Integrated Waterflooding

Course Overview

Waterflood is the most widely deployed incremental recovery process in the oil industry. Although it is now firmly established that the process can add significant incremental volumes to field recovery, the process is very rarely optimised. Historically, waterflood has been seen as primarily the domain of the reservoir engineer but, given that problems can become manifest across virtually all disciplines, a fully optimised development needs the successful input of all of those disciplines. This course has therefore been developed to train staff on all aspects of waterflood. It therefore facilitates a fully integrated approach to field optimisation.

Course instructor: Dr. Dave Chappell

Dave holds a PhD in chemistry from the University of Liverpool. After a post doctoral research posting at the University of Western Australia he entered the oil industry with Baker as an oilfield chemicals specialist. From there he joined Shell where he first worked as a production chemist in Brunei and where he had his first direct waterflood experience in the Champion and Seria fields. After 3 years he was transferred to Oman where he initially worked as a production chemist on the North Oman fields, and in which he worked in developing the initial waterflood development plans for the Barja, Arzauz and Zauliyah fields. He then worked as a production technologist on the large Yibal waterflood development before moving to lead the production technology team working the Lekhwair cluster of waterflooded fields.

After 6 years in Oman Dave moved to Thailand to lead the studies team assessing the scope for waterflood in Srinkt, Thailand’s largest onshore field. Following completion of the field development plans he transferred to the Netherlands where he was appointed as one of the core members when Shell created a central waterflood team, tasked with optimisation of waterfloods across the Shell group in both the development and operate phases of the field lifecycle. Apart from a short spell working on a deepwater waterflood development in Mauritania he has been with the central waterflood team for the 15 years it has been in existence, the last 7 years of which he has been the group leader. During this period over well in excess of 100 fields have been reviewed and Dave has consequently developed unrivalled experience in waterflood design and operation across the full range of waterflood scenarios including both carbonate and sandstone settings, deepwater, tight reservoirs, heavy oils, etc. For a number of years he operated as the sole dedicated waterflood expert in Shell and for the last 7 years of his Shell career he acted as the principal waterflood expert in the Shell group of companies. Consequently, he developed an all encompassing appreciation of all facets of waterflooding including petroleum engineering, facilities, operations, and chemistry aspects. He recently retired from Shell and now operates as an independent consultant.
1. Introduction
Factors of importance to waterflooding
The history of waterflood development in the industry
Drive mechanisms
Waterflood timing

2. Basic Principles
Fluid and rock properties
Compressibility
Permeability
Wettability

3. Water Source and Chemistry
Available water sources
Water properties
Clay swelling
Scaling
Reservoir souring
Low salinity flooding
Influence of geology on waterflooding effectiveness
4. Geology
Impact of reservoir architectures
Aquifers
Clastic depositional environments
Carbonate depositional environments
Turbidites
Influence of geology on waterflooding effectiveness

5. Recovery Processes
Displacement theory
Fractional flow
Displacement models
Volumetric analysis
Voidage replacement

6. Matrix/Fractured Injection
Designing for matrix injection
Modelling fractured injection
Water quality impacts
Surveillance
Flood and sweep impacts
Containment
7. Flood Design
Pattern selection and well spacing
Analytical performance prediction
Injectivity
Pilots

8. Wells
Horizontal vs vertical wells
Completion types
Smart wells
Profile control (water shut-off)

9. Surveillance
Importance of surveillance to waterflood operations
General surveillance plans and requirements
10. Dehydration
- Equipment options
- Influence on water quality

11. Water Treatment
- Oil removal
- Solids removal
- Oxygen removal
- Biocide programmes
- Process optimisation
- Innovative designs

12. Operations
- Metering
- Availability
- Throughput
- Water quality

Section learnings are cemented through the use of exercises. In addition there is a field case history to further highlight topics discussed during the course. This looks at a real field at 4 stages of its lifecycle. Following an initial depletion period, the following phases are addressed:

- Pilot
- Implementation
- Remediation
- Optimisation (inc infill)

In teams, course participants will identify problems associated with the waterflood implementation and develop remediation plans.