New Insight into Integrated Reservoir Management using Top-Down, Intelligent Reservoir Modeling Technique; Application to a Giant and Complex Oil Field in the Middle East

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Outline

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Objective

• To demonstrate the validity of a recently developed reservoir modeling technique called “Top-Down, Intelligent Reservoir Modeling” by applying the technology on a large and complex Oil field in the Middle East
Introduction

• Top-Down Modeling approaches reservoir simulation and modeling from an opposite angle compared to conventional reservoir simulation.

• Top-Down Modeling attempts to provide insight into fluid flow in the reservoir by starting with actual field measurements such as well production history and well logs.
Introduction

• Can be used as an alternative to traditional reservoir simulation
  – Cost
  – Man Power

• May be considered a compliment to the conventional technique
  – Optimum development strategy
  – Recovery enhancement

• Time and resources required: Only a small fraction performing a conventional reservoir simulation and modeling
Introduction

- In this study, Top-Down Modeling is performed on a giant and complex oilfield in the Middle East
  - Has been producing for half a century
  - Natural depletion
  - Strong water drive
Methodology

• Works performed by IOC:
  – Building the geological model
  – Developing three dimensional geological models base on stochastic modeling techniques for HM and production forecasting
  – This model is basis for estimation of initial and remaining hydrocarbons volumes in the reservoir.

• Results obtained from of this comprehensive reservoir simulation and modeling using conventional reservoir simulator have been used to examine the validity of Top-Down Modeling.
Top-Down Intelligent Reservoir Modeling
Top-Down Intelligent Reservoir Modeling

• Top-Down, Intelligent Reservoir Modeling
  – Starting with well-known reservoir engineering techniques
    • Decline Curve Analysis
      – Intelligent Decline on GOR and WC
    • Type Curve Matching
    • (single-well) production History Matching
    • Volumetric Reserve Estimation and calculation of Recovery Factors

• All these analyses are performed on individual wells
  – Calculating Multiple Production Indicators (First 3, 6, and 9 month cumulative production as well as 1, 3, 5, and 10-year cumulative oil, gas and water production and Gas Oil Ratio and Water Cut)
Top-Down Intelligent Reservoir Modeling

- Generating the Voronoi cell for each well
- Extent of each cell determined by
  - Hydrocarbon pore volume
  - Time and amount of production
- Associating the Voronoi cells with the relevant Cartesian grids for any given well
• Generating high-level earth model using Geostatistical techniques such as Kriging or Sequential Gaussian Simulation

• Estimating volumetric reserves using the earth model and the associated Voronoi cells

• Calculating well-based and field-wide recovery factors
Top-Down Intelligent Reservoir Modeling

• A large volume of data that is representative of the reservoir behavior in both space and time is generated

• Fusing a large number of discrete data and single-well models into a cohesive and continuous full field model using Fuzzy Pattern Recognition (FPR)
Top-Down Intelligent Reservoir Modeling

- Performing the Fuzzy Pattern Recognition
Estimating the Location of Gas Cap Development

• According to reservoir simulation results (Full field study) there are two gas caps in south east which are in communication
  – Primary
  – Secondary

• The southern gas cap (Primary) has expanded deeper than the central gas cap (Secondary).
Gas cap formation as a function of time

- Identification of primary and Secondary Gas caps generation based on total Field GOR.

- Comparing the Top-Down Modeling’s analysis and predictions to the reservoir simulation result indicates that Top-Down Modeling has predicted the primary and secondary gas cap formation with reasonable accuracy.
Water Cut Analysis

- Water production is limited, but increasing
- Water cut distribution as a function of time in various reservoir segments
Remaining Reserve as a Function of Time

- The reservoir simulation indicates large areas of remaining reserves in the southeast and central areas of the reservoir
Proposed Infill Drilling Location

- Proposed infill drilling location based on the result of conventional reservoir simulation model.
- In this period of drilling, the drainage targets are set to the South Eastern part and middle of reservoir that has higher remaining oil.
- According to Top-Down Modeling the south east and middle section of the reservoir have the higher remaining reserves.
- The upper part of reservoir has a higher permeability but because this area has problem with water production has not been proposed for drilling.
Model Calibration and Validation

- Developing a predictive model using neural networks (back-propagation technique)
- Training and verifying the NNs
- Forecasting the cumulative production of two most recent drilled wells
- Comparing the cumulative production predicted for these two wells with the real production history
Comparing the cumulative production predictions with actual values for Well AZ-340 and Well AZ-337. The graphs show the historical production data (blue dots) plotted against the cumulative production predictions (green and purple lines) over time, with predictions for both wells aligning closely with the actual data.
Conclusion

• In this study, a new reservoir modeling technology has been applied to a giant and complex oilfield.

• Top-Down Intelligent Reservoir modeling, incorporates Artificial Intelligent and Data Mining techniques such as data driven NN modeling and fuzzy pattern recognition in conjunction with classic reservoir engineering analyses in order to combine single well analyses into a cohesive full field model.

• Top-Down intelligent reservoir modeling allows the reservoir engineer to plan and evaluate future development options for the reservoir and continuously update the model that has been developed as new wells are drilled and more production data and well logs become available.
Conclusion

• Top-Down Modeling demonstrate its capability by estimating reservoir and petrophysical parameters, remaining reserve, gas cap location predication, proposed infill drilling locations and estimating new well performance with acceptable accuracy in comparison with the result of full-field analysis, which has been done by an IOC utilizing conventional reservoir simulator.