A New Method For Estimating The Peak Gas Rate

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Abstract

Every winter from November of the first year to March of the next year, gas consumption would roar. As a result, all gas fields will increase gas rate to meet the needs. Traditionally, peak rate and rational rate are usually determined by methods such as pressure drop rate, Rate Transient Analysis (RTA), and numerical simulation. These approaches have been verified in the production, but they show flaws like heavy workload and poor time effectiveness. Theoretical research indicates that a plot of the increment of gas rate and the pressure drop rate should be linear, when pseudo-steady state is reached. In consequence, based on numerical simulation, correlations of the increment of gas rate and pressure drop rate were developed respectively for a series of reservoir pressure and well types. Field applications show that this method can not only process a huge batch of data in one time, but quickly estimate the rational and peak gas rate in real time.

Introduction

Changqing oilfield company provides fuel for more than 13 provinces and so it enjoys the reputation of the natural gas base in China. As a major block in Changqing, it is vital to predict the rate during the peak gas supply period. However, after ten years of production since 1997, ever-decreasing pressure has caused great difficulties in maintaining plateau and meeting the needs of consumption in winter. Conventional gas rate predicting methods include pressure drop rate (Luo et al. 2008), rate transient analysis (Blasingame et al. 1991; Oghena 2012) and numerical simulation (Li et al. 2004). But they show flaws like heavy workload and poor time effectiveness. Therefore, this study aimed at establishing a quick and accurate way to predict peak gas rate.

Peak Gas Rate Evaluation

Flow Performance in Pseudo Steady State. Theoretical research indicates that if a surrounded well produced at a constant flow rate, every cell pressure will decline with a constant rate when the effect of the outer boundary has been felt (**Figure 1**). And this period of time is called the pseudo steady state (PSS) which develops with a linear relationship of gas rate and reservoir pressure. Field applications show that type I wells in Jingbian gas field need 0.5 year to reach the SSS, type II wells 1 year and type II wells 2.5 years. With ten years of producing history, most wells in the study area has reached the SSS and so the relationship of gas rate and reservoir pressure can be widely established.

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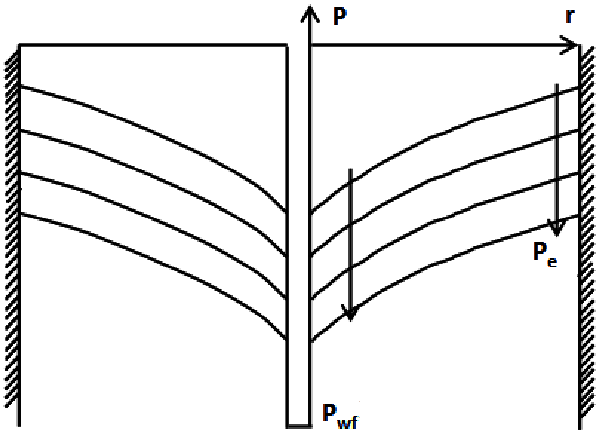

Figure 1—Pressure distribution under pseudo steady state.

Correlation of Casing Pressure and Reservoir Pressure. Reservoir pressure is hard to get, but the casing pressure can be monitored with real time. As a result, this article developed a quick way to estimate reservoir pressure by casing pressure.

First as shown in **Eq. 1**, applying Cullender-Smith method (Wang et al. 2011), bottom-hole-pressure can be obtained

$$\int_{p_{tf}}^{p_{wf}} \frac{\frac{p}{ZT}}{\left(\frac{p}{ZT}\right)^2 + \frac{1.324\times10^{-18} f q_{sc}^2}{d^5}} dp = \int_0^h 0.03415\gamma_g dh \quad (1)$$

Then with the bottom-hole-pressure, reservoir pressure could be abstained by solving the gas well inflow **Eq. 2** (Wang et al. 2014)

$$P_R^2 - P_{wf}^2 = Aq + Bq^2 \quad (2)$$

Based on the above methods, reservoir pressures were calculated as shown in **Figure 2**, which indicates the reservoir pressure and casing pressure yield a linear relationship. Compared with real reservoir pressure, the average errors of this method is only about 3% (**Figure 3**).

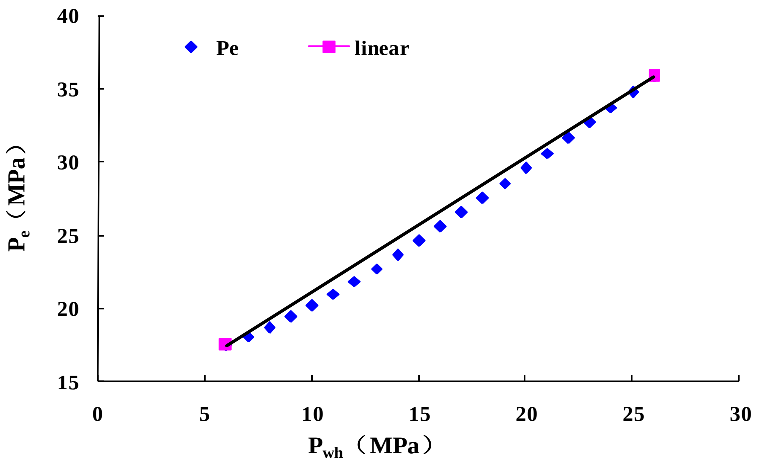

Figure 2—Relationship of Casing Pressure Reservoir Pressure.

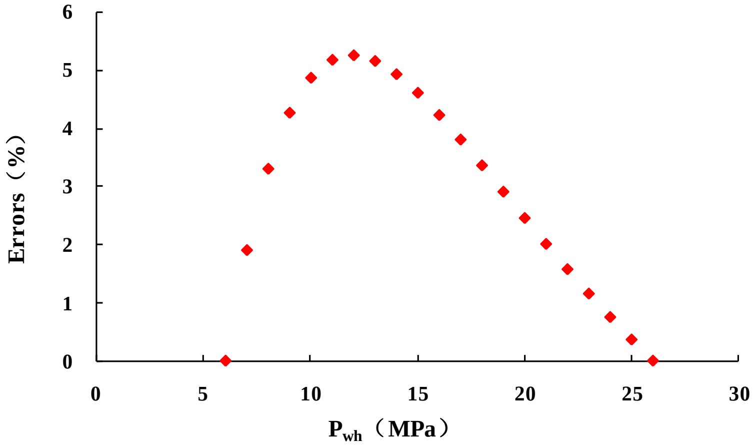

Figure 3—Errors of the Calculating Method.

Graphical Correlation of Pressure Drop Rate and Increment of Gas Rate. Base on the theoretical research and numerical simulation analysis, correlations of pressure drop rate as a function of increment of gas rate and reservoir pressure were established for three types of wells, respectively (**Figures 4** through **6**).

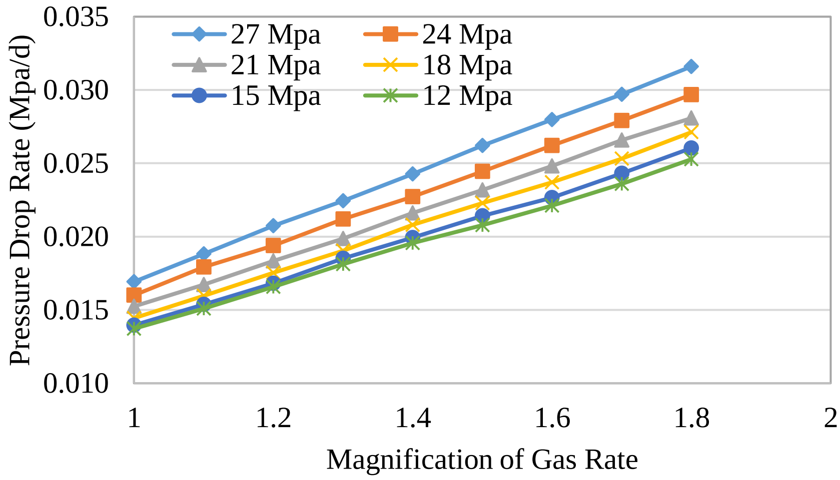

Figure 4—Correlation of pressure drop rate and increment of gas rate of type I well.

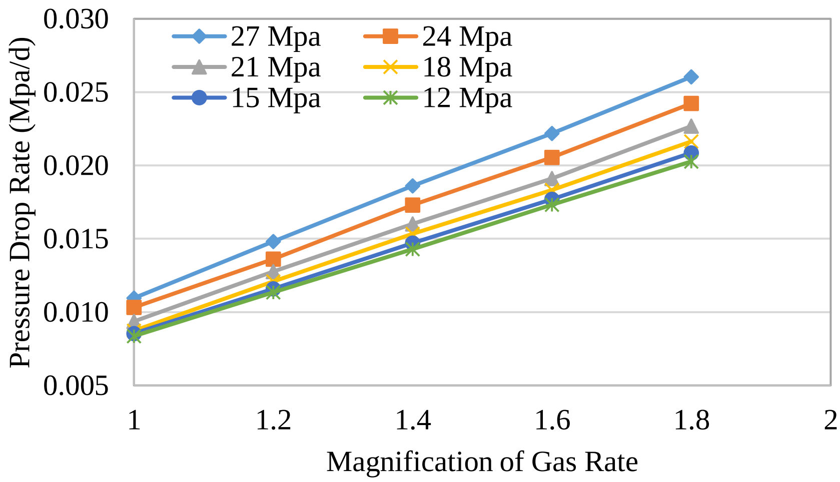

Figure 5—Correlation of pressure drop rate and increment of gas rate of type II well.

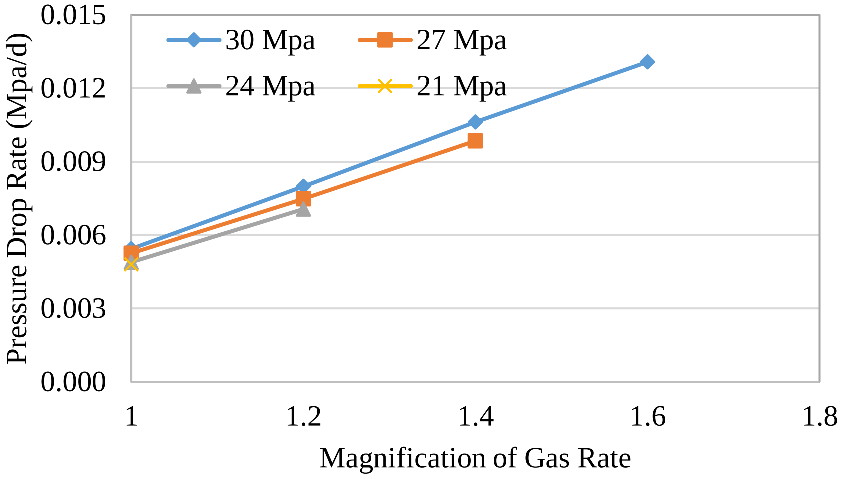

Figure 6—Correlation of pressure drop rate and increment of gas rate of type III well.

After determining the reservoir pressure, these graphic correlations can be used for peak gas rate evaluation quickly and massively. But Fig. 6 shows that when reservoir pressure is less than 21 MPa, even tiny rate increase will cause huge casing pressure drop, then these wells are not qualified for peak gas production.

Field Application

In order to verify the graphic correlations, 22 wells in Jingbian gas field were put into calculations and results show that errors of this method is only about 10%.

Well X-1 was selected for peak gas production on Oct 12th, 2016. As shown in **Figure 7**, with the reservoir pressure of 17.2 MPa, when gas rate increase 1.3 times, from $12\times10^4 m^3/d$ to $15.3\times10^4 m^3/d$, casing pressure drop rate increases to 0.0188 MPa/d. And the graphic correlation (**Figure 8**) indicates the rate increase corresponds to a pressure drop rate of 0.0179 MPa/d, which yield errors of 4.8%.

Well X-2 was selected for peak gas production on Oct 6th, 2016. As shown in **Figure 9**, with the reservoir pressure of 15.1 MPa, when gas rate increase 1.3 times, from $2.2\times10^4 m^3/d$ to $2.8\times10^4 m^3/d$, casing pressure drop rate increase to 0.0113 MPa/d. The graphic correlation (**Figure 10**) indicates the rate increase corresponds to a pressure drop rate of 0.0120 MPa/d, which yield errors of 5.8%.

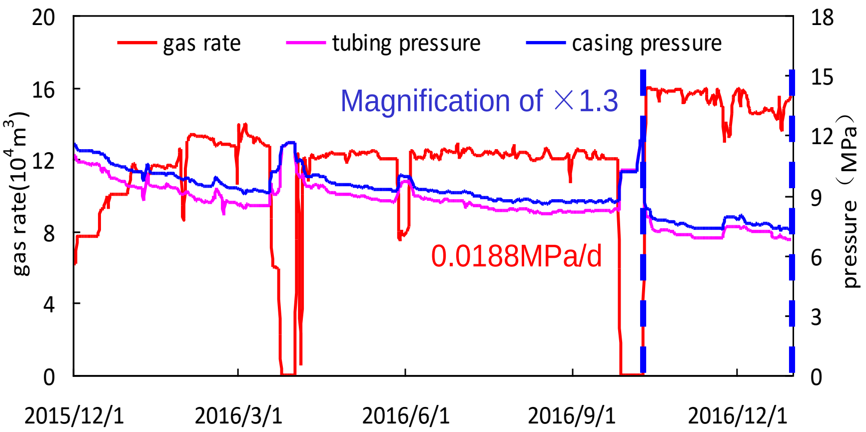

Figure 7—Well X-1 production history (I).

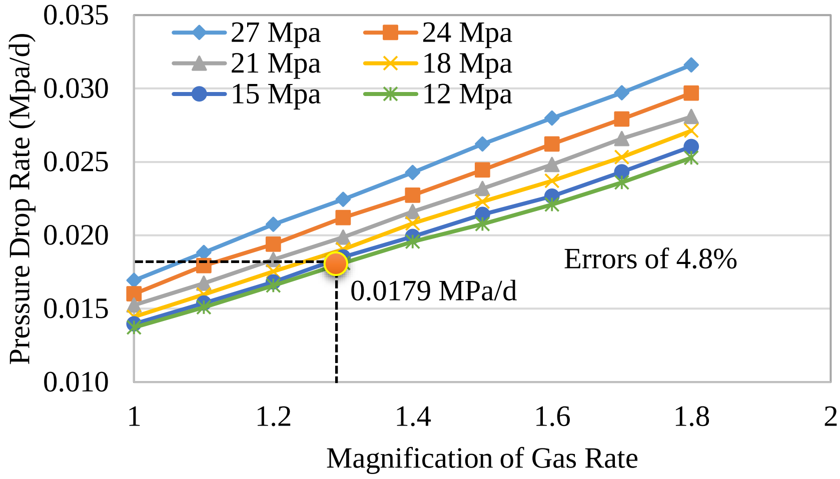

Figure 8—Well X-1 gas rate evaluation chart (I).

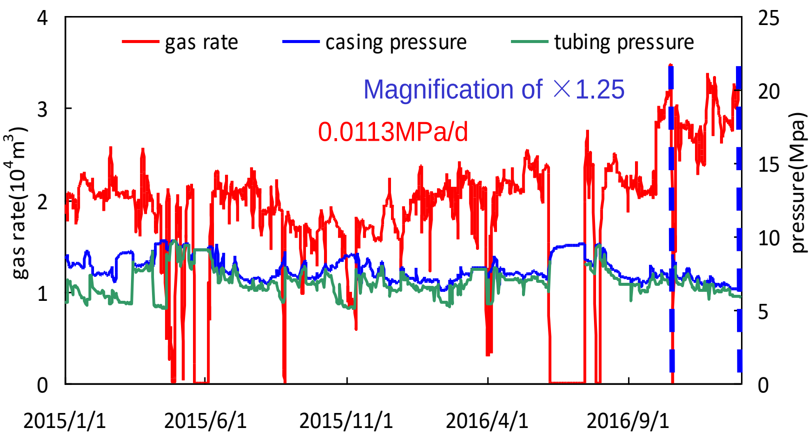

Figure 9—Well X-2 production history (II).

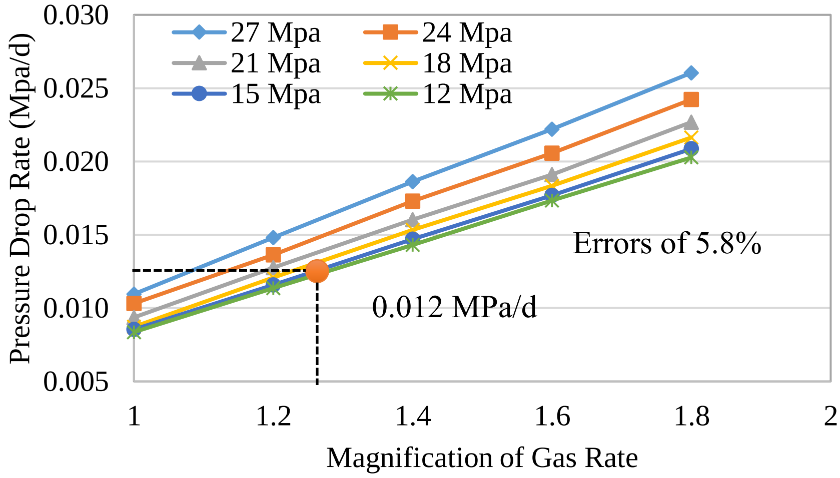

Figure 10—Well X-2 gas rate evaluation chart (II).

Conclusions

Theoretical research shows that when pseudo steady state is reached, gas rate and pressure drop rate yield a linear relationship. Base on the theoretical research and numerical simulation analysis, correlations of pressure drop rate as a function of increment of gas rate and reservoir pressure were established for three types of wells, respectively. These graphic correlations not only can process a huge batch of data in one time, but quickly estimate the peak gas rate in real time. Field applications show that the errors of this method are less than 10%.

Conflicts of Interest

The author(s) declare that they have no conflicting interests.

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