CBM extraction system simulation research

Mingjing Xu
China University of Mining and Technology, Faculty of Safety Engineering, University Road No.1, Xuzhou City, Jiangsu Province, 221116

Introduction

The simulation model of CBM extraction system is constructed with COMSOL Multiphysics®. And this model is based on a coupled model, which consist of two simulation models, which are CBM extraction pipeline system and gas drainage borehole simulation model.

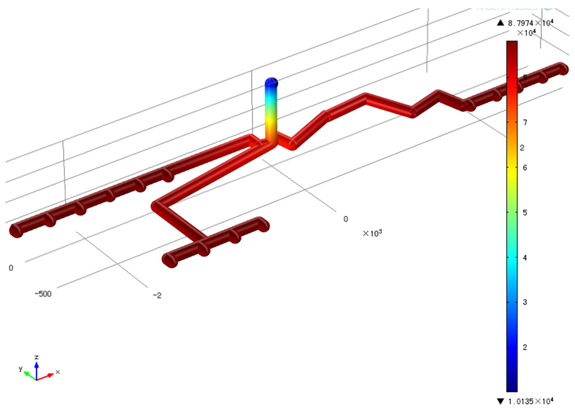


Fig 1. CBM pipeline system model

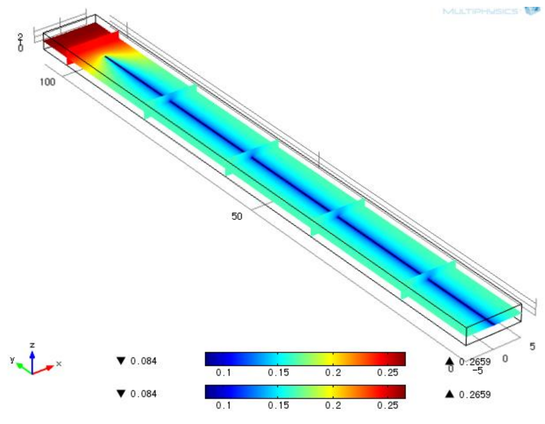


Fig 2. gas drainage borehole model

Model 1. CBM pipeline system model

The model used **pipe flow module** in COMSOL Multiphysics® V5.1. The extraction borehole mouth is set as inlet boundary, and extraction pump station is set as outlet boundary. And all the assumption follow the assumption in pipe flow module.

Boundary Conditions:

$$Q_v = c_1 p^2 + c_2 p + c_3 \quad \textbf{(outlet)} \qquad q_m = f(t) \quad \textbf{(inlet)}$$

Model 2. Gas drainage borehole model

The assumptions of simulation model include ideal gas assumption, isotropic permeability assumption, isotropic body assumption and there is no leakage in borehole. The **Darcy's law interface** is used in the simulation model. The boundary conditions of the simulation model include mass source and boundary pressure of wall of borehole.

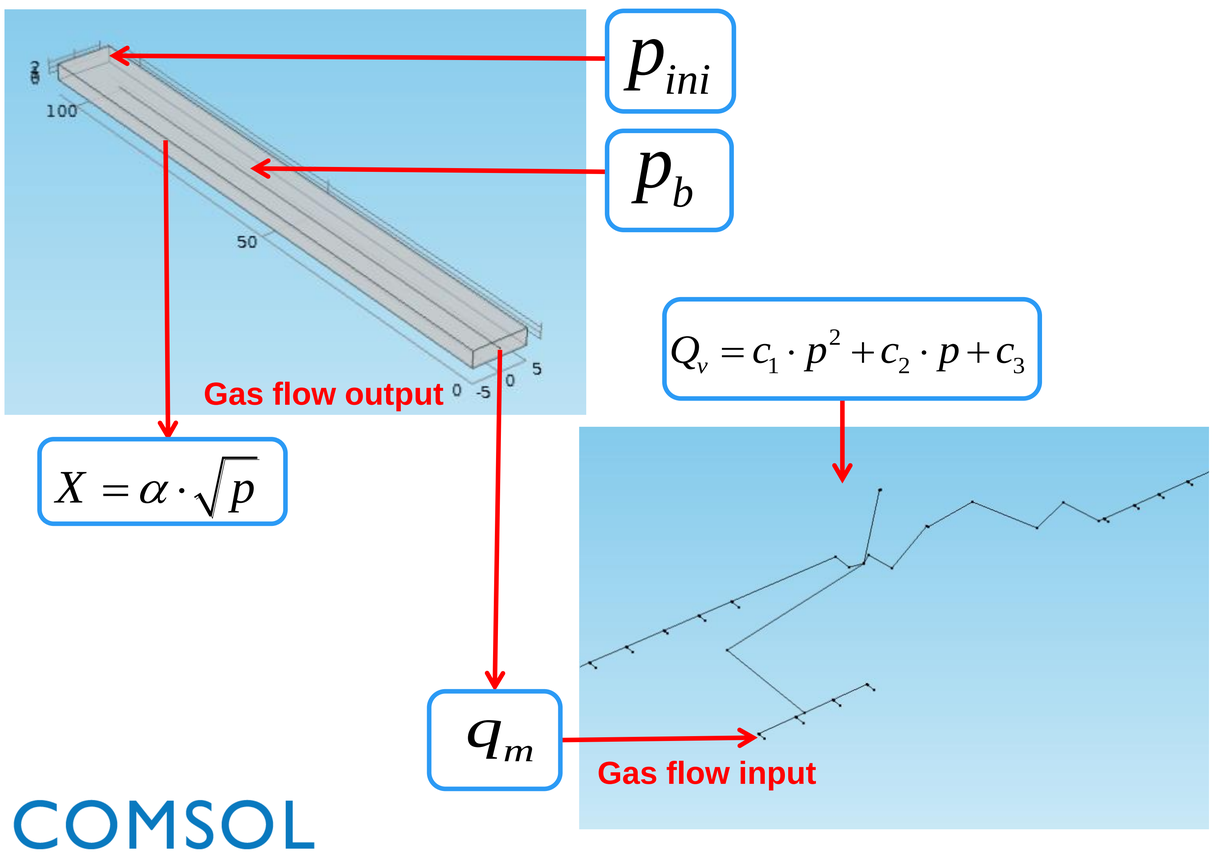
Boundary Conditions:

$$p_{ini} = 0.29MPa \qquad p_b = 85kPa \qquad q_m = \frac{dX}{dt} = f(t)$$

Assumption:

$$X = \alpha \cdot \sqrt{p}$$

The assumption of gas drainage comply with Zhou's theory. Where X is gas content, α is a coefficient to represent permeability.



Result

The result of gas drainage borehole model is shown as Fig 3-6. From 1 day, after extracting gas, to 3 days, the maximum gas pressure of coal bed decreased from 0.28 to 0.24MPa. Gas content decreased from 9.3 to 8.6m^3/t.

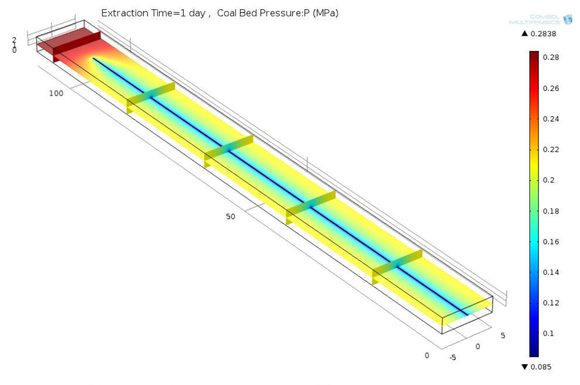


Fig 3. 1 day later, Pressure

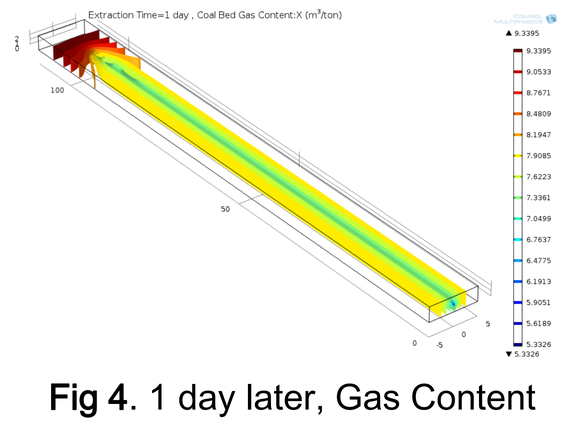


Fig 4. 1 day later, Gas Content

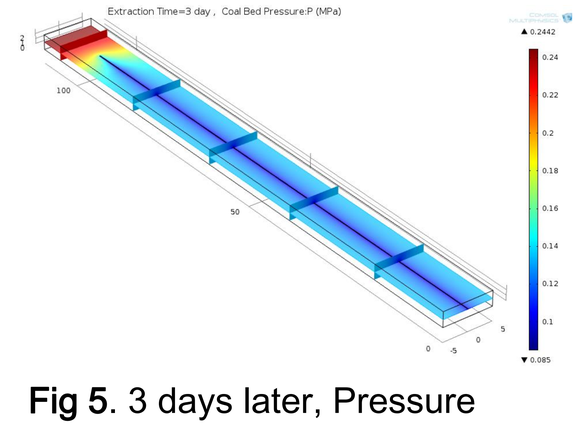


Fig 5. 3 days later, Pressure

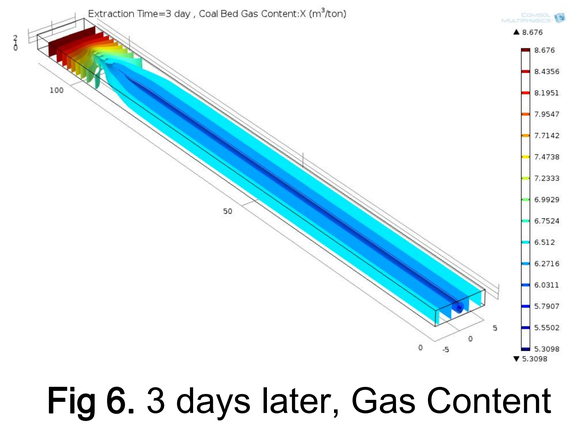


Fig 6. 3 days later, Gas Content

The result of CBM pipeline system model is shown as Fig 7-10.

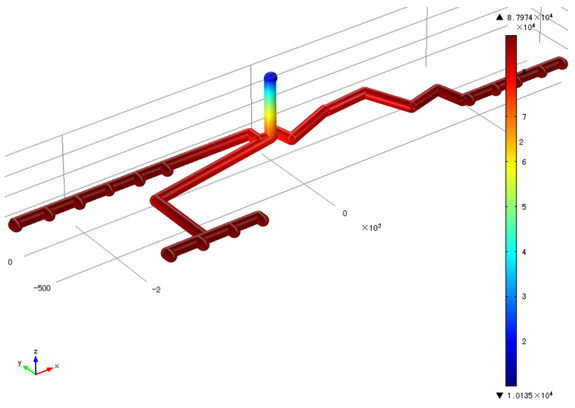


Fig 7. pressure distribution

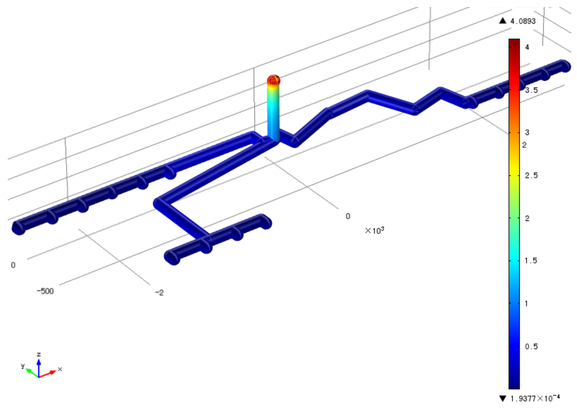


Fig 8. volume flow rate distribution

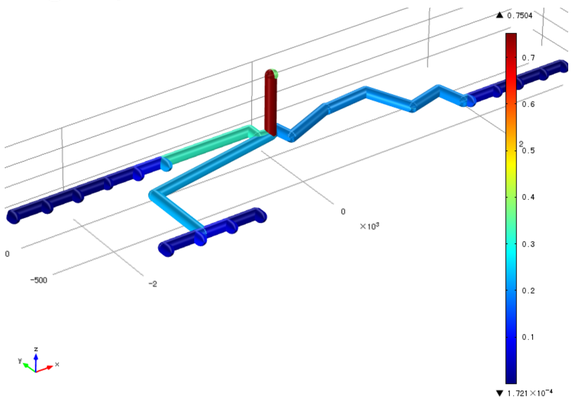


Fig 9. mass flow rate distribution

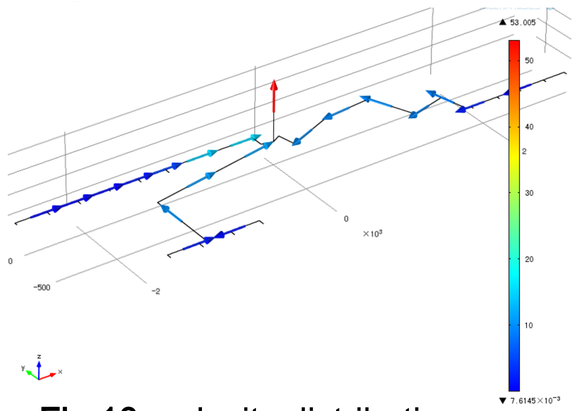


Fig 10. velocity distribution

Conclusion

The assumption of gas drainage is proved to be correct, because result of gas drainage borehole model is in line with reality. And we found that the resistance of extraction system is mainly the body force of gas from bottom hole to wellhead force (gravity).

Reference

1. Zhou Shining, Lin Baiquan, The Theory of Gas Flow and Storage in Coal Seams, China Coal Industry Publishing House, ISBN 7-5020-1458-6, p15-18(1999).
2. S.E. Haaland, "Simple and Explicit Formulas for the Friction Factor in Turbulent Flow," Journal of Fluids Engineering (ASME), vol. 103, no. 5, p89-90(1983).

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