Thermal Recovery

Program Objectives

Thermal recovery is defined as a process in which heat is introduced into a subsurface accumulation of organic compounds for the purpose of recovering hydrocarbons through wells. The course begins with a brief introduction to the objectives of the short course followed by a summary of various thermal recovery techniques including cyclic steam stimulation (CSS), steam flood, and in-situ combustion. Fundamentals of thermal recovery including viscosity versus temperature functions, thermal expansivity of oil and rock and recovery mechanisms are then introduced. This is followed by explanation of analytical and semi-analytical models for evaluation of recovery efficiency. The differences of hot-water drives, cyclic steam injection, steam drives, in-situ combustion are explained in detail using examples. The importance of reservoir description in reservoir simulations is shown and several field examples and case histories are presented. The application of horizontal and multilateral wells is explained by illustrating the differences among CSS, steam assisted gravity drainage (SAGD), heated annulus steam drive (HASD) and water-alternating-steam-process (WASP) used in horizontal wells, and new well completion and sand control methods with field examples. Surveillance and facilities/operations considerations of steam floods arepresented thereafter. Finally the course will address on how to screen and plan each project based on its own merits.

Course Outline

Day 1

- Introduction
  - Heavy Oil Definitions
  - Heavy Oil Genesis
- Summary of Processes
  - Steamflooding
  - Cyclic Steam Stimulation
  - In-Situ Combustion
- Heat transfer Principles
- Mechanisms of Heat Transfer
  - Hot Waterfloods
  - Steamfloods
  - Hot Gasfloods
- Thermal Projects in US and World
- History of Thermal Oil Recovery

Day 2

- Thermodynamic Properties of Water and Steam
  - PVT properties
  - Vapor pressure, p-T diagrams, p-H diagrams
- Analytical Models
  - 1-D
  - Two Phase
  - Fractional Flow Theory for Black Oil and Heavy Oil
  - Predicting Waterflood Performance for Heavy Oil
- Problems and Solutions to Heavy-Oil Reservoirs
  - Recovery Efficiency
  - Mobility Ratio, Displacement Efficiency
  - Thermal Recovery
  - Effect of Temperature on Viscosity

Day 3

- Reservoir Heating by Fluid Injection
- Energy Balance and Heat Loss Rates
- Marx-Langenheim Solution
- Heated Area Growth Rates
- Heat Retention and Heating Efficiency
- Oil Recovery and Heat Efficiency (Steam-Oil Ratios)
- Economic Limit and Well Spacing

Day 4

- Cyclic Steam Stimulation
  - General Features
  - Screening Criteria and Design
- In-Situ combustion
  - Targets, Chemical Reaction
  - Process variations and Screening Criteria
- Simulation Considerations
- Horizontal and Multilateral Well Applications
- Facilities/Operations Considerations
- Scale-Up for Field Studies
- Screening, Planning, and Surveillance

Day 5

- Case Study (Kern River Steamflood, USA)
- Review of Class Special Project
- Exam