Dynamics of reservoir pressure and the influences on coal seam gas production

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Introduction

Coal seam gas (CSG) is known as an important unconventional natural gas resource and the mitigation and utilization of CSG can significantly reduce the gas-related mining hazards such as gas explosion and gas outburst and reduce greenhouse gas emission. The dynamics of reservoir pressure are key factors in determining the effective desorption range, the interwell interference, and gas productivity. The objectives of this study are to establish a model to calculate the dynamics of reservoir pressure and bottom-hole pressure (BHP) during CSG production and on this basis, to analyse the influences of reservoir pressure dynamics on CSG production. Firstly, a new method was proposed to calculate the dynamics of reservoir pressure with considerations of CSG sorption and production data. Then, with the deliverability equation under pseudosteady-state flow, the variations of BHP were analysed and compared.

Methods

Assuming conditions:

- CSG reservoir is flat;
- Thickness of CSG reservoir is uniform;
- Boundary of CSG reservoir is closed;
- Isothermal during CSG reservoir depletion.

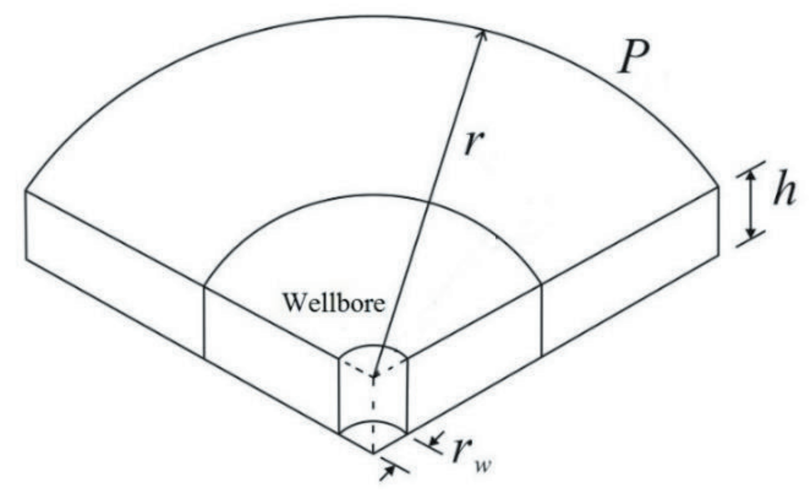


Fig.1 CSG reservoir model

Based on the production data, the CSG recovery rate during production can be computed as:

$$\eta = \frac{Q_{sc}}{\pi R^2 h \rho V_i} \quad (1)$$

In accordance with the Langmuir curve, the gas recovery rate can also be calculated as follows:

$$\eta' = \left[1 - \frac{P\left(P_L + P_{cd}\right)}{P_{cd}\left(P_L + P\right)}\right] \quad (2)$$

If applying Eq. (2) into the process of gas production, it means P (abandonment pressure) becomes a dynamic reservoir pressure. Theoretically, the gas recovery based on the production data, which is based on the Langmuir curve are equal:

$$\eta' = \eta \quad (3)$$

Solving for the dynamic reservoir pressure, it is expressed as:

$$P = \frac{P_{cd} P_L (\pi R^2 h \rho V_i - Q_{sc})}{P_{cd} Q_{sc} + \pi P_L R^2 h \rho V_i} \quad (4)$$

For the pseudosteady-state flow, the deliverability equation in metric units is as follows (Liao 2012):

$$m(P) - m(P_{wf}) = \frac{1.31 \times 10^{-3} q_{sc} T}{K_g h} (In \frac{R}{r_w} - 0.75 + S) \quad (5)$$

Solving for the BHP,

$$P_{wf}^2 = P^2 - \frac{1.31 \times 10^{-3} \mu_g Z q_{sc} T}{K_g h} (In \frac{R}{r_w} - 0.75 + S) \quad (6)$$

Where R is external radius of drainage boundary, m; h is thickness of CSG reservoir, m; ρ is density of coal, t/m^3; Q_{sc} is total gas production, m^3; P is reservoir pressure, MPa; P_L is Langmuir pressure, MPa; P_{cd} is critical desorption pressure, MPa; P_{wf} is BHP, MPa; q_{sc} is gas flow rate, m^3/d; K_g is gas permeability, mD; T is coal seam temperature, K; r_w is wellbore radius, m; s is wellbore skin factor; μ_g is gas viscosity, mPa·s; and Z is gas deviation factor.

Results and discussion

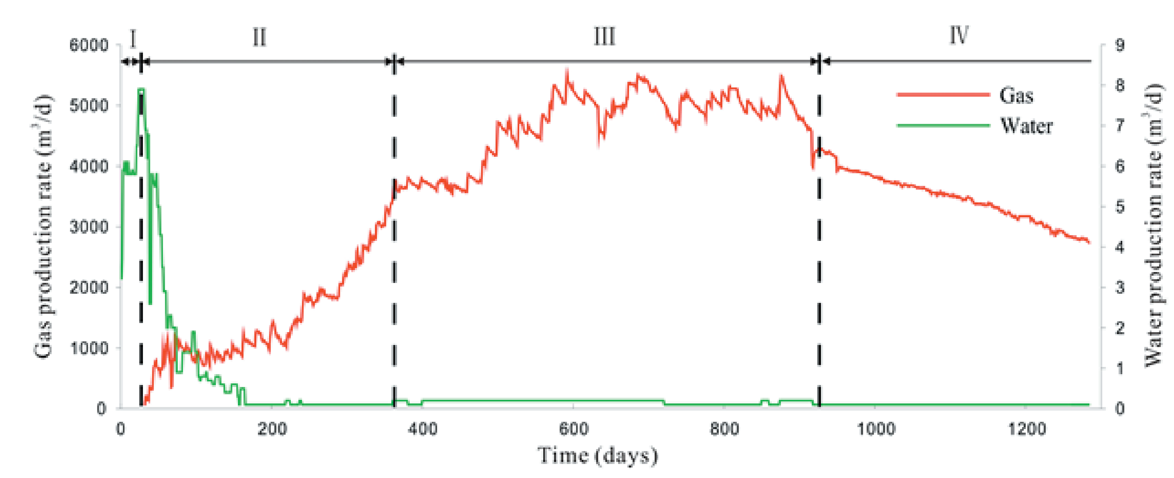
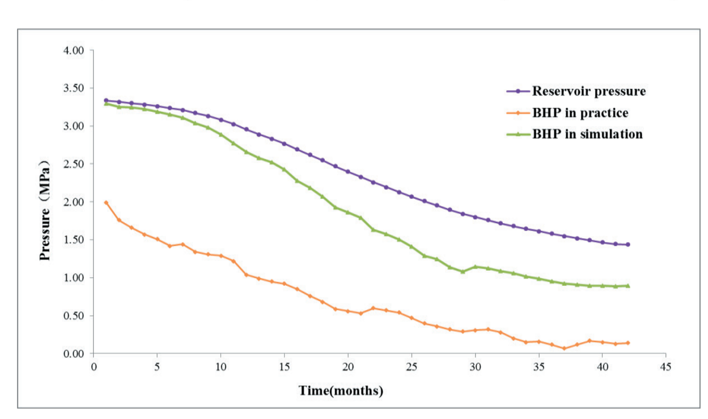


Fig. 2 Gas and water production of well X1 in Qinshui Basin. Ⅰ Single-phase water production stage; Ⅱ Two-phase gas-water production stage; Ⅲ Stable gas production stage; Ⅳ Declining gas production stage.



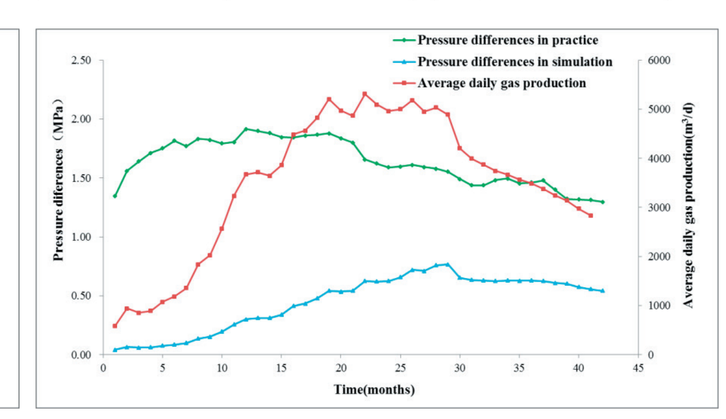


Fig.3 Variations of reservoir pressure and BHP

Fig.4 Variations of pressure differences

1) There are similar variation trends between the reservoir pressure and BHP with calculation that both showed a slow-fast, and slow variation pattern. While the BHP in practice is evidently lower compared with BHP with calculation .
2) There are similar variation trends between the pressure difference with calculation and gas production rate. But the pressure difference in practice is evidently higher compared with pressure difference with calculation .
3) The controlling of BHP of Well X1 should adapt the variations of reservoir pressure.

Bibliography

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