Reservoir Simulation

Introduction

Reservoir simulations are widely used to study reservoir performance and to determine methods for enhancing the ultimate recovery of hydrocarbons from the reservoir. They play a very important role in the modern reservoir management process, and are used to develop a reservoir management plan and to monitor and evaluate reservoir performance during the life of the reservoir, which begins with exploration leading to discovery, followed by delineation, development, production, and finally abandonment.

1.1 What is Reservoir Simulation?

Reservoir simulation mimics the behavior of a real reservoir system (geology +engineering) through a model (numerical) based on realistic assumptions.

Reservoir numerical simulation can be close to reality, but it is never the reality (should approach reality with time).

Simulation requires a computer, and compared to most other reservoir calculations, large amounts of data. Basically, the simulation model requires that the field under study be described by a grid system, usually referred to as cells or gridblocks. Each cell must be assigned reservoir properties to describe the reservoir. The computer simulator will allow us to describe a fully heterogeneous reservoir, to include varied well performance, and to study different recovery mechanisms. Reservoir simulation usually includes the following components:

- Geometric Model
- Mathematical Model
- Numerical Model
- Computer Model

Geometric Model: The physical (reservoir) system must be constructed outside of the earth system. The communication conditions between the reservoir system and its surroundings will be substituted by a set of boundary conditions. This substitution is one source of errors.

Mathematical Model: The physical system to be modeled must be expressed in terms of appropriate mathematical equations. This process almost always involves assumptions. The assumptions are necessary from a practical standpoint in order to make the problem tractable.

Numerical Model: The equations constituting a mathematical model of the reservoir almost always too complex to be solved by analytical methods. Approximation must be made to put the equation in a form that is amenable to solution by computers. Such a set of equations forms a numerical model.

Computer Model: A computer program or a set of programs written to solve the equations of the numerical model constitutes a computer model of the reservoir. The use of a computer model to solve practical problems is referred to Reservoir Simulation.

1.2 Main Objectives of Reservoir Simulation

- To build a model of the reservoir and to examine its performance in terms of production and pressure.
- To predict future performance.
- To find ways to increase ultimate recovery or to recover the hydrocarbons more economically.

1.3 Methodology of Reservoir Simulation

- The reservoir id divided into a number of blocks (or grid blocks)
- Basic geological and reservoir data is provided for each block.
- Wells are positioned within the arrangement of blocks.
- The target rate and well pressure are specified as a function of time.
- The appropriate equations derived from the Darcy's Law are solved to give the pressure and saturations each block as well as the production and injection for each well.

1.4 Elements of a Reservoir Simulation Study

In general, the elements of a reservoir simulation study are as follows:

- Setting Up the Study
- Defining the study's objectives
- Formulating a model
- Data Preparation
- Collecting rock and fluid data
- Reservoir description
- Collecting well performance and completion data
- Defining producing conditions
- History Matching
- Adjusting reservoir parameters to match past performance (usually pressure)
- Predicting Performance
- Running the simulator and analyzing the output
- Sensitivity Analysis
- Identifying critical parameters
- Evaluating alternate strategies for development

1.5 What can a Reservoir Simulation Model Answer?

- How should the field be developed and produced in order to maximize the economic recovery of hydrocarbon?
- What is the best enhanced recovery scheme for the reservoir? How and when should it be implemented?
- What is the ultimate economic recovery for the field?
- What type of laboratory data are required? What is the sensitivity to various data?
- What are the critical parameters that should be measured in the field application of a recovery scheme?
- What is the best completion scheme for wells in a reservoir?
- What portion of the reservoir is the production coming from?

1.6 Application of Beneficial Reservoir Simulation Applications

- Optimum Well pattern, well spacing, completion intervals.
- Infill drilling.
- Conversion of producers to injectors.
- Potential for horizontal wells, optimum well spacing offset from WOC and GOC.
- History matching to determine the reservoir size, original oil in place, and aquifer size.
- Production forecast to justify the construction of facilities, (e.g. gas processing plant, pipeline)
- Feasibility of EOR schemes (gas injection, CO_2 flood, steam injection etc.)