf}$ (psi) | $P_{ws}$ (psi) |
|----------------|----------------|----------------|
| 927            | 813.6          | 827.5          |
| 2047           | 780.1          | 833.2          |
| 4190           | 692.6          | 833.2          |
| 6229           | 583.0          | 826.8          |

From these data, the results obtained as shown in table 3 below:

Table 3. The result from modified isochronal test method.

| Parameter                              | Value   |
|----------------------------------------|---------|
| $n$ extended flow, (mscf/D)/(psi^2)    | 0.7001  |
| $C$ extended flow, (mscf/D)/(psi^2)    | 0.6369  |
| AOFP, mscf/D                           | 8214.01 |

This method is used for planning production prediction from well which is seen from the AOFP value. Calculating GIIP by using a variable from the well test method is the value of the investigation radius. This value is used to calculate the area of the well. The radius of investigation is considered a circle. Gas Initial in Place can be calculated with equation 1. The result is 458,36 x 10^6 Scf.

Figure 3. Production forecast.

Table 4. Result from production forecast.

| Scenario     | Cum. Gas Prod (10^6 Scf) | Recovery Factor (%) | And of Production |
|--------------|--------------------------|---------------------|-------------------|
| GIIP (10^6 Scf) : 458,36 |                          |                     |                   |
| 1st Scenario | 62                       | 13.5                | 01-Feb-20         |
| 2nd Scenario | 366                      | 79.8                | 01-Jan-21         |
4. Conclusions
The well test results carried out in this research with the Type Curve Pressure Derivative produced a skin. Skin factors show a negative value which means that the wellbore is no found formation damage.

Result from well test with the Type Curve Pressure Derivative Method, to determine the Absolute Open Flow Potential (AOFP) is done using the Modified Isochronal Test method. This AOFP value is useful for knowing the production capability of the reserve capacity in the well.

The combination of the Well Test Method with the volumetric method in this study is to use the value of the radius of the investigation from the results of the well test, and then this value is used to determine the area of the wellbore. This area used in volumetric equations (GIIP).

After knowing the value of AOFP and gas reserves, production planning is carried out by simulating with several production scenarios before being carried out directly on the well. The best result is that 2nd scenario produces.

References
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