Reservoir simulation: A tool for making informed decisions on well spacing in unconventional plays

Miles Palke

The results of dynamic modeling as applied to well-spacing optimization in various unconventional plays were presented by **Miles Palke**, head of the reservoir simulation group at Ryder Scott. He recently made his remarks at the SPE Hydrocarbon Economics and Evaluation Symposium in Houston.

JPT magazine published an article in late November, "How Close is Too Close? Well Spacing Decisions Come with Risks," featuring Palke and others.

"There is no formula for properly spacing wells in unconventional plays. When a reservoir consultant recently described conversations with clients about how many wells they could drill per acre, it sounded like a doctor advising a patient considering back surgery," the article stated.

"I am not trying to tell producers what their spacing should be," Palke told the magazine, adding that the modeling and production history matching that Ryder Scott offers is part of "a process to help clients make informed decisions."

The question on spacing of wells has always been, "Where is the point of diminishing returns as well spacing gets tighter?"

Conventional vs. Unconventional Reservoirs

Conventional Reservoirs

- Matching static pressures dominated by reservoir parameters.
- History matches focus purely on reservoir parameters.
- Well productivity (completion, skin, PI) more directly considered in predictions than during history matching.
- Many uncertain parameters to adjust.
- Difficulty achieving a history match.
- Frequently full-field simulation models with many wells.

Unconventional Reservoirs

- Matching flowing pressures dominated by a combination of reservoir and wellbore parameters.
- History match about result of completion as much as purely reservoir parameters.
- Well productivity (completion, skin, PI) directly considered during entire process, not just for predictions.
- Many more uncertain parameters to adjust.
- Nature of data makes history matching more difficult.
- Frequently models of single wells or small groups of wells.

Most reservoir simulation models constructed in the industry use the familiar black oil formulation, but Ryder Scott uses compositional or chemical tools as needed, said Palke, who added that he uses an equation of state (EOS) PVT (pressure volume temperature) model to develop detailed EOS-based fluid characterizations for inclusion even in black oil models.

History matching is frequently the only information available to help identify the value of parameters that determine the outcome of the sensitivity analysis, Palke told the audience. The history-matching process narrows down the value of key parameters that determine optimal spacing.

"The best well spacing may depend on fracture half-length, or other parameters whose effective values are estimated through history matching."

Fracture half-length is the distance from the wellbore to the outer tip of a fracture propagated from the well by hydraulic fracturing.

He has also used rate-transient analysis to "precondition" simulation models to make history matching more efficient, but has experienced mixed results. "Translating (RTA) results into the simulation grid sometimes has a limited benefit because of inconsistency in modeling approaches," said Palke.

Relative permeability is a large driver of reservoir performance, especially regarding fractional flow of different fluids, however the use of relative permeability and PVT data remain an area of interest for research on unconventional reservoirs.

Although he cautioned about generalizing from the information he provided on individual unconventional plays, Palke

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summarized the following "take-aways" from his reservoir simulation work.

> *"Operators turn to consultants such as Ryder Scott for history-matched reservoir models..."*
>
> – *JPT* Magazine

General observations

- Optimization of spacing has a strong relationship to fracture half-length.
- Half-length is usually varied in the history matching exercise, but . . .
- History matches are non-unique, and depend on other input parameters.
- Allow other sources of information to influence the history matching:
  - Micro-seismic
  - Presence or absence of frac hits
  - Fracture analysis
  - RTA
- Consider conducting sensitivity studies to cover uncertainty in other unmatched parameters, such as petrophysical values.
- Fracture half-length contributes to the optimal well spacing.
  - Other parameters, such as permeability and layering, can make a significant difference.
- Fracture half-length can be history matched, but is usually highly dependent on fracture height.
- In these cases, the challenge is in matching the pressure history along with each phase rate.
- Equivalent matches were achieved for varying fracture half-lengths, making the selection of the optimal well spacing subject to a residual uncertanty.
- Information from outside the simulation study must be considered in the decision-making.

"Operators turn to consultants such as Ryder Scott for history-matched reservoir models because they want results that line up with the output from actual wells," the *JPT* article stated. "But that leaves a lot of room for judgment calls."

Palke told the magazine, "Using the same wells for an equivalent history match, you can arrive at a range of options from 80 acres to 120 acres per well. If you have a big land position, that (difference) is a lot of wells. You would want to do a lot of work to decide which of those is the best decision."

Early Leader – Cont. from page 8

are just a few of the words employeees used to describe Fickert. He was the embodiment of order in all aspects of his life.

Ziehe said, "I remember a time when Bill invited me to go deer hunting in Fredericksburg. He gave me a multi-page map, beginning with a Texas state map and star marking the town."

In true engineering fashion, the maps became increasingly detailed, each page showing another level, from Fredericksburg to the highway exit, then turns off small roads to dirt roads.

"The last map showed the farm property and house location, and most importantly, the deer blinds," said Ziehe.

Fickert served in the U.S. Air Force in the Pacific Theater during World War II. His next stop was the University of Texas. With petroleum engineering degree in hand, he began a nearly 30-year career at Ryder Scott, which owes its reputation, in part, to Fickert and others who shaped the firm's early history.

He was made a partner in January 1962 and retired in 1986 as a senior vice president. Fickert taught short courses and seminars, including "Economics of Waterflooding the Garyburg Dolomite in South Cowden Field," and "Waterflood Case History Caprock Queen Field."

He was an elder and committee chairman at Christ Presbyterian Church in Midland, TX, and taught Sunday school to junior-high students. Since 1971, Fickert had been a member of Memorial Drive Presbyterian Church in Houston, where he was also an elder and volunteer.

He is survived by a sister, **Joan Finkboner** of Illinois; daughter, **Karen Ann** and son-in-law **Scott McCoy** of Austin; son, **Gary Lee Fickert** of Houston and three grandchildren: **Shawn Thomas McCoy**, **Kristin Nicole Fickert** and **John Austin Fickert**.

In addition to his family, Fickert leaves behind his "Ryder Scott family," including those he helped mold several decades ago.