Identifying Infill Locations and Underperformer Wells in Mature Fields using Monthly Production Rate Data, Carthage Field, Cotton Valley Formation, Texas

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Introduction

Most common data available especially in mature fields is Production Rate Data.
Introduction

- Production Data Analysis methods
  - Decline Curve Analysis
    - Arps
  - Type Curve Matching
    - Fetkovich
    - Carter
    - Wattenbarger
    - Blasingame
    - Cox
    - Agarwal
Introduction

State-of-the-Art Production Data Analysis

- Inherent subjectivity.
- Addresses individual wells rather than the entire field.
Objective

- Using Intelligent Production Data Analysis Tool (IPDA™):
  - Minimize subjectivity.
  - Address the entire field.
  - Identify opportunities in mature fields:
    - Sweet spots for infill drilling.
    - Underperformer wells.
Methodology

- An iterative approach that integrates:
  - Decline curve analysis.
  - Type curve matching.
  - Single-well reservoir simulator.
- Full-field analysis
  - Fuzzy pattern recognition.
Methodology

- The methodology is demonstrated through application to a mature field in the U.S.
  - Carthage field, Cotton valley formation in Texas
  - 349 wells were used in this analysis.
  - Only publicly available production rate data were used.
Methodology

- Single-Well Reservoir Simulation
- History Matching
- Monte Carlo Simulation
- EUR Frequency Distribution

Production Data

- EUR
- DCA
- TCM

Parameters:

- $Q_i$, $D_i$, $b$
- $K$, $X_f$, $A$
Decline Curve Analysis

Qi, Di, b, EUR
Type Curve Matching

Used in reservoir simulation
Type Curve Matching

K, Xf, A, EUR
Type Curve Matching
Reservoir simulation is performed on the wells using a single-well radial simulator.

Results of type curve matching are used as the starting point for the reservoir properties.

30 year EUR is used as the controlling parameter to hold the integrity of the three methods.

We might need to go back to DCA and TCM through an iterative process to reach a reasonable match.
Reservoir Simulation - HM

K, h, X_f, A, Φ, EUR…
First Phase – Reservoir Characterization

- Decline Curve Analysis
  - $Q_i$, $b$, $D_i$, EUR
- Type Curve Matching
  - $kh$, $X_f$, $A$, $P_{gi}$, $\Phi$, $S$, EUR
- History Matching
  - EUR, $A$, $k$, $h$, $\Phi$, $S$, …
First Phase – Reservoir Characterization

- Once a reasonable match is achieved, the reservoir properties might be different from those calculated from Type Curve Matching.
- To resolve this, we perform Monte Carlo Simulation.
Monte Carlo Simulation
Relative Reservoir Quality Index

- Upon completion of the first step, a set of reservoir properties are obtained that could be close to reality, at least in their range.
- In the second step, we use fuzzy pattern recognition to detect trends and make field-wide judgments. Production Indicators (PI) are generated.
- The reservoir can be partitioned based on each one of these PIs and the Relative Reservoir Quality Index (RRQI) values are generated.
Results – Relative Reservoir Quality Maps

Fuzzy pattern recognition based on the first 3 months of production.

Low relative reservoir quality index (RRQI) represents higher quality reservoir characteristics.
Results – Relative Reservoir Quality Maps

The RRQI for some of the wells has decreased after 3 years of production.

Note that some of the wells have moved to a lower quality zone (higher RRQI value).
Results – Relative Reservoir Quality Maps

Relative Reservoir Quality Index based on the last month of production.
Reservoir Characteristics

Drainage Area

Fracture Half Length

Permeability
Underperformer Wells

- It is a multi-level analysis.
  - First level includes two production indicators. In this analysis these two PIs are:
    - First 3 months of production and
    - First 3 years of production.
  - Level two includes the results from decline curve analysis.
    - Qi and
    - 30 year EUR
Underperformer Wells

- Conditions for a well to be flagged as an underperformer are:
  - Its value of a particular PI should be at the bottom 25% of PI values of all the wells in that same RRQI.
  - Its PI value should be less than the average of the PI value of the wells that belong to the next RRQI (lower quality zone)
Underperformer Wells

Underperformer wells are identified using the two-level analysis and are shown in blue.
Conclusions

- Reservoir characterization through an iterative process and integrating DCA, TCM and single-well reservoir simulation.
- Relative reservoir quality maps using fuzzy pattern recognition and identification of
  - Sweet spots
  - Underperformer wells.
Questions?