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Improved Gridding Technique for Coupling Geomechanics to Reservoir Flow

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Abstract

The application of geomechanics in reservoir flow simulation has increased substantially since it was recognized that the modeling of geomechanical effects was necessary to predict important phenomena such as compaction, subsidence, wellbore failure, etc. However, its application is strongly limited due to the use of a one-grid system for both reservoir flow and geomechanics deformation. In the case of a large field-scale simulation, the use of a one-grid system gives rise to an extremely large number of gridblocks. On one hand, for an accurate modeling of fluid flow, the gridblocks need to be reasonably small around wells and sharp fronts. Yet, these small gridblocks may not be essential for geomechanics computations. On the other hand, accurate geomechanics calculations may require many gridblocks in the overburden, underburden and sideburden (country rock) that are not necessary for fluid flow. In this work, a separate-grid technique is combined with an iterative coupling method to resolve the above problem. In this separate-grid technique, the reservoir flow grid and the geomechanics grid are distinct in order to model efficiently both fluid flow phenomena and geomechanics deformations. A method to couple the two grid systems is described. The use of this grid coupling approach reduces the simulation run time substantially with results that are very close to the one-grid method. A series of examples illustrating the application of this two-grid concept and the corresponding run-time reduction are described.

Introduction

The coupling between a reservoir (fluid and heat flow) simulator and a geomechanics (constitutive stress-strain) simulator is still an active area of research. Among the different time/implicitness coupling approaches, i.e. fully coupling, iterative coupling, explicit coupling and pseudo coupling[1], the iterative coupling approach is still considered as the most practical technique in field applications[2,3,4]. Compared to a fully coupled approach, iterative coupling is easier to maintain than the fully coupled approach and yet gives comparable results. Nevertheless, irrespective of the time coupling method being used, problems related to large computer memory requirements and long CPU running time still exist. This is because a geomechanics simulator normally solves a much larger number of unknowns per gridblock than a reservoir simulator does. If the same (coincident) grid is used for both simulators, a full-field coupled problem requires significantly more CPU time and memory than the run without coupled geomechanics calculations, which makes the coupled runs unattractive.

In order to overcome this challenge an improved gridding technique is introduced, whereby the reservoir and geomechanics grids are not required to be coincident. A reservoir grid can cover a sub-region of a geomechanics grid, and vice versa. With this approach, overburden, underburden and sideburden blocks included in a geomechanics grid can be eliminated from the reservoir grid if there is no fluid or heat flow in those regions. In addition the two grids can be refined or coarsened in different regions independently according to the scale of the various physical processes of interest. For typical thermal recovery processes with fronts, the number of geomechanics gridblocks can be much smaller than the number of reservoir gridblocks, resulting in a much reduced CPU time and memory requirement for a coupled run.