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CO2驱油过程中多场全耦合数学模型

盛金昌

(河海大学 水利水电工程学院, 江苏 南京 210098)

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摘要 CO2是一种温室气体,是促使全球气温升高的主要原因之一,CO2的地下贮存(注入到地下含水层)是减少CO2排放的一种很好选择。如果在石油开采的三次采油阶段用CO2来驱油,这样既可以利用废弃的油气田来贮存CO2,又可以达到增加油气产量的目的。CO2驱油过程是一个流、固、热、多相流等多场耦合作用过程。首先,建立一套流、固、热、多相流等多场全耦合控制方程组及其相应的耦合本构关系;然后,采用FEMLAB为工具来模拟三次采油阶段CO2驱油过程中的流、固、热、物质守恒等多场之间的全耦合作用,是第一个人机交互式的基于偏微分方程组的多物理场耦合分析的工程工具,利用FEMLAB,该4个耦合方程组成的方程组可以一次同时被求解出来;最后,应用该模型来求解一个二维油田的驱油情况,数值计算结果表明,原位应力、注入温度、注入压力等因素对CO2的地下贮存效率、驱油速度等有重要影响。

关键词 [环境工程](#) [CO2地下贮存](#) [驱油](#) [耦合作用过程](#) [数学模型](#)

分类号

COUPLED MULTIPHYSICS MODEL OF CO2 INJECTION FOR ENHANCED OIL RECOVERY

SHENG Jinchang

(College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing, Jiangsu 210098, China)

Abstract

Carbon dioxide(CO2) is a kind of greenhouse gas, which causes near-surface temperature increased. Geologic disposal of CO2(injection of CO2 into aquifer) has been suggested as a promising means of reducing emissions of greenhouse into the atmosphere. Oil displacement by injection CO2 of into reservoir during enhanced oil recovery stage will not only increase oil throughput but also inject CO2 into reservoir. Oil displacement by CO2 injection is coupled multiphysics processes which incorporate cross-coupled fluid flow, energy conservation, mechanical equilibrium and mass conservation. A set of quadruply coupled equations(fluid flow, convection- diffusion, energy conservation and mechanical equilibrium) with a number of cross-couplings and coupled constitutive relations is formulated to quantify the multi-physics of oil displacement by CO2 injection, implemented into and solved by using FEMLAB. FEMLAB is the first engineering tool that performs equation-based multi-physics modeling in an interactive environment. With FEMLAB, the coupled multi-physics model can be solved simultaneously. The applicability of this model has been demonstrated through an example of simulations for a two-dimensional reservoir of size 1 000 m×1 000 m with one injection and one production wells. Model results illustrate the significant importance of the cross-couplings between individual(thermal, hydrological, chemical and mechanical) physics.

Key words [environmental engineering](#) [geological disposal of CO2](#) [oil displacement](#) [coupled multiphysics processes](#) [mathematical model](#)

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