Rock Mechanics in Hydrocarbon Extraction

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Abstract

The main focus of “laboratories” of Shell International Exploration & Production is on hydrocarbon exploration (finding) and production. Apart from limited tar sand excavations (by drag lines), oil and gas are being drilled and produced via drill holes. Associated with production are injection of water, solvents or heat (steam) to facilitate the production.

Geomechanics focuses on borehole related problems, such as fracturing, hole collapse and sand production, and reservoir related problems, such as fault reactivation, cap rock integrity, subsidence, pore collapse and stress changes. Stress changes may determine the (im)possibilities for infill drilling, required to replace damaged wells or to target undepleted zones.

A borehole stability program (Stabor) is built on Diana, including plastic strain failure criteria.

Reservoir Geomechanics usually incorporates the full overburden section and considerable parts of the side and underburden, in order to limit distortions from the model’s side surfaces. Modeling is usually applied to predict rock deformation from modeled pore pressure distributions or to predict pore pressure distribution from measured rock deformation.

Although semi-analytical solutions exist and are being used, complex settings require complex packages (non linear FEM) and complex meshes. The greatest challenge (in effort) is still to create a proper FEM mesh, which honours the complex geology, (including faults, erosion zones and salt intrusions) but still supplies a limited amount of properly shaped elements.

Shell uses Gocad (a Paradigm product) to construct surface meshes from geological models, which contain the surfaces and faults. Gocad creates consistent triangulated surfaces (shared nodes at intersections) or tetrahedron volume meshes, to be used in Finite Element packages like Diana.

Geomec is a Shell-proprietary GUI built on Diana that can create volume meshes from surface meshes (or import volume meshes) and that provides an easy way to populate the mesh with distributed material data, pore pressures and temperatures. It also postprocesses calculation results from Diana.
Planned is to also use Diana capabilities to calculate heat flux and fluid flow in the overburden, since the reservoir simulators frequently ignore these, while being important for cap rock integrity.

Major bottleneck of the present Diana capabilities is the ability for multinode parallel computations to run large non-linear models. A translator to Abaqus and Elfen is foreseen for 2008.