Fractured Reservoir Modeling, Surveillance and Management in the World's First TAGOGD Project, Oman

Keith Rawnsley[1], Mohammed Gharbi[1], Ibrahim Ismaili[1], Solenn Bettembourg[1], Pristiwanto Putra[1], and Majdi Breiki[1]

[1]Petroleum Development Oman

ABSTRACT

The world's first full field thermally-assisted-gas-oil-gravity-drainage (TAGOGD) project has been operating for over 1 year in Oman. The reservoir is a faulted and fractured carbonate containing heavy oil. By injecting steam into the fracture system the matrix blocks containing oil are surrounded by steam and heated by conduction. The viscosity of the oil reduces dramatically as it is heated allowing the gas-oil-gravity drainage process to become more efficient. The heat also has the benefit of causing thermal expansion of the oil which also contributes to the increased recovery. Overall the expected increase in recovery factor is a factor of 10.

The oil that is draining down under gravity, or is expelled from the matrix blocks due to expansion, is collecting in a rim of oil floating in the fracture system. To maximise the recovery the oil rim is being pulled down from a position near the top of the reservoir to the bottom of the matrix oil column some 140m below. This is done by offtaking gross volumes through producer wells and aquifer pump off wells. In parallel steam is injected into the crest of the field to fill the fracture system above the oil rim with steam. An extensive well and geophysical surveillance system is deployed to monitor the progress of the oil rim lowering and the heating, as well as assuring reservoir integrity. In addition, a dedicated well and reservoir management system is required to control this unique project.

The efficiency of the heating process is governed by the size of the matrix blocks surrounded by the fractures. Large blocks take much longer to heat and result in a reduced, possibly un-economic, production forecast. For this reason full field fracture models were built, constrained to the available data, covering the range of uncertainty, and used to underpin the production forecasts required to make the financial investment decision to start the project in 2007. At this time the available fracture data from the reservoir was from a handful of wells with borehole images, some core and relatively low quality 3D seismic. In addition a steam pilot carried out from 1995 to 2005 provided localised dynamic constraint on the crest of the field. Since 2007 a further 70+ wells have been drilled, nearly all with deviated or horizontal trajectories to intersect fractures, and all with high quality borehole images. These provide an excellent opportunity to evaluate the initial fracture models. Furthermore the 1 year+ of project operation has provided considerable additional dynamic constraint. Reservoir simulation is a major challenge, requiring double porosity, multi-component and thermal effects at the full field scale.

This contribution will present the overall TAGOGD strategy and the underlying fracture modelling and simulation work. The progress of the project to date, as seen through the reservoir surveillance system and management systems will be shown.