Spherical Gas Migration Modelling Using Mechanical Damage Model

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1. Introduction

The flow of repository gases through clay-rich material is usually described by assuming four basic phenomenological models: (1) diffusion; (2) two-phase flow models; (3) models where gas flows along localized dilatant pathways and (4) models where gas fractures the material. Although classic two-phase flow models are highly extended and employed, they are not able to describe the full complexity of gas migration processes, and therefore, new and novel numerical representations for the quantitative description of advective gas flow in clay-based repository systems are required. In this study, we developed a gas migration model using a mechanical damage model, and compared the results of a laboratory gas injection test and numerical analysis for a model validation.

2. Numerical Model

2.1 Mechanical Damage Model

In order to model the gas migration phenomena, we adopted elastic damage model by Tang et al. [1]. In this model, the elastic modulus degrades gradually as damage progresses, and elastic modulus of damaged element is as follows:

$$E = (1 - D)E_0 \qquad (1)$$

where D represents the damage variable, and E and E_0 are the elastic moduli of the damaged and undamaged elements, respectively.

2.2 Gas Injection Experiment

The experiment undertaken by the British Geological Survey (BGS) consisted of a spherical gas injection test performed on a pre-compacted bentonite subject to a constant volume boundary condition [2].

2.3 Properties

Table 1 shows properties of bentonite. Elastic modulus, Poisson ratio, porosity, and permeability are given properties. Other mechanical and hydraulic properties are issued by references except damage model properties.

Table 1. Properties of bentonite

Properties	Bentonite	
Elastic model	Elastic modulus (Pa)	3.07E+08
	Poisson ratio	0.4
Damage model	Tensile strength (Pa)	1.00E+06
	Residual tensile strength (Pa)	2.00E+05
	Compressive strength (Pa)	1.20E+6
	Residual compressive strength (Pa)	3.00E+6
	Tensile strain limit	5.00E-03
Biot coefficient		0.86
Porosity (-)		0.44
Intrinsic Permeability (m^2)		3.40E-21

3. Results

Fig. 1 shows injection pressure evolution. Trend of injection pressure has a good fitting with respect to experimental results. However, fluctuation due to the damage is no modelled because damage of bentonite is preserved and outflux is continuous in the numerical model.

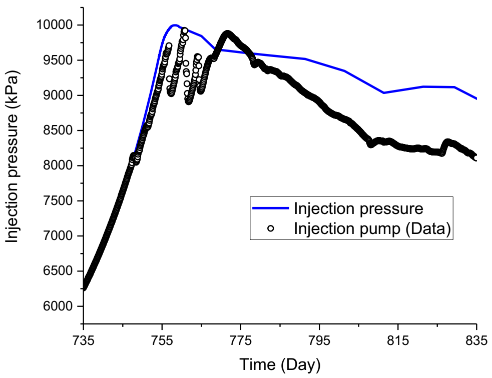

Fig. 1. Injection pressure evolution.

4. Conclusion

For modelling about gas migration, we developed a gas migration model using mechanical damage model and compared the results of laboratory gas injection experiment and numerical analysis. In general, Trend of injection pressure has a good fitting with respect to experimental results. However, fluctuation due to the damage is no modelled because damage of bentonite is preserved and outflux is continuous in the numerical model.

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