

New Workflows Reduce Forecast Cycle Time, Refine Uncertainty

The application of global optimization methods to reservoir simulation through assisted history matching (AHM) and dynamic uncertainty quantification workflows has been heralded as a “game changer” and is significantly reducing the cycle time for history matching and production forecasting of reservoir models, as well as helping to quantify dynamic uncertainty.

Reliable reservoir-simulation models are the foundation of the decision-making process when it comes to field development planning. Subsurface-asset teams constantly strive to improve their understanding of the reservoir on the assumption that the more accurately their model matches past reservoir behavior, the more value it will have in making future development decisions. But with dozens of parameters influencing flow in the reservoir, and most of them changing in three dimensions throughout the field, there are many possible solutions that can match past production profiles. In short, the concept of a single perfect match is not realistic, nor does the best match mean the best prediction—a shortcoming of tradi-

tional workflows for history matching that can find only one match.

Faster History Matches

Fortunately for the reservoir engineer, a new class of AHM tools that use global optimization methods is coming to his aid. These tools not only provide an enabling technology for the new workflows needed to find the multiple solutions that exist to the typical history-matching problem, but usually can do this more quickly than a single history match can be found manually.

One tool now available is the Multipurpose Environment for Parallel Optimization (MEPO) from Scandpower Petroleum Technology. The method offers both a framework for assisted history matching and a choice of optimization methods to suit different development scenarios. Among the most versatile are evolutionary algorithms, such as genetic algorithms, which (as their name suggests) mimic evolution by spawning successive generations of simulation models and then extract the attributes

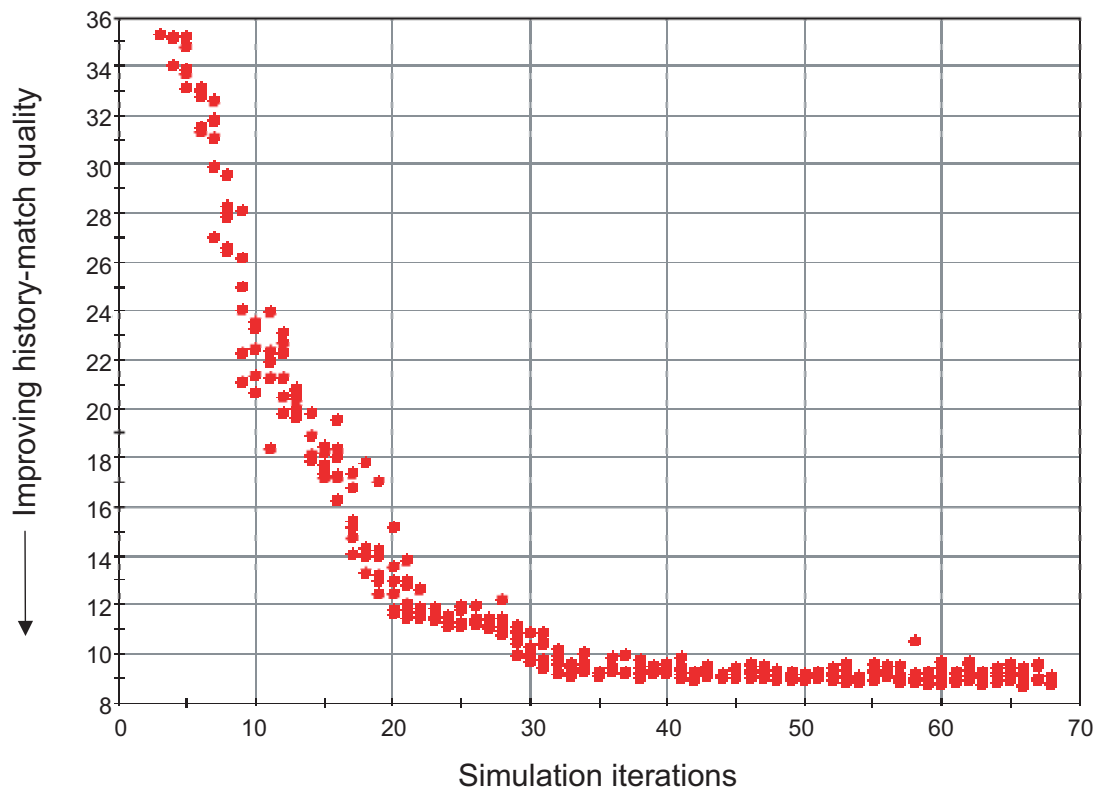


Fig. 1—By quantifying the quality of the match, optimization tools can give a visual representation of the progress of the history match.

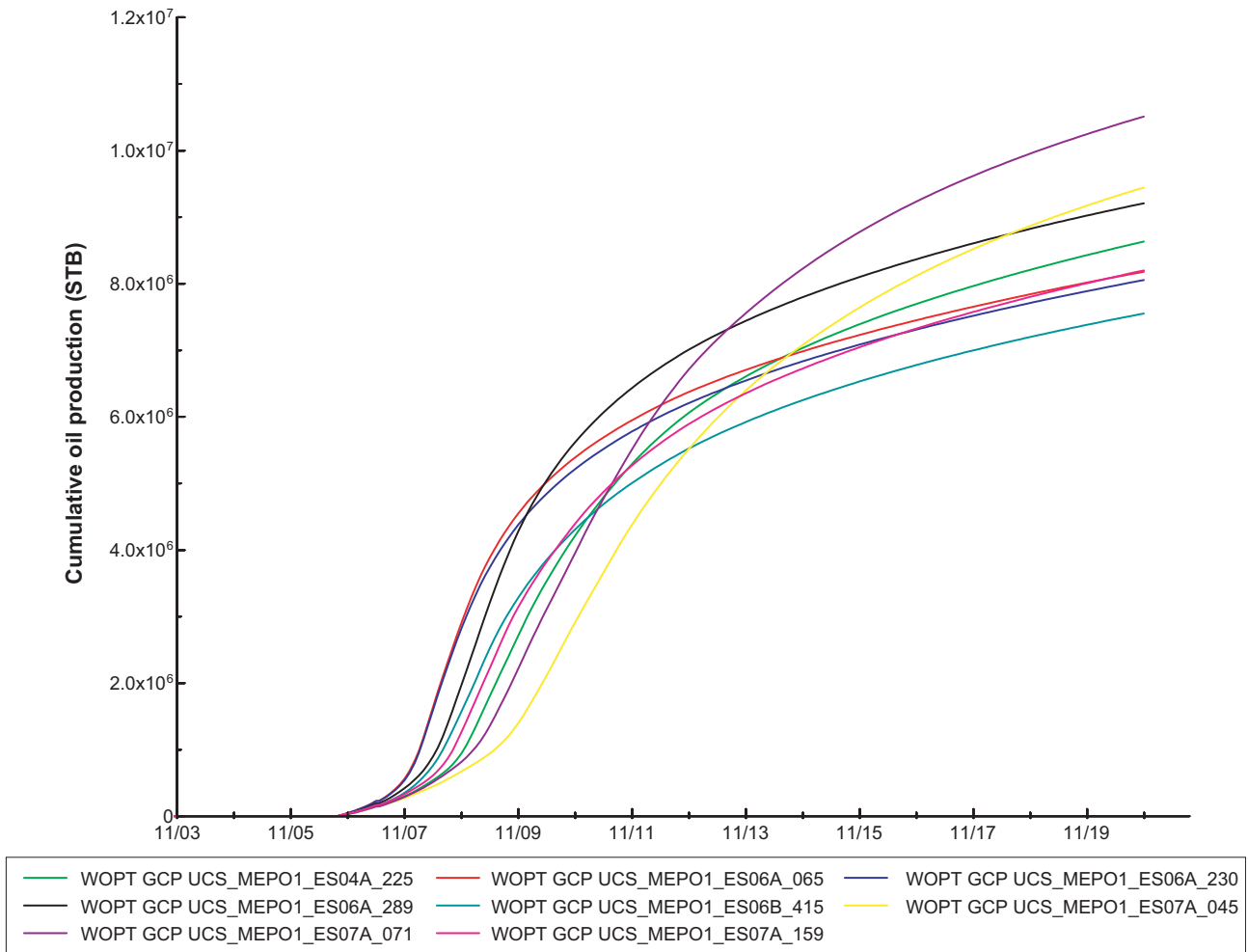


Fig. 2—No such thing as the perfect match: Eight equally good matches from this Chevron field model of the North Sea Captain field.

of those models that produce results closest to the actual history in order to create the next generation. Progressive cycles of runs converge on groups of good solutions.

Another “smart” feature is its ability to take advantage of parallel computers such as Linux clusters or personal computer networks. Whereas the human engineer generally makes his runs in serial fashion, looking at the results and making decisions about the next run, it is possible using the new method to make tens of runs at the same time and learn from all of them, dramatically shortening the whole cycle.

Of the dozens of AHM and uncertainty studies performed, almost all have demonstrated reductions in cycle time for the history-matching phase, usually around 50–80% time reduction, and sometimes as much as 95%. **Fig. 1** shows improving history-match quality (reducing overall error) of a typical simulation-model

study in which several good matches were found in roughly 30 iterations, each iteration consisting of six simultaneous runs (i.e., a total of 180 simulations). This particular model had been history matched on three separate occasions previously, and each occasion took close to a month to complete manually. Using MEPO, the model was matched in 2 days.

Quantifying Uncertainty

In addition to significantly reducing the time required to tune the simulation model to match past production history, AHM tools also enable the engineer to better quantify the uncertainty in future predictions. An example is shown in **Fig. 2**. In this case, Chevron U.K. used MEPO to help history match the Upper Captain Sand reservoir of its North Sea Captain field, and eight distinct matches to production history were obtained. Despite the fact that

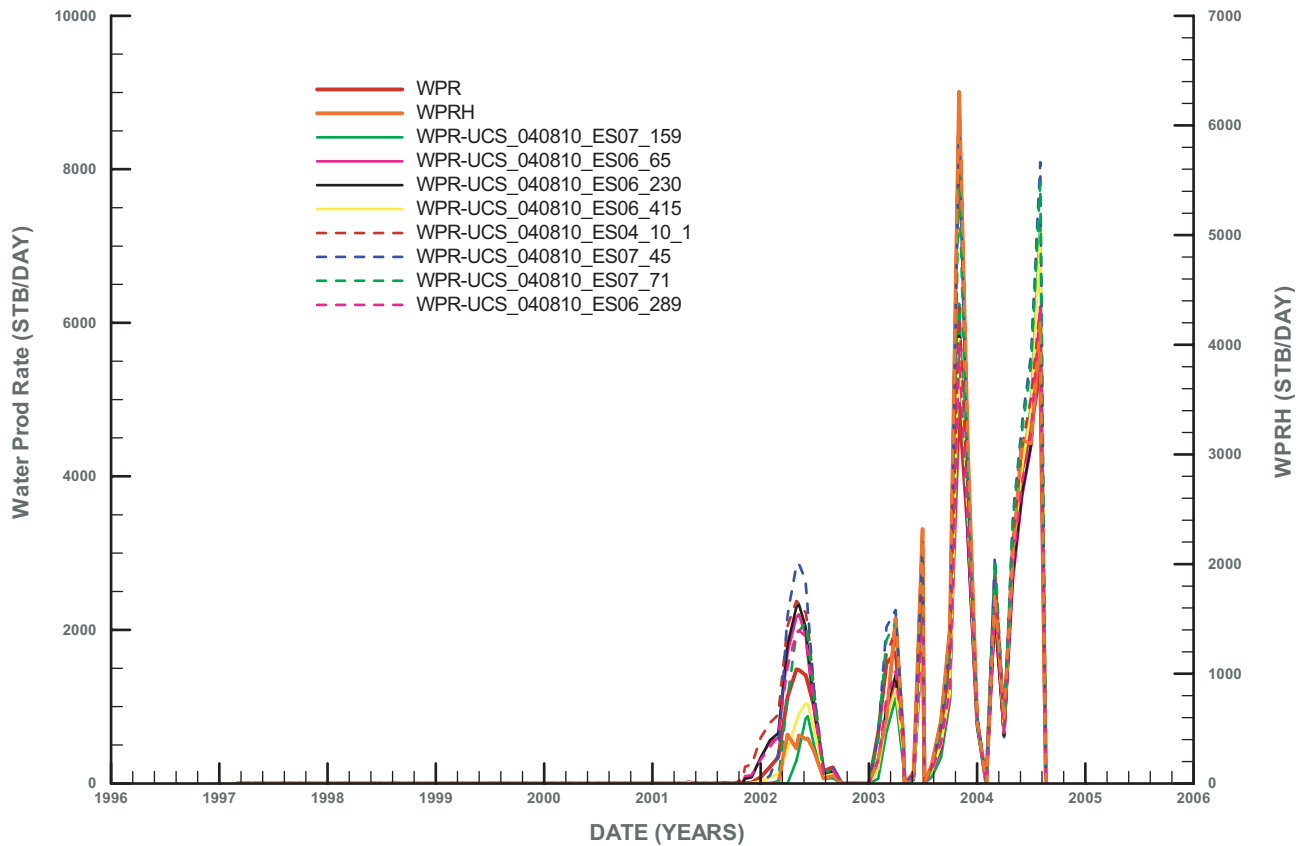


Fig. 3—Multiple production predictions in the North Sea Captain field demonstrate a higher degree of uncertainty than anticipated.

the simulation model took between 7 and 17 hours to run, almost a thousand runs looking at different permutations of key reservoir parameters were made in a few weeks on a small Linux cluster using MEPO and a proprietary Schlumberger Eclipse simulator. From these 960 simulation runs, the eight good-quality history matches were obtained, each of which matched the observed historical production data through different combinations of reservoir parameters.

Despite the fact that all eight models gave similar matches to past performance, production forecasts varied significantly when the models were run into the future to generate predictions. This does not mean that some of the models were “wrong” in some way—they are all “right,” and are all valid estimates of future performance. In this case, the spread in predictions demonstrated a larger uncertainty in possible future production than was previously realized (Fig. 3). This is not unusual: Many studies have shown that multiple alternative history matches demonstrate a 15–20% uncertainty in reserves. What this really yields is a way of quantifying the intrinsic risk in production forecasts.

Picking Optimal Scenarios

Another application of optimization tools is their use for selecting the optimal field-development scenario from a range of options. BP recently described an example of this from its Teak field in Trinidad, where it wanted to select the best location for an infill well from three potential candidates. BP applied its proprietary Top-Down Reservoir Modeling philosophy to generate 16 acceptable history matches using AHM methods. Each matched model was then run in prediction mode with and without each of the potential infill candidates in turn. All three candidates showed roughly equal potential to add reserves to the field development; and on the basis of the manual history match alone, there would be little to choose between them. However, the uncertainty analysis demonstrated that one location had a much greater likelihood of a successful well than the other two. Moreover, this approach was quick to implement—BP estimated that its approach resulted in an approximately 10-fold work-cycle reduction over a conventional workflow. **JPT**

Information provided by David Millar, Scandpower Petroleum Technology.