Lecture 11 summary

Major Elements of a Reservoir Simulation Study- history matching

5.3. History Matching

Illustrative History Matching Strategies

There is no single, universally accepted strategy for performing a history match.

Nevertheless, there are some general guidelines that can help move a history match toward successful completion. Table 12 presents one set of history matching guidelines.

Table 12 Suggested History Matching Procedure

Step	Remarks
I	Match volumetrics with material balance and identify aquifer support.
II	Match reservoir pressure. The match of average field pressure establishes the global quality of the model as an overall material balance.
III	Match saturation dependent variables. These variables include WOR and GOR. WOR and GOR are often the most sensitive production variables in terms of both breakthrough time.
IV	Match well flowing pressures.

If the first two steps cannot be achieved, the model is inadequate and revisions will be necessary.

An inadequate model may be due to a variety of problems: for example, the wrong model was selected, the reservoir is poorly characterized, or field data is inaccurate or incomplete.

Among the data variables matched in a typical study are pressure, production rate, water-oil ratio (WOR) and gas-oil-ratio (GOR). More specialized studies, such as compositional or thermal studies, should also match data unique to the process, such as well stream composition or the temperature of produced fluids.

The pressure is usually the first dynamic variable to be matched during the history matching process.

History Matching Parameters

A fundamental concept in history matching is the **hierarchy of uncertainty** which is a ranking of model input data quality.

The modeler uses the hierarchy of uncertainty to rank data from most reliable to least reliable.

Data reliability is determined when data are collected and evaluated for completeness and validity.

This is such an important step in establishing a feel for the data that the modeler should be closely involved with the review of data.

How changes in some history match parameters affect matches of saturation and pressure gradients?

The change in pore volume can affect pressure as it changes with time. As another example, relative permeability changes are useful for matching saturation variations in time and space. Notice that fluid property data are seldom changed to match field history. This is because fluid property data tend to be more accurately measured than other model input data. History matching must not be achieved by making incorrect parameter modifications. In general, modified parameter values must be physically meaningful.

Evaluating the History Match

One way to evaluate the history match is to compare observed and calculated parameters.

Typically, observed and calculated parameters are compared by making plots of pressure versus time, cumulative production (or injection) versus time, production (or injection) rates versus time, and GOR, WOR, or water cut versus time. Other comparisons can and should be made if data are available. They include, for example, model saturations versus well log saturations, and tracer concentration (such as salinity) versus time. In the case of compositional simulation, dominant components (typically methane) should be plotted as a function of time.

In many studies, the most sensitive indicators of model performance are plots of GOR, WOR, or water cut versus time. These plots can be used to identify problem areas.

Deciding on a Match

There are several ways to decide if a match is satisfactory.

In all cases, a clear understanding of the study objectives should be the standard for making the decision.

If a coarse study is being performed, the quality of the match between observed and calculated parameters does not need to be as accurate as it would need to be for a more detailed study.

For example, pressure may be considered matched if the difference between calculated and observed pressures is within ±10% drawdown. The tolerance of ±10% is determined by estimating the uncertainty associated with measured field pressures and the required quality of the study.

A study demanding greater reliability in predictions may need to reduce the tolerance to ± 5% or even less, but it is unrealistic to seek a tolerance of less than 1%.

Another sensitive indicator of the quality of a history match is the match of WOR, GOR, or water cut. Three factors need to be considered: breakthrough time, the magnitude of the difference between observed and calculated values, and trends.

Adjustments in the model should be made to improve the quality of each factor. A match of the field is more easily obtained than a match of individual well performance. Indeed that matching every well is virtually impossible.

As a rule of thumb, the field match may be valid for a year or more without updating, and we can expect the well match to be valid for up to six months without updating.

History Match Limitations

History matching (or model calibration) may be thought of as an inverse problem.

An inverse problem exists when the dependent variable is the best known aspect of a system and the independent variable must be determined. For example, the “dependent variable” in oil and gas production is the production performance of the field. Production performance depends on input variables such as permeability distribution and fluid properties. The goal of the history match is to find a set of input variables that can reconstruct field performance.

In the context of an inverse problem, the history matching problem is solved by finding a set of reasonable reservoir parameters that minimizes the difference between model performance and the historical performance of the field. As usual, we must remember that we are

solving a nonunique problem whose solution is often as much art as science.

Data limitations are more difficult to resolve because the system is inherently underdetermined: we do not have enough data to be sure that our final solution is correct.

In many instances, observed data can be inaccurate.

The goal of history matching is to prepare a flow model that can contribute to reservoir management decision making.