CNPC Xinjiang Enhances Waterflood Recovery with Automated Pattern Flood Management, Junggar Basin

Automated workflow for modeling and streamline simulation using the Petrel platform and ECLIPSE FrontSim quickly improves injection performance

CHALLENGE
Enhance recovery from a mature waterflood that had developed highly irregular patterns in a large faulted multilayer reservoir with complex distributions of the remaining oil.

SOLUTION
Employ an automated workflow using a reservoir model in the Petrel* E&P software platform and ECLIPSE* FrontSim for exploring pattern flood management to efficiently optimize the rate of the water allocated to individual injectors.

RESULTS
- Significantly increased oil production in 60% of the producing pilot wells while reducing their water cut.
- Decreased injection levels in 50% of the injectors.
- Cut water handling costs for the reduced volumes in both production and injection.
- Slashed the time required for determining optimal injection allocation factors from more than a month to less than a week.

CONTENDING WITH DECLINING WATERFLOOD EFFICIENCY
Xinjiang Oilfield Company, one of the largest units of PetroChina Company Ltd. (CNPC), is the largest petroleum-producing enterprise in Western China. Operations include several mature fields that are producing at high water cut after many years of waterflooding. As a proponent of developing and applying new technologies to improve production efficiency, Xinjiang was investigating how to raise recovery in one of these fields, the Huoshaoshan oil field in the Junggar basin. Consisting of hundreds of wells, the field had developed irregular flood patterns after decades of production. High reservoir heterogeneity and extensive layering and faulting compounded the challenge to optimizing recovery.

Several solutions had previously been tested by CNPC Xinjiang’s experts to reduce water cut without reducing oil production. However, most of these solutions were time consuming and difficult to conduct or cost prohibitive, whereas the methods that were easy to implement worked only temporarily or inconsistently. Using a traditional manual workflow was taking the field technicians more than a month to update the injection allocation for all injectors in the field.

CASE STUDY
Software

The regular pattern employed with traditional allocation assumes uniform geology for the reservoir (top), whereas ECLIPSE FrontSim accounted for the complexity of the reservoir’s structure, stratigraphy, and oil distribution in computing a realistic pattern configuration (bottom).
Implementing automated streamline simulation

Injection control is key to improving reservoir performance, but in practice it is hard to achieve in large waterfloods involving many wells and complex geology.

To meet this challenge, Schlumberger applied technologies and workflows that have been proved to optimize waterflooding for enhanced oil recovery (EOR). ECLIPSE FrontSim waterflood performance analysis together with a detailed well production history review was performed to identify the prevailing injection patterns and flag underperforming wells. Upon completing the reservoir study, the Schlumberger experts proposed applying streamline simulation as particularly suitable for efficiently evaluating and optimizing the interaction of the injector and producer wells.

Modeling and simulating the injection patterns in the integrated Petrel platform and ECLIPSE FrontSim streamline simulator corroborated the understanding developed from dynamic data analysis and matched the historical performance. The ECLIPSE FrontSim module for pattern flood management (PFM) was then applied to automatically optimize injection allocations for different production targets in the reservoir. The injection rate for each well was easily extracted from the PFM simulation for review by CNPC Xinjiang's experts prior to implementation on a quarterly basis.

Optimizing the waterflood: Successful field trials

The combination of Schlumberger software technology and consulting expertise and collaboration with CNPC Xinjiang’s experts improved the performance of the pilot area wells over the ensuing quarters of operation. The PFM approach made it possible to reduce water injection in more than 50% of the injectors while more than 60% of the producers experienced increased production and reduced water cut. The concurrent productivity of the asset team notably increased upon automation of the workflow for the identification of optimal injection allocation factors. The efficiency gain from automation was significant, delivering what typically took over a month in just under a week.

Identification of ineffective water injection by applying PFM with ECLIPSE FrontSim was used to adjust the injection rate in the pilot wells.

Automated waterflood management increased oil production performance and reduced water cut in this group of pilot wells.