A Mixed Discretization Scheme for CO2 Leakage Mechanisms

al Khoury, Rafid; Musivand Arzanfudi, Mehdi

Publication date
2015

Document Version
Accepted author manuscript

Citation (APA)
al Khoury, R., & Musivand Arzanfudi, M. (2015). *A Mixed Discretization Scheme for CO2 Leakage Mechanisms*. Abstract from 7th International Conference on Porous Media and Annual Meeting, Padova, Italy.

A Mixed Discretization Scheme for CO2 Leakage Mechanisms

Presenter: Rafid Al-Khoury

AUTHORS

Rafid Al-Khoury (1), Mehdi Musivand Arzanfudi (2)

1. Senior Researcher / Dr, Delft University of Technology, Room 6.46, Faculty of Civil Engineering and Geosciences, 2628 CN, Delft, NL
2. PhD Student, Delft University of Technology, Room 6.43, Faculty of Civil Engineering and Geosciences, 2628 CN, Delft, NL

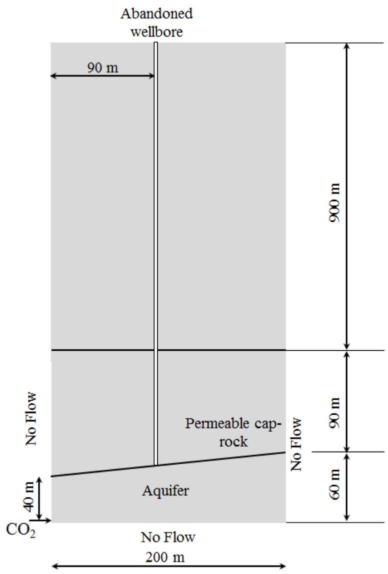
ABSTRACT

A computational model for multiple CO2 leakage mechanisms is introduced. Leakage through cap layers and abandoned wellbores are considered. For the first, leakage in a rigid heterogeneous layered medium constituting layers of different physical properties is simulated. Such a leakage exhibits a discontinuity in the saturation field at the interface between layers. For the second, a one-dimensional compressible two-fluid domain, representing a homogeneous air gas and a multiphase CO2 with a jump at the interface between them, is modelled using the drift-flux model. All important physical phenomena and processes occurring along the wellbore path, including fluid dynamics, buoyancy, phase change, compressibility, thermal interaction, wall friction, and slip between phases, together with the jump in density and enthalpy between air and CO2, are considered. For both mechanisms, the governing field equations are derived based on the averaging theory and solved numerically using a mixed finite element discretization scheme. This scheme entails solving different balance equations using different discretization techniques, which are tailored to accurately simulate the physical behaviour of the primary state variables.
For the cap layer leakage mechanism, the standard Galerkin finite element method is utilized to discretize the water phase pressure field, and a stationary partition of unity finite element method is utilized to discretize the non-wetting phase saturation field. The boundary between layers is embedded within the finite elements, alleviating the need to use the typical interface elements, and allowing for the use of structured, geometry-independent and relatively coarse meshes. For the wellbore leakage mechanism, the standard Galerkin FEM is utilized to model the diffusive field, and the moving partition of unity method, together with the level-set method, are utilized to model the advective terms. The numerical results show that this discretization scheme provides an accurate and effectively mesh-independent solution. Due to the significant difference in the time scale between wellbore and reservoir model, a multi-time-step scheme is proposed. A coupling approach is developed to make the connection between the reservoir and wellbore models. The proposed computational method allows the use of structured, relatively coarse and geometry- and mesh-independent finite element meshes.

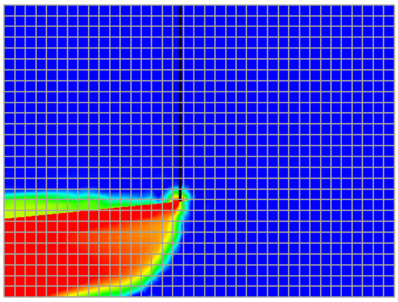
REFERENCES

[1] Musivand Arzanfudi, M., Al-Khoury, R. & Sluys, L.J.: A computational model for CO2 geo-sequestration in heterogeneous layered media. Advances in Water Resources 73 (2014), 214-26.
[2] Musivand Arzanfudi, M. & Al-Khoury, R.: A compressible two-fluid multiphase model for CO2 leakage through a wellbore. International Journal for Numerical Methods in Fluids In Press.
[3] Al-Khoury, R. & Sluys, L.J.: A computational model for fracturing porous media. International Journal for Numerical Methods in Engineering 70 (2007), 423-444.
[4] Talebian, M., Al-Khoury, R. & Sluys, L.J.: Coupled electrokinetic–hydromechanic model for CO2 sequestration in porous media. Transport in Porous Media 98 (2013) 287-321.

GRAPHICS



Graphic1



Graphic2