Real-Time Production Optimization of a Production Network with ESP-boosted wells: A Case Study

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Abstract:

Managing and optimizing the production of large oilfield with hundreds of ESP (Electric Submersible Pump)-boosted wells arranged in a large production network can be a very challenging task. On a daily/weekly basis, production engineers have to make decisions regarding (1) the update of individual ESP frequencies and (2) shut-in of high water producing wells. In general, it is not possible to do this manually just relying on intuition or in semi-analytical or empirical procedures. This is because in networks there is flow interdependence between wells and because several operational constraints have to be taken into account. This paper proposes to employ Real Time Production Optimization (RTPO) on a numerical model of the production system as a decision support tool to find values of ESP frequencies that maximize oil production while honoring multiple operational constraints.

The optimization problem is formulated such as the flow equilibrium in the production network and the optimization problem are solved simultaneously with a Mixed Integer Linear Programming (MILP) formulation. The well and flowline flow performance curves (pressure drop, ESP frequency, water cut, etc.) that are strongly non-linear are approximated with piecewise linear functions. These functions are generated from a model made in a commercial black box simulator. The optimization workflow has been partly automated using commercial tools and guidelines are provided to implement a full automation.

The formulation is applied to a scaled-down case, including 15 wells producing into a common surface network. The RTPO tool is used to compute the optimal operating conditions in a base case with multiple operational constraints: minimum ESP suction pressure, maximum well liquid rate, limited power capacity, limited water handling capacity and ESP flow range. To evaluate the flexibility of the optimization scheme, changes are introduced in the production system: (1) increasing water cut in a well, (2) reduced water handling capacity, (3) reduced power capacity and (4) offline wells.

The proposed optimization solution is faster than a non-linear optimization scheme, guaranties convergence towards the global maximum and it represents with an appropriate level of accuracy the original black-box model. Additionally, it is suitable for providing solutions in the timeframe of weekly/daily field operations, therefore, it is a good candidate to provide real-time decision support.