SPE147110 - Numerical Modelling of Massive Sand Production

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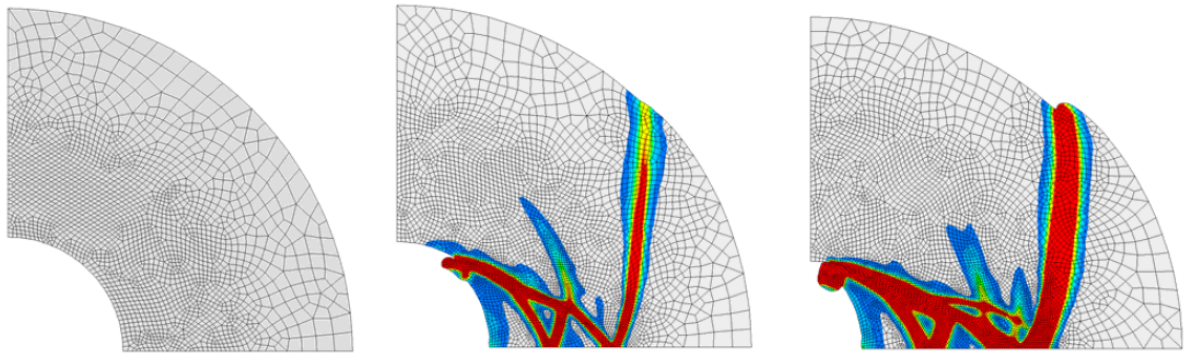
Abstract

Primary production of heavy oils where significant sand is produced (generally referred to CHOPS for Cold Heavy Oil Production with Sand) is one of the heavy oil recovery processes that have been used to recover bitumen from weakly consolidated reservoirs. There has been significant debate over the exact mechanisms that allow the sand to be produced and whether the process creates a radial zone of high permeability around the wellbore or more linear high permeability channels (wormholes) out from the reservoir. Numerical modelling of the sand production process presents significant numerical challenges mainly because it is a highly-coupled nonlinear process and requires constitutive models that are able to capture the material instability. In this paper, we present a numerical approach to explicitly model the sand production process using the Finite Element Method and Arbitrary Lagrangian Eulerian (ALE) formulation. A Number of novel features have been developed and integrated into the ALE formulation to tackle the challenges associated with sand production simulation, such as Eulerian boundary, automatic adaptive remeshing (see example below), and advanced constitutive models. By combining these features, our model enables stable coupling between fluid flow and geomechanics, and is capable of modelling large deformation and highly nonlinear geomechanical behaviours. Some examples are provided to demonstrate the soundness, accuracy, and effectiveness of the numerical model. For simulations of the CHOPS process, the model shows that a key aspect of the process is the shifting of the overburden stress from parts of the reservoir sand that fail and are produced to those where the sand has not failed. It is this mechanism that allows wormholes to form in the numerical models. The models have also shown conditions which can be induced in the reservoir to enhance formation of wormholes.



(a) Initial unstructured mesh

(b) Adaptive refinement in the zones of high shear strain localization

(c) Simulation subsequent to gross collapse through adaptive remeshing

Automatic adaptive remeshing for TWC simulation (Rockfield, 2007)

Link: https://www.onepetro.org/conference-paper/SPE-147110-MS