Enhanced Oil Recovery Field Case Studies Chapter 13 Water Based Eor In Carbonates And Sandstones New Chemical Understanding Of The Eor Potential Using Smart Water

Steam assisted gravity drainage (SAGD), since its inception over 30 years ago, has been developed into one of the primary thermal recovery processes for bitumen in Canadian oil sands deposits. This chapter is aimed to provide a high-level description of process principle, features, and challenges. The focuses will be on the evaluation of resource quality suited for SAGD development, the process of start-up to initiate and establish the gravity drainage, the well design, and operational aspects to achieve stable operation and maximize thermal performance, as well as the importance of integration between the subsurface and surface processes, and finally the trend of solvent addition to steam to improve the thermal performance of SAGD.

Sustainable world economy requires a steady supply of crude oil without any production constraints. Thus, the ever-increasing energy demand of the entire world can be mostly met through the enhanced production from crude oil from existing reservoirs. With the fact that newer reservoirs with large quantities of crude oil could not be explored at a faster pace, it will be inevitable to produce the crude oil from matured reservoirs at an affordable cost. Among alternate technologies, the chemical enhanced oil recovery (EOR) technique has promising potential to recover residual oil from matured reservoirs being subjected to primary and secondary water flooding operations. Due to pertinent complex phenomena that often have a combinatorial role and influence, the implementation of chemical EOR schemes such as alkali/surfactant/polymer flooding and their combinations necessitates upon a fundamental understanding of the potential mechanisms and their influences upon one another and desired response variables. Addressing these issues, the book attempts to provide useful screening criteria, guidelines, and rules of thumb for the identification of process parametric sets (including reservoir characteristics) and response characteristics (such as IFT, adsorption etc.,) that favor alternate chemical EOR systems. Finally, the book highlights the relevance of nanofluid/nanoparticle for conventional and unconventional reservoirs and serves as a needful resource to understand the emerging oil recovery technology. Overall, the volume will be of greater relevance for practicing engineers and consultants that wish to accelerate on field applications of chemical and nano-fluid EOR systems. Further, to those budding engineers that wish to improvise upon their technical know-how, the book will serve as a much-needed repository.

This chapter introduces the reader to the fundamentals of field implementation for chemical EOR projects. Chemical handling, processing, and injection schemes are discussed and current-day facilities and equipment systems are shown from actual projects. Design requirements for processing polymer, alkaline agents, and surfactants provide the reader with an understanding of special considerations for facility process flow design, materials of construction, project logistics, and daily operations. Useful spreadsheets for calculating chemical consumption rates and polymer system design basics are shown. Basic water quality issues are introduced for polymer, surfactant-polymer, alkaline-polymer, and alkaline-surfactant-polymer projects.

Chemical Enhanced Oil Recovery Handbook: Screening, Formulation, and Implementation offers engineers a platform to discover the latest strategies and technologies for maximizing the ultimate recovery factor from operating fields. This comprehensive handbook, based on years of field experience, provides engineers with the methods, tools, and techniques needed to successfully plan, evaluate, manage, and complete an enhanced oil recovery project. The book features a clear and rigorous exposition of theory, sections concerning real-world applications, and a password protected website. The handbook illustrates the EOR decision-making workflow using field case examples from several countries. Assets evaluated include reservoir types ranging from oil sands to condensate reservoirs. Different stages of development and information availability are discussed. Results show the advantage of a flexible decision-making workflow. This approach combines geologic and engineering data, minimizing experts' bias, and also combines technical and financial figures. The proposed methodology has proved useful to evaluating projects and properties very rapidly to identify when upside potential exists. Other topics covered include: chemical injection, gas injection, ultrasonic stimulation equipment and process, microbial injection, thermal recovery, and carbon dioxide-enhanced oil recovery. Each topic is accompanied by a description of the equipment and processes, case studies, and modeling methods. Features the latest case studies from Asia, Canada, Mexico, South America, and the United States Evaluates assets including reservoir types ranging from oil sands to condensate reservoirs Discusses different stages of development and information availability Provides preliminary analytical simulations to estimate oil recovery potential Includes step-by-step modeling techniques for each method

Enhanced Oil Recovery Field Case Studies

Chapter 14. Facility Requirements for Implementing a Chemical EOR Project
Modern Chemical Enhanced Oil Recovery
Chapter 8. Alkaline-Surfactant Flooding
Chapter 2. Enhanced Oil Recovery by Using CO2 Foams: Fundamentals and Field Applications

This chapter briefly presents the interactions between alkali and polymer and the drive mechanisms of alkaline-polymer flooding. The alkaline-polymer field cases presented in this chapter include those in Almy Sands (Isenhour Unit), Moorcroft West and Thompson Creek in Wyoming, David Lloydminster "A" Pool and Etzikom in Canada, and Xing-28 Block (Liaohe Field) and Yangsanmu in China.

This chapter describes polymer flooding applications as a mobility control and profile modification process to enhance oil recovery from mature fields. Successful experience from the Daqing Oilfield, the largest oil field application of polymer flooding, is summarized. The experience will be of considerable value to future polymer flood applications elsewhere in oil fields with appropriate reservoir conditions. Based on laboratory research and field applications at Daqing, technologies were developed that expand conventional ideas concerning favorable conditions for mobility improvement by polymer flooding. These include: 1. The oil strata and well pattern design should be optimized and integrated considering interwell connectivity and permeability differential among the oil zones. 2. The injection procedures and formulation are the key points when designing a polymer project—such as profile modification before polymer injection and zone isolation during polymer injection, higher molecular weight (MW) of the polymer used in the injected slugs, large polymer bank size, higher polymer concentrations and injection rate based on the well spacing, and injection pressure. 3. Surface mixing, injection facilities, oil production, and produced water treatment are important to reservoir engineering aspects of polymer flooding.

Fundamentals of Enhanced Oil and Gas Recovery from Conventional and Unconventional Reservoirs delivers the proper foundation on all types of currently utilized and upcoming enhanced oil recovery, including methods used in emerging unconventional reservoirs. Going beyond traditional secondary methods, this reference includes advanced water-based EOR methods which are becoming more popular due to CO2 injection methods used in EOR and methods specific to target shale oil and gas activity. Rounding out with a chapter devoted to optimizing the application and economy of EOR methods, the book brings reservoir and petroleum engineers up-to-speed on the latest *studies to apply. Enhanced oil recovery continues to grow in technology, and with ongoing unconventional reservoir activity underway, enhanced oil recovery methods of many kinds will continue to gain in studies and scientific advancements. Reservoir engineers currently have multiple outlets to gain knowledge and are in need of one product go-to reference. Explains enhanced oil recovery methods, focusing specifically on those used for unconventional reservoirs Includes real-world case studies and examples to further illustrate points Creates a practical and theoretical foundation with multiple contributors from various backgrounds Includes a full range of the latest and future methods for enhanced oil recovery, including chemical, waterflooding, CO2 injection and thermal*

Crude oil development and production in U.S. oil reservoirs can include up to three distinct phases: primary, secondary, and tertiary (or enhanced) recovery. During primary recovery, the natural pressure of the reservoir or gravity drive oil into the wellbore, combined with artificial lift techniques (such as pumps) which bring the oil to the surface. But only about 10 percent of a reservoir's original oil in place is typically produced during primary recovery. Secondary recovery techniques to the field's productive life generally by injecting water or gas to displace oil and drive it to a production wellbore, resulting in the recovery of 20 to 40 percent of the original oil in place. In the past two decades, major oil companies and research organizations have conducted extensive theoretical and laboratory EOR (enhanced oil recovery) researches, to include validating pilot and field trials relevant to much needed domestic commercial application, while western countries had terminated such endeavours almost completely due to low oil prices. In recent years, oil demand has soared and now these operations have become more desirable. This book is about the recent developments in the area as well as the technology for enhancing oil recovery. The book provides important case studies related to over one hundred EOR pilot and field applications in a variety of oil fields. These case studies focus on practical problems, underlying theoretical and modelling methods, operational parameters (e.g., injected chemical concentration, slug sizes, flooding schemes and well spacing), solutions and sensitivity studies, and performance optimization strategies. The book strikes an ideal balance between theory and practice, and would be invaluable to academicians and oil company practitioners alike. Updated chemical EOR fundamentals providing clear picture of fundamental concepts Practical cases with problems and solutions providing practical analogues and experiences Actual data regarding ranges of operation parameters providing initial *design parameters Step-by-step calculation examples providing practical engineers with convenient procedures*

Field Planning and Development Strategies

Chapter 12. Surfactant Enhanced Oil Recovery in Carbonate Reservoirs

Hybrid Enhanced Oil Recovery Processes for Heavy Oil Reservoirs

Chapter 9. ASP Fundamentals and Field Cases Outside China

Chapter 10. ASP Process and Field Results

This chapter first reviews thermal properties of rock and fluids and related energy concepts. The fundamentals of heat transfer and heat loss, theories to estimate the heated area and oil recovery performance are briefly presented. The mechanisms and screening criteria of steam flooding are discussed. After the general practice in steam flooding projects is discussed, field cases are presented which include Kern River in California, Duri steam flood in Indonesia, West Coalinga Field in California, Karamay Field and the Qi-40 block in Laohe, China.

Oil Recovery in Shale and Tight Reservoirs delivers a current, state-of-the-art resource for engineers trying to manage unconventional hydrocarbon resources. Going beyond the traditional EOR methods, this book helps readers solve key challenges on the proper methods, technologies and options available. Engineers and researchers will find a systematic list of methods and applications, including gas and water injection, methods to improve liquid recovery, as well as spontaneous and forced imbibition. Rounding out with additional methods, such as air foam drive and energized fluids, this book gives engineers the knowledge they need to tackle the most complex oil and gas assets. Helps readers understand the methods and mechanisms for enhanced oil recovery technology, specifically for shale and tight oil reservoirs Includes available EOR methods, along with recent practical case studies that cover topics like fracturing fluid flow back Teaches additional methods, such as soaking after fracturing, thermal recovery and microbial EOR

Microbial-enhanced oil recovery (MEOR) is the use of microorganisms to increase the recovery of oil from existing oil reservoirs. There are nearly 400 US patents dealing with MEOR, some of which add microorganisms to nearly depleted oil reservoirs while others rely on the indigenous microorganisms. The patent literature is reviewed and two successful field trials by the author are described. A completed field trial using microbial permeability profile modification (MPPM) in a field using waterflooding as the secondary method of oil recovery was proven to recover over 360,000bbl of oil since 2004 and is predicted to recover another 230,000bbl of oil by 2018. A second field trial using MPPM is being employed in a field with a petroliferous formation at 115°C. The field is undergoing CO_2 flooding as the secondary recovery method and MPPM has been proven to produce extra oil from five surrounding wells.

One of the most accepted and widely used technologies for enhanced oil recovery is injection of gas or solvent that is miscible or near miscible with reservoir oil. Understanding gas flooding requires a good understanding of the interaction of phase behavior and flow in the reservoir, and how oil and gas develop miscibility.

Chapter 1. Gas Flooding

Primer on Enhanced Oil Recovery

Chapter 5. Surfactant–Polymer Flooding

Polymer Flooding

Chemical Enhanced Oil Recovery Handbook

Chemical Methods, a new release in the Enhanced Oil Recovery series, helps engineers focus on the latest developments in one fast-growing area. Different techniques are described in addition to the latest technologies in data mining and hybrid processes. Beginning with an introduction to chemical concepts and polymer flooding, the book then focuses on more complex content, guiding readers into newer topics involving smart water injection and ionic liquids for EOR. Supported field case studies illustrate a bridge between research and practical application, thus making the book useful for academics and practicing engineers. This series delivers a multi-volume approach that addresses the latest research on various types of EOR. Supported by a full spectrum of contributors, this book gives petroleum engineers and researchers the latest developments and field applications to drive innovation for the future of energy. Presents the latest research and practical applications specific to chemical enhanced oil recovery methods Helps users understand new research on available technology, including chemical flooding specific to unconventional reservoirs and hybrid chemical options Includes additional methods, such as data mining applications and economic and environmental considerations

Provides an easy-to-read introduction to the area of polymer flooding to improve oil production The production and utilization of oil has transformed our world. However, dwindling reserves are forcing industry to manage resources more efficiently, while searching for alternative fuel sources that are sustainable and environmentally friendly. Polymer flooding is an enhanced oil recovery technique that improves sweep, reduces water production, and improves recovery in geological reservoirs. This book summarizes the key factors associated with polymers and polymer flooding—from the selection of the type of polymer through characterization techniques, to field design and implementation—and discusses the main issues to consider when deploying this technology to improve oil recovery from mature reservoirs. Essentials of Polymer Flooding Technique introduces the area of polymer flooding at a basic level for those new to petroleum production. It describes how polymers are used to improve efficiency of "chemical" floods (involving surfactants and alkaline solutions). The book also offers a concise view of several key polymer-flooding topics that can't be found elsewhere. These are in the areas of pilot project design, field project engineering (water quality, oxygen removal, polymer dissolution equipment, filtration, pumps and other equipment), produced water treatment, economics, and some of the important field case histories that appear in the last section. Provides an easy to read introduction to polymer flooding to improve oil production whilst presenting the underlying mechanisms Employs “In A Nutshell” key point summaries at the end of each chapter Includes important field case studies to aid researchers in addressing time- and financial-consumption in dealing with this issue Discusses field engineering strategies appropriate for professionals working in field operation projects Essentials of Polymer Flooding Technique is an enlightening book that will be of great interest to petroleum engineers, reservoir engineers, geoscientists, managers in petroleum industry, students in the petroleum industry, and researchers in chemical enhanced oil recovery methods.

Commercial application of chemical enhanced oil recovery (cEOR) processes is expected to grow significantly over the next decade. Thus, Chemical Enhanced Oil Recovery (cEOR): A Practical Overview offers key knowledge and understanding of cEOR processes using an evidence-based approach intended for a broad audience ranging from field operators, researchers, to reservoir engineers dealing with the development and planning of cEOR field applications. This book is structured into three sections; the first section surveys overall EOR processes. The second section focuses on cEOR processes, while the final section describes the electrorheology technology. These sections are presented using a practical and realistic approach tailored for readers looking to improve their knowledge and understanding of cEOR processes in a nutshell.

The book covers the most recent scientific literature in chemical enhanced oil recovery. After introducing the subject of EOR, detailed advances in polymer flooding are presented, and is exemplified in terms of both experimental work and mathematical simulations. Also, employing the emerging technique of nanotechnology to boost the performance of existing chemical enhanced oil recovery processes is described.

Enhanced Oil Recovery

Chapter 13. Water-Based EOR in Carbonates and Sandstones: New Chemical Understanding of the EOR Potential Using “Smart Water”

a Practical Overview

Chapter 11. Foams and Their Applications in Enhancing Oil Recovery

Chapter 16. Cyclic Steam Stimulation

This chapter first summarizes the fundamentals about foams used in enhancing oil recovery. These fundamentals include characteristics of foams, foam stability, mechanisms of foam flooding to enhance oil recovery, and foam flow behavior. Foam application modes and the factors that need to be considered in designing foam flooding applications are discussed. Some survey results about foam projects are summarized. Finally, several field application cases to enhance oil recovery are presented.

Oil and gas companies are looking for proven hydrocarbon reserves from their existent drained reservoirs with

the objective to extend the production and economical life of their fields. The chemical enhanced oil recovery (CEOR) has raised with a myriad type of process that goes beyond the primary and secondary recovery. The polymer flooding (PF) is a widely applied process in reservoirs with low swept efficiency after the water flooding (WF) process. Colombian field has one of the first polymer pilots in the region with positive results of oil recovery in "A" sands. Thus, the operator is interested in the expansion of PF for the same reservoir and even in deeper reservoir sands. This thesis focuses in the evaluation of different scenarios of PF and surfactant polymer flooding (SPF) for the producer layers A and B with a mechanistic model, thus obtaining new recommendations for the recovery strategy in the field. Therefore, a sector model was constructed from a full field commercial simulator to the in-house simulator: UTCHEMRS. In addition, this sector model was migrated to a second commercial simulator allowing a performance comparison for three simulators. UTCHEMRS model was validated with the commercial simulators through the history matching (HM) phase. The primary and waterflood history match was in agreement with the field data. Simulation results suggested that PF for the base case in "A" sands presented an incremental oil recovery of up to 12% additional to water flooding. Additionally, PF was extended to the lower layer "B" sand to investigate the potential of polymer injection. The PF injection in both reservoirs simultaneously loses swept efficiency and decreases the oil recovery in 3%. However, a hypothetical case of new infill producer wells with the objective of testing the individual reservoir performance has revealed that PF is having important raises in oil recovery for B sands as well. Though, further research should be developed in order to strengthen this interpretation. Finally, the results of SPF case for A sands are inconclusive because a laboratory tests of surfactant phase behavior is needed to ensure the lowest IFT in reservoir conditions

In this chapter, the fundamentals of surfactant flooding are covered, which include microemulsion properties, phase behavior, interfacial tension, capillary desaturation, surfactant adsorption and retention, and relative permeabilities. The surfactant–polymer interactions are discussed. The mechanisms and screening criteria are briefly discussed. The field cases presented include low-tension waterflooding (Loma Novia, Wichita County Regular field), sequential micellar/polymer flooding (El Dorado, Sloss), micellar/polymer flooding (Torchlight and Delaware-Childers), and Minas SP project preparation and SP flooding (Gudong).

In this chapter, we briefly present the fundamentals of alkaline flooding which include comparison of alkalis, alkaline reactions with crude oil, water and reservoir rock, and alkaline flooding mechanisms. Typical field injection data like alkaline injection concentrations and volumes, and field application conditions are

discussed. Finally, we present two mobility-control cases in Russia, one case using high alkaline concentration in Hungary, one caustic-flooding case in India, three cases in the United States, and one case in a Canadian heavy oil field.

Enhanced Oil Recovery of the Nipisi Field

Fundamentals and Applications

Essentials of Polymer Flooding Technique

Chapter 4. Polymer Flooding Practice in Daqing

A Case Study

This chapter presents models of wettability alteration using surfactants and upscaling models related to oil recovery in fractured carbonate reservoirs. Chemicals used in carbonate reservoirs are reviewed. The presented field cases where surfactants were used to stimulate oil recovery are the Mauddud carbonate in Bahrain, the Yates field and the Cretaceous Upper Edwards reservoir in Texas, the Cottonwood Creek field in Wyoming, and the Baturaja formation in the Semoga field in Indonesia.

Hybrid Enhanced Oil Recovery Processes for Heavy Oil Reservoirs, Volume 73 systematically introduces these technologies. As the development of heavy oil reservoirs is emphasized, the petroleum industry is faced with the challenges of selecting cost-effective and environmentally friendly recovery processes. This book tackles these challenges with the introduction and investigation of a variety of hybrid EOR processes. In addition, it addresses the application of these hybrid EOR processes in onshore and offshore heavy oil reservoirs, including theoretical, experimental and simulation approaches. This book will be very useful for petroleum engineers, technicians, academics and students who need to study the hybrid EOR processes, In addition, it will provide an excellent reference for field operations by the petroleum industry. Introduces emerging hybrid EOR processes and their technical details Includes case studies to help readers understand the application potential of hybrid EOR processes from different points-of-view Features theoretical, experimental and simulation studies to help readers understand the advantages and challenges of each process

Primer on Enhanced Oil Recovery gives the oil and gas market the introductory information it needs to cover the physical and chemical properties of hydrocarbon reservoir fluids and rock,

drilling operations, rock-fluid interactions, recovery methods, and the economy of enhanced oil recovery projects. Beginning with introductory materials on basic physics and oil-rock interaction, the book then progresses into well-known types of EOR, such as gas injection and microbial EOR. Other sections cover hybrid EOR, smart water/low salinity and solar EOR. Worldwide case study examples give engineers the go-to starting point they need to understand the fundamentals of EOR techniques and data. Discusses basic physics and chemistry in oil, oil-rock interaction, variation of oil, and interaction properties with temperature Helps readers understand why and when EOR can be used Includes data on EOR implementation and economics

Enhanced oil recovery field case studies bridge the gap between theory and practice in a range of real-world EOR settings. Areas covered include steam and polymer flooding, use of foam, in situ combustion, microorganisms, "smart water"-based EOR in carbonates and sandstones, and many more. Oil industry professionals know that the key to a successful enhanced oil recovery project lies in anticipating the differences between plans and the realities found in the field. This book aids that effort, providing valuable case studies from more than 250 EOR pilot and field applications in a variety of oil fields. The case studies cover practical problems, underlying theoretical and modeling methods, operational parameters, solutions and sensitivity studies, and performance optimization strategies, benefitting academicians and oil company practitioners alike. Strikes an ideal balance between theory and practice.

Chemical Methods

Chapter 22. Cold Production of Heavy Oil

Chapter 18. In Situ Combustion

A Field Case Study

Chemical Enhanced Oil Recovery

Water flooding of oil reservoirs has been performed for a century in order to improve oil recovery for two reasons: (1) give pressure support to the reservoir to prevent gas production and (2) displace the oil by viscous forces. During the last 30 years, it was discovered that the wetting properties of the reservoir played a very important role for the efficiency of the water

flood. Even though much work have been published on crude oil–brine–rock (CBR) interaction related to wetting properties, Professor N.R. Morrow, University of Wyoming, asked the audience the following question at the European enhanced oil-recovery (EOR) meeting in Cambridge, April 2011: Do we understand water flooding of oil reservoirs? If we are not able to explain why injection fluids of different ionic composition can have a great impact on displacement efficiency and oil recovery, the answer to Morrow's question is NO. Researchers have to admit that we do not know the phenomena of water flooding well enough. The key to improve our understanding is to obtain fundamental chemical understanding of the CBR interaction by controlled laboratory studies, and then propose chemical mechanisms, which should be validated also from field experience. In this chapter, I have tried to sum up our experience and chemical understanding on water-based EOR in carbonates and sandstones during the last 20 years with a specific focus on initial wetting properties and possibilities for wettability modification to optimize oil recovery. Chemically, the CBR interaction is completely different in carbonates and sandstones. The proposed chemical mechanisms for wettability modification are used to explain field observations.

Cold production is a solution-gas drive process in which a reservoir saturated with live heavy oil reservoir is depleted as quickly as possible to generate relatively stable gas bubbles leading to higher oil recoveries (5–10% original oil in place (OOIP)) than for light oils (2–5% OOIP). More specifically, these bubbles increase the oil/gas mixture compressibility, which maintains the reservoir pressures for longer times than for light oils.

This chapter contains a thorough coverage of in situ combustion (ISC) as an enhanced oil recovery method, describing its complex aspects in a simple and practical manner. It is the first really international treatise of the subject as the international experience was carefully put together.

Formation Damage during Improved Oil Recovery: Fundamentals and Applications bridges the gap between theoretical knowledge and field practice by presenting information on formation damage issues that arise during enhanced oil recovery. Multi-contributed technical chapters include sections on modeling and simulation, lab experiments, field case studies, and newly proposed technologies and methods that are related to formation damage during secondary

and tertiary recovery processes in both conventional and unconventional reservoirs. Focusing on both the fundamental theories related to EOR and formation damage, this reference helps engineers formulate integrated and systematic designs for applying EOR processes while also considering formation damage issues. Presents the first complete reference addressing formation damage as a result of enhanced oil recovery Provides the mechanisms for formation damage issues that are coupled with EOR Suggests appropriate preventative actions or responses Delivers a structured approach on how to understand the fundamental theories, practical challenges and solutions

Chapter 21. Field Applications of Organic Oil Recovery—A New MEOR Method

Chemical Enhanced Oil Recovery (cEOR)

Enhanced Oil Recovery in Shale and Tight Reservoirs

Chemical Enhanced Oil Recovery Simulation in Highly Stratified Heterogeneous Reservoir

Enhanced Oil Recovery Field Case StudiesGulf Professional Publishing

This chapter first reviews the mechanisms, theories, and screening criteria of cyclic steam stimulation (CSS) projects. Then we will focus on the practice of CSS projects. Finally field cases are presented which include Cold Lake in Alberta, Canada, Midway Sunset in California, Du 66 block in the Liaohe Shuguang field, Jin 45 Block in the Liaohe Huanxiling field, Gudao Field, Blocks 97 and 98 in the Karamay field, and Gaosheng Field in China.

Enhanced Oil Recovery Field Case Studies bridges the gap between theory and practice in a range of real-world EOR settings. Areas covered include steam and polymer flooding, use of foam, in situ combustion, microorganisms, "smart water"-based EOR in carbonates and sandstones, and many more. Oil industry professionals know that the key to a successful enhanced oil recovery project lies in anticipating the differences between plans and the realities found in the field. This book aids that effort, providing valuable case studies from more than 250 EOR pilot and field applications in a variety of oil fields. The case studies cover practical problems, underlying theoretical and modeling methods, operational parameters, solutions and sensitivity studies, and performance optimization strategies, benefitting academicians and oil company practitioners alike. Strikes an ideal balance between theory and practice Focuses on practical problems, underlying theoretical and modeling methods, and operational parameters Designed for technical professionals, covering the fundamental as well as the advanced aspects of EOR

Enhanced-Oil Recovery (EOR) evaluations focused on asset acquisition or rejuvenation involve a combination of complex decisions, using different data sources. EOR projects have been traditionally associated with high CAPEX and OPEX, as well as high financial risk, which tend to limit the number of EOR projects launched. In this book, the authors propose workflows for EOR evaluations that account for different volumes and quality of information. This flexible workflow has been successfully applied to oil property evaluations and EOR feasibility studies in many oil reservoirs. The methodology associated with the workflow relies on traditional (look-up tables, XY correlations, etc.) and more advanced (data mining for analog reservoir search and geology indicators) screening methods, emphasizing identification of analogues to support decision making. The screening phase is combined with analytical or simplified numerical simulations to estimate full-field performance by using reservoir data-driven segmentation procedures. Case Studies form Asia, Canada, Mexico, South America and the United States Assets evaluated include reservoir types ranging from oil sands to condensate reservoirs. Different stages of development and information availability are discussed

Advances in Polymer Flooding and Nanotechnology

Chapter 19. Introduction to MEOR and Its Field Applications in China

Theory and Practice

Chapter 15. Steam Flooding

Chapter 20. The Use of Microorganisms to Enhance Oil Recovery

Based on the enhanced oil recovery (EOR) survey in Oil and Gas Journal (2010), approximately 280,000bbl of oil per day or 6% of US crude oil production was produced by carbon dioxide (CO2) EOR. Just like any other gas injection processes, field CO2 flooding projects suffer from poor sweep efficiency due to early gas breakthrough, unfavorable mobility ratio, reservoir heterogeneity, viscous fingering and channeling, and gravity segregation. Many of these problems are believed to be alleviated or overcome by foaming the injected CO2. Since the 1970s, CO2-foam flooding has been used as a commercially viable method for EOR processes. Foams, defined as a mixture of internal gas phase in a continuous external liquid phase containing surfactant molecules, can improve sweep efficiency significantly by reducing gas mobility, especially in the reservoirs with a high level of geological heterogeneity. This chapter consists of three main parts: the first part (Section 2.1) deals with fundamentals on foams in porous media and recent advances in this field of research, including three foam states (weak-foam, strong-foam, and intermediate states) and two steady-state flow regimes of strong foams; the second part (Section 2.2) overviews field examples of foam-assisted CO2-EOR processes; and the third part (Section 2.3) covers typical field injection and production responses if CO2-foam pilot or field-scale treatments are successful.

This book covers all aspects of polymer flooding, an enhanced oil recovery method using water soluble polymers to increase the viscosity of flood water, for the displacement of crude oil from porous reservoir rocks. Although this method is becoming increasingly important, there is very little literature available for the engineer wishing to embark on such a project. In the past, polymer flooding was mainly the subject of research. The results of this research are spread over a vast number of single publications, making it difficult for someone who has not kept up-to-date with developments during the last 10 to 15 years to judge the suitability of polymer flooding to a particular field case. This book tries to fill that gap. The basic mechanisms of the process are described and criteria given where it may be employed. Basic elements of the chemistry of EOR-polymers are provided. The fundamentals of polymer physics, such as rheology, flow in porous media and adsorption, are derived. Practical hints on mixing and testing of polymers in the laboratory are given, as well as instructions for their application in the oil field. Polymer flooding is illustrated by some case histories and the economics of the methods are examined. For the essential subjects, example calculations are added. An indispensable book for reservoir engineers, production engineers and laboratory technicians within the petroleum industry.

Developments in microbial-enhanced oil recovery (MEOR) have made huge advancements over the last few years. A new programmatic approach to MEOR is organic oil recovery (OOR), the management of the microbial ecology to facilitate the release of oil from the reservoir. Using this breakthrough process, which does not require microbes to be injected, over 180 applications have been conducted between 2007 and 2011 in producing oil and water-injection wells in the United States and Canada. This chapter reviews the OOR process, a summary of results and two case studies in detail.

This chapter covers the alkaline surfactant–polymer (ASP) process and field results. Background information describing the history of alkaline, alkaline surfactant, alkaline polymer, and ASP flooding processes is given, followed by a review of the requirement of high acid content in the crude oil for these processes to be effective.

Processes and Operations

Screening, Formulation, and Implementation

Chapter 6. Alkaline Flooding

Chapter 7. Alkaline-Polymer Flooding

Fundamentals of Enhanced Oil and Gas Recovery from Conventional and Unconventional Reservoirs

This chapter presents microbial-enhanced oil recovery (MEOR) mechanisms first. Microbes and nutrients used in MEOR are introduced. Screening criteria are listed. Finally, several microbial field applications are presented. These applications include single-well microbial huff-and-puff, microbial waterflooding, wellbore stimulation to remove wellbore or formation damage, and MEOR using indigenous microbes.

This chapter discusses about these interactions between alkali and surfactant: (1) addition of an alkali in a surfactant solution equivalently adds salt; (2) addition of an alkali in a surfactant solution changes the surfactant phase behavior; and (3) addition of an alkali in a surfactant solution reduces surfactant adsorption. After presenting those fundamentals, two field pilots are presented: Big Sinking field in East Kentucky and White Castle field in Louisiana.

Written by foremost experts in the field, and formulated with attention to classroom use for advanced studies in reservoir characterization and processes, this book reviews and summarises state-of-the-art progress in the field of enhanced oil recovery (EOR). All of the available techniques: alkaline flooding; surfactant flooding; carbon dioxide flooding; steam flooding; in-situ combustion; gas injection; miscible flooding; microbial recovery; and polymer flooding are discussed and compared. Together with Volume I, it presents a complete text on enhanced recovery technology and, hence, is an almost indispensible reference text. This second volume compliments the first by presenting as complete an analysis as possible of current oilfield theory and technology, for accomplishment of maximum production of oil. Many different processes have been developed and field tested for enhancement of oil recovery. The emerging philosophy is that no single process is applicable to all petroleum reservoirs. Each must be treated as unique, and carefully evaluated for characteristics that are amenable to one or two of the proven technologies of EOR. This book will aid the engineer in field evaluation and selection of the best EOR technology for a given oilfield. Even the emerging technology of microbial applications to enhance oil recovery are reviewed and explained in terms that are easily understood by field engineers. The book is presented in a manner suitable for graduate studies. The only addition required of teachers is to supply example problems for class work. An appendix includes a reservoir mathematic model and program for general application that can also be used for teaching.

The fundamentals of individual chemical process (alkaline, surfactant, and polymer) and their two-component combinations have been discussed in preceding chapters. This chapter only briefly discusses the synergy and practical issues in the three-component combination—Alkaline-surfactant-polymer process. The practical issues discussed are produced emulsion, scaling, and chromatographic separation. Overall performance and amount of chemicals used in field projects are summarized. Most of the Chinese field cases were presented in Sheng (2011). In this chapter, we only present a few field cases outside China. These projects are the Lawrence field in Illinois, the Cambridge Minnelusa field, the West Kiehl field

and Tanner field in Wyoming, and Lagomar LVA-6/9/21 area in Venezuela.
Chapter 17. SAGD for Heavy Oil Recovery
Formation Damage During Improved Oil Recovery
Enhanced Oil Recovery, II
Chemical Nanofluids in Enhanced Oil Recovery