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Diluent Injection Optimization for a Heavy Oil Field

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Abstract:

Past studies have shown that use of diluent injection with ESPs can be an efficient artificial lift method for heavy oil fields. It consists of injecting a light oil diluent to reduce the oil density and viscosity. This paper describes an integrated modeling solution designed to maximize the reservoir oil production while minimizing the diluent requirement and keeping the crude oil quality within technical and marketing specifications. The field studied is a heavy oil asset located in the UK continental shelf. It consists of two reservoirs with API gravities of 14 and 12, and oil viscosities at reservoir conditions of 70 cp and 500 cp. The field includes some 60 production wells.

Diluent can be injected (1) in each individual well at the ESP, (2) in the surface processing facility prior to the second stage separator and (3) prior to loading. Operating constraints include (1) minimum wellhead pressure, (2) diluent availability, (3) final crude quality specifications, (4) maximum field oil and liquid production rate. The difficulty of the production optimization problem lies in the nonlinearity of the well production curves and viscosity model. In this paper, we develop a Mixed Integer Linear Programming (MILP) formulation by piecewise linearizing the nonlinear behaviors. For each well at each time step, we adjust the blackoil rates from a reservoir simulator to create piecewise linear well performance curves giving the reservoir oil production as a function of diluent injected at ESP.

The proposed integrated solution is used for the entire production life of the field, which is still in the development phase. The solution is coupled with a reservoir simulator (1) to determine optimal diluent requirements over time, (2) forecast field production of reservoir oil, diluent, water and gas, and (3) foresee eventual bottlenecks in the infrastructure design (e.g. limiting constraints). The proposed solution can easily be used as a RealTime Production Optimization (RTPO) tool to find the optimal operating point based on the latest measurements (or realtime data). The optimal solution ensures the highest field reservoir oil production while meeting all constraints and keeping the diluent consumption at a minimum. The increase of the field oil production rate due to optimal diluent allocation ranges from 2 to 10 %. Cumulative reservoir oil production increases by approximately 3 million sm3.

The uniqueness of the solution comes from the integration of all operating constraints into a single mathematical formulation. The computational time (1s - 10s) of the proposed solution outperforms any classical nonlinear approach. This allows running many sensitivity analyses of the entire integrated asset model.

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