Determination of Coal Permeability Using Pressure Transient Methods

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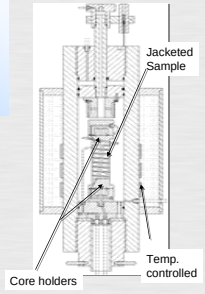
Abstract

Coalbed methane is a significant natural resource in the Appalachian region. It is believed that coalbed methane production can be enhanced by injection of carbon dioxide into coalbeds. However, the influence of carbon dioxide injection on coal permeability is not yet well understood. Competitive sorption of carbon dioxide and methane gases onto coal is a known process. Laboratory experiments and limited field experience indicate that coal will swell during sorption of a gas and shrink during desorption of a gas. The swelling and shrinkage may change the permeability of the coal. In this study, the permeability of coal was determined by using carbon dioxide as the flowing fluid. Coal samples with different dimensions were prepared for laboratory permeability tests. Carbon dioxide was injected into the coal and the permeability was determined by using pressure transient methods. The confining pressure was variedto cover a wide range of depths. The permeability was also determined as a function of exposure time of carbon dioxide while the confining stress was kept constant. CT scans were taken before and after the introduction of carbon dioxide. Results show that the porosity and permeability of the coal matrix was very low. The paper presents experimental data and theoretical aspects of the flow of carbon dioxide through a coal sample during pressure transient tests. The suitability of the pressure transient methods for determining permeability of coal during carbon dioxide injection is discussed in the paper.

Objectives

- Gain basic knowledge concerning CO_2 sequestration in geologic formation
- Determine permeability changes caused by sorption of CO_2



Mathematical Formulation

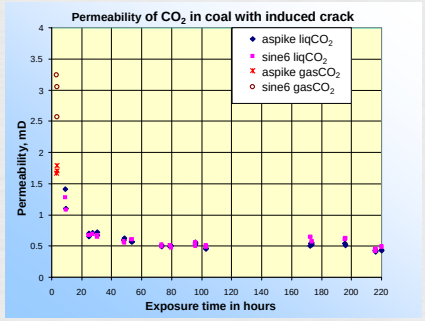
$$\frac{\partial^2 P}{\partial x^2} = a^2 \frac{\partial P}{\partial t}$$

Initial and Boundary Conditions

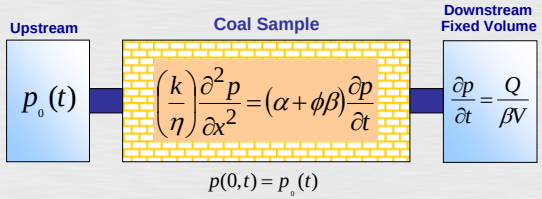
P (0, 0) = Pi
P (x, 0) = P0

For t > 0 and x = 0 $P(0,t) = P_0(t)$

For t > 0 and x = L $\frac{\partial P(L,t)}{\partial t} = \frac{Q}{\beta V}$



Experimental Setup



k = Permeability
α = Pore volume compressibility
β = Fluid compressibility
ϕ = Porosity
η = Viscosity
V = Fixed Volume (down stream)
Q = Flow Rate

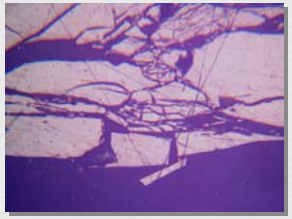
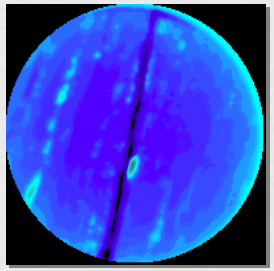


Photo-micrograph of a Coal Sample



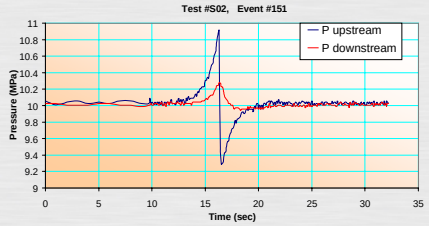
CT Scan of a Fractured Coal Sample

Experimental Conditions

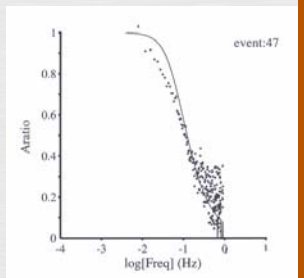
- Fractured coal samples were used to study the swelling behavior of coal
- Confining pressure up to 50 MPa was used

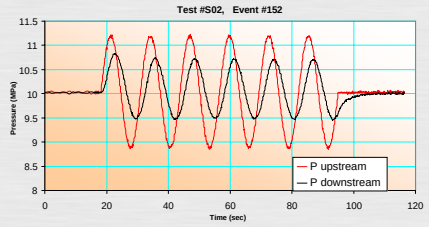
Results

- Permeability of coal sample used in the experimental program is very low (less than 0.001 mD)
- Permeability decreased with sorption of carbon dioxide indicating swelling of coal matrix



Pressure Pulse Used in the Test





Sine Wave Pressure Pulse

Fractured Coal Sample

Conclusions

- Permeability of coal appears to decrease with Carbon Dioxide exposure time
- Pressure transient methods provide satisfactory results when carbon dioxide is used with coal samples
- Decrease in fracture permeability is an indication of coal swelling as a result of sorption of carbon dioxide on coal