Petro Management Group Ltd.

Heavy Oil Development

Course Objective:

This is the most complete heavy oil recovery course presently in the industry, as it gives knowledge, in a very integrated way, not only about thermal methods but also on primary recovery (including CHOPS method) and waterflooding and polymer flooding applications for heavy oils. The course covers the reservoir engineering aspects of oil recovery by steam-injection based oil recovery processes, in situ combustion (ISC), and primary recovery by CHOPS (**c**old **h**eavy **o**il **p**roduction with **s**ands). Therefore, it is a complete course in the sense that primary, secondary, and even tertiary recovery of the heavy oil is presented. The emphasis is both on the fundamentals and physical simulation, and on the field applications, including piloting and commercial scale; the largest commercial operations are analysed for each process. Also, the emerging technologies are presented for each category of processes.

Who Should Attend:

This course is aimed at reservoir, petroleum and exploitation engineers/technologists, and geologists who are involved in the area of heavy oil projects.

Course Instructors:

Dr. ALex Turta, Ph.D., P.Eng.has over 35 years of industry experience in the area of EOR, particularly in the area thermal and chemical flooding. He was instrumental in conceiving and developing the concept of short-distance oil displacement, and based on that the Toe-to-Heel Air Injection process (THAI) and implementation. He also was instrumental in development of the SelectEOR software for screening of EOR schemes. Dr. Turta has conducted numerous EOR studies in North America and internationally including pilot design, monitoring and evaluation, particularly thermal projects. He also publishednumerous papers on the subject and was the co-author of the book “Enhanced Oil Recovery. Field Case Studies” in 2013.

Course Agenda:

A) Cold Heavy Oil Production With Sands (CHOPS)

- Introduction/Background/History; Who invented CHOPS?!
- Primary Recovery by Solution Gas Drive (SGD) and Enhanced Solution Gas Drive (ESGD) or Foamy Oil Mechanism; the crucial difference between SGD and ESGD
- CHOPS (**C**old **H**eavy **O**il **P**roduction with **S**and) as a means to activate the ESGD Mechanism/ Progressive Cavity Pumps (PCP) use to sustain CHOPS
- Field Observations; use of PCP's
- Laboratory investigations for foamy oil and CHOPS
  - A) Foamy oil
    - Micromodels
    - Pressure depletion tests
    - Oil-gas dispersion mobility tests
  - B) CHOPS
    - Sand production in lab tests; laboratory wormholes and scouring regions
    - Sand transportation within wormholes
- Heavy oil reservoir characteristics making reservoirs amenable to CHOPS exploitation; vertical wells versus horizontal wells (HW) use
- State of reservoir at the end of CHOPS exploitation; assessment of CHOPS related heterogeneities; representation of wormholes in the simulator.
- Pros and cons for CHOPS acceptance (thickness criterion); when to opt for CHOPS and when for other approaches. Technical limitations in further advancement of CHOPS
- Example of almost complete information for a field exploited by CHOPS (L. reservoir); other field examples
- Technical means to promote CHOPS exploitation; triggering the generation of wormholes (sand production on demand)

B)Waterflooding and Polymer Flooding of Heavy Oils

WaterfloodingWith Vertical Wells

- Essential Buckley Leverett Fundamentals
- Prediction, its lack of reliability
- Field Reality
- Conclusions

WaterfloodingWith Horizontal Wells

- Using Side-By-Side (SBS) or Face-to-face (FTF) Horizontal Wells
- Toe-to-Heel Waterflooding (TTHW) process, including its field testing in Medicine Hat Glauconitic C (MHGC) reservoir, Canada and Wolco Field in USA
- Conclusions; limits in application

Polymer Flooding Heavy Oil Reservoirs

- The theory behind the success; essential fundamentals
- Laboratory testing
- Commercial application of polymer flooding in Marmul, Oman and Pelican Lake, Canada
- Conclusions

C) Steam-Injection Based Oil Recovery Processes

- Fundamentals
  - Liquid to vapour phase change for water and the heat content of steam
  - Heat losses during steam/hot water injection
  - Screening criteria for the steam-based injection methods
- Cyclic Steam Stimulation (CSS)
  - Mechanisms
  - Implementation
  - Prediction techniques
  - Use of CSS for conditioning of reservoir in view of application of thermal drive methods (steamflooding and in-situ combustion)
  - Examples of commercial operations
- Hot waterflooding
  - Pros and cons
  - Limited experience/lessons from some field pilots
  - Recent trends for application/field testing
- Steamdrive
  - Mechanisms
  - Implementation
  - Prediction techniques and evaluation
  - Some commercial operations
  - Recent trends; use of horizontal wells for heat mining
- Steam Assisted Gravity Drainage (SAGD) and improved SAGD processes
  - Some characteristics of oil sands
  - SAGD and its mechanisms
  - Implementation

- Case histories
- Commercial applications
- VAPEX and its limited success in the field
- Recent improvements (in-fill horizontal producers, solvent and heat combinations (ES-SAGD), etc

D) Oil Recovery by In-Situ Combustion

1) Qualitative Description of In-Situ Combustion Techniques

- Forward and Reverse Combustion
- Dry, Wet and Superwet Combustion
- Segregated In-Situ Combustion
- Cyclic In-Situ Combustion (CISC)

2. Mechanisms of the Forward Combustion

- The Main Chemical Reactions. HTO and LTO
- Kinetics of oxidation; Apparent Atomic H/C ratio
- Fuel Availability and Air Requirement

3. The Laws of the ISC Front Propagation

- Dry Combustion
- Moderate wet and superwet combustion

4. Basic ISC Laboratory Tests

- Ramped Temperature Oxidation (RTO) of Oil in Porous Media
- ARC technique
- Combustion Front Propagation in a One-Dimensional Cell – Combusion Tube (CT) Tests

5. Theoretical Aspects and Modelling of ISC

- Analytical Models
- Numerical Models
- Main limitations of the Models

6. **Design of an ISC Field Project. Operation Procedures**

- Ignition Operation
- Injection Program
- Performance Prediction Methods: Nelson &McNiel, Gates and Ramey, etc

7. **Implementation, Operation, Monitoring and Evaluation of an ISC Pilot**

- Screening Criteria
- Line Drive versus Pattern Application
- Choosing the Best Location of the Pilot
- Tracking the ISC front. Gas analyses, BHT measurements, observation wells and coring wells in the burned zone
- Operation/Facilities Problems and Remedies; Burning back the injector, Risk of explosion, Corrosion and Erosion, Emulsion, Sand production, Poor injectivity / productivity, Severe gas production,

8. **Current Status of ISC Projects. Commercial Application**

- The World's most significant commercial ISC applications
- Horizontal wells in ISC processes
- Emerging ISC Processes; Toe-To-Heel Air Injection (THAI), COSH, and Top-DownISC; Field piloting of the THAI in oil sands and in the Lloydminster heavy oil area