Flow Regime Analysis on Pressure Build-up Test Result of Z-01 Well Using Dual Porosity Reservoir Model

(Analisis Flow Regime Pada Hasil Pressure Build-Up Test Sumur Z-01 Dengan Model Reservoir Dual Porosity)

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Abstract
Flow regime analysis on the results of pressure build-up Z-01 well test was conducted to determine the type of flow that occurs in each time section. In the early time stage there is a flow which is dominated by linear flow which is then followed by bilinear flow. At the middle time there is a radial flow where the pressure disturbance has spread towards the reservoir. In the late time flow stage is dominated by steadystate flow where the flow is affected because there is a support pressure caused by the constant pressure boundary. In the analysis of pressure build-up used to determine reservoir parameters can be used in the middle time region. This is used because the plot results between ΔP vs. log HTR (Horner Time Ratio) are straight lines which can be used to calculate reservoir parameter values such as permeability (k), formation damage factor (s). This test was analyzed using the Ecrin software and obtained a dual porosity model with a permeability value of 4.8 md, skin -3.57. From the analyzed model, it is obtained that the well fracture-finite conductivity model means that the Z-01 well has been stimulated to increase production.

Keywords: Flow Regime, Time Region Section, Pressure Build-up, Dual Porosity, Fracture-Finite Conductivity

Sari
Analisa flow regime pada hasil pressure build-up test sumur Z-01 dilakukan untuk mengetahui jenis aliran yang terjadi pada setiap time region section. Pada tahap early time terjadi aliran yang didominasi oleh linear flow yang kemudian dilanjutkan dengan aliran bilinear flow. Pada tahap middle time terjadi aliran radial flow dimana gangguan tekanan sudah menjalar menuju reservoir. Pada tahap late time aliran didominasi oleh steadystate flow dimana aliran ini dipengaruhi karena terdapatnya support pressure yang disebabkan oleh adanya constant pressure boundary. Pada analisa pressure build-up yang digunakan untuk menentukan parameter-parameter reservoir dapat digunakan pada middle time region. Hal ini digunakan karena pada hasil plot antara ΔP vs log HTR (Horner Time Ratio) didapatkan garis lurus yang dapat digunakan untuk mengkalkulasikan nilai parameter reservoir seperti nilai permeabilitas (k), faktor kerusakan formasi (s). Pada pengujian ini dianalisa dengan menggunakan software Ecrin dan didapatkan model dual porosity dengan nilai permeabilitas 4.8 md, skin -3.57. Dari model yang dianalisa didapatkan hasil dengan well model fracture-finite conductivity yang berarti sumur Z-01 telah dilakukan stimulasi untuk meningkatkan produksi.

Kata kunci: Rejim Aliran, Daerah Waktu, Pressure Build-up, Porositas Ganda, Rekahan dengan Konduktivitas Terbata

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I. INTRODUCTION
Fluid flow in reservoir may change from a flow pattern to another flow pattern. This occurs due to the shape and size of the reservoir. Z field is an onshore gas field located in Central Sulawesi Province, Indonesia. First production from the field was in early 2016. There are eight wells producing gas from a carbonate reservoir. Pressure build-up test was conducted in Z-01 Well in order to estimate the productivity of the well as well as the reservoir characteristics.

The aim of this study was to analyze flow regimes at early time, middle time and late time sections on the results of pressure build-up Z-01 well test. The analysis results were used to determine the reservoir model and well model. The informations The determination of reservoir and well models was an important step to estimate the parameters of the reservoir such as the permeability value (k) and the formation damage factor (skin factor).

II. METHOD
The procedure of the research is depicted in Figure 1. The study analyzed wellbore storage effect, flow regimes, and reservoir characterization based on pressure build up test data. Several flow regimes were identified such as fracture linear flow, bilinear flow, radial flow, and pseudo study state flow [1, 2]. The Plots used to identify the flow
regimes.

Horner plot and pressure derivative plot were used to evaluate the characteristics of reservoir. Several data were obtained from this evaluation such as permeability, skin factor, omega (ω), lamda (λ), and fracture length (x_f) [3, 4, 5].

The data of deliverability test using modified isochronal test were analyzed to determine the flow potential and establish the inflow performance relationships (IPR) of the gas well [6].

The data of reservoir rock and fluid, well and properties were collected from Z-01 Well and the field cover reservoir thickness (h), porosity (φ), compressibility of formation (c_i), total compressibility (c_t), gas deviation factor (z), formation volume factor of gas (B_g), specific gravity of gas (ρ_g), gas viscosity (μ_g), gas density (ρ_g), gas liquid ratio (GLR), reservoir pressure (p_r), reservoir temperature (T_r), producing time (tp), shut-in time (Δt), gas flow rate (q_d), and well radius (r_w). The data are listed in Table 1.

III. RESULTS AND DISCUSSION

In order to determine the reservoir model, several relationships between pressure and time of the pressure build-up test result were made and analyzed to identify the type of flow regimes that occur in each time region.

Figures 2 to 4 depict flow regimes which take place during early time region. Figure 2 shows a plot between ΔP vs Δt on the log-log scale. It indicates that in the initial part of early time region is affected by wellbore storage. In the same time, the linear fracture flow regime also takes place. It can be detected by plotting ΔP vs √Δt as shown in Figure 3. This flow regime informs that there is fracture in the reservoir rock. This linear fracture flow is then followed by a bilinear flow as shown in Figure 4.

In the middle time region, a radial flow regime can be indentified using pressure derivative plot as shown in Figure 5. Radial flow is reached when the pressure derivative curve in the figure becomes horizontal. The figure shows that the period of radial flow is very limited. This is due to the effect of reservoir boundary. The curve is then concave downward. This indicates that the reservoir has a constant pressure boundary occurring from 5.5 hours to 35.98 hours. The all flow regimes that happen during the pressure build up well at Z-01 well are shown in Figure 6.

The data of middle time region where radial flow took place was analyzed using Horner plot (Figure 7) to estimate reservoir parameters such as permeability and skin factor. The permeability and skin factor of the reservoir were 4.7 mD and -3.6, respectively (Table 2).

The middle time segment of pressure derivative curve indicates that the reservoir can be modeled as a dual porosity reservoir. Parameters of dual porosity model, namely omega (ω), lamda (λ), and fracture length (x_f) of the reservoir were 7.69 x 10^5, 0.0155, and 48.9 ft., respectively (Table 2).

Figure 8 shows the plot of deliverability test. Based on the figure, parameters for constructing the curve of inflow performance relationship (IPR) such as absolute open flow potential (AOFP), constant C, and exponent n as given in Table 3. The IPR curve of the Z-01 Well is depicted in Figure 9.

IV. CONCLUSIONS

Conclusion that can be drawn from the analysis that had been conducted is as follows. At initial pressure build up test, the data were affected by wellbore storage. Several flow regimes can be identified during the well test using several plots, namely fracture linear flow, bilinear flow, radial flow, and pseudo steady state flow. The reservoir was predicted to have fracture and matrix system. In addition, it has constant pressure boundary.

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Figure 1. Research Flow Chart
Table 1. Reservoir and Well Data

| Parameters | Values | Unit |
|------------|--------|------|
| h          | 141    | ft   |
| $\phi$     | 0.147  |      |
| $c_f$      | 0.00003| psi$^{-1}$ |
| $c_t$      | 0.000279 | psi$^{-1}$ |
| $z$        | 0.96   |      |
| $B_g$      | 0.001155 | ft$^3$/scf |
| $\gamma_g$ | 0.77   |      |
| $\mu_g$   | 0.019721 | cp |
| $\rho_g$  | 0.259  | g/cc |
| GLR        | 69787  | ft$^3$/bbl |
| $p_r$      | 2988   | psia |
| $T_r$      | 713.5  | R |
| $t_p$      | 17.7   | hrs |
| $\Delta t$ | 35.99  | hrs |
| $q_f$      | 8.503  | MMscfd |
| $r_w$      | 0.27   | ft   |

Table 2. Evaluation Results

| Parameters   | Values | Unit |
|--------------|--------|------|
| Permeability (k) | 4.8    | mD   |
| Skin Factor (s)    | -3.63  |      |
| Omega ($\omega$)   | 7.69 x 10$^{-6}$ |      |
| Lambda ($\lambda$) | 0.0155 |      |
| Fracture Half Length ($x_f$) | 48.9 | ft |

Table 3. Deliverability Test Results

| Parameters | Values | Unit |
|------------|--------|------|
| C          | 0.125  | MSCF/D/psia |
| n          | 0.839  |      |
| AOFP       | 73000  | MSCF/D |
Figure 2. Wellbore Storage Effect

Figure 3. Fracture Linear Flow
Figure 4. Bilinear Flow Regime

Figure 5. Pressure Derivative Curve
Figure 6. Flow Regime Periods of Z-01 Well

Figure 7. Horner Plot
Figure 8. Deliverability Test Plot

Figure 9. IPR Plot