Feasibility of Reservoir Heating by Electromagnetic Irradiation

Introduction

Conventional thermal EOR methods, such as fireflooding and steamflooding, are commercially viable when properly applied. Every conventional method has one or more limitations. If the reservoir is shallow, the reservoir pressure may be too low to maintain a steam drive. If a reservoir is too deep, wellbore heat losses become excessive. Fireflooding does not have the same depth constraints as steamflooding, but fireflood success depends on crude composition. Each of the conventional thermal methods requires sufficient reservoir transmissibility to achieve fluid injection. EMH has the potential for overcoming some of the limitations of conventional thermal methods. Reviews of EMH techniques have been presented by Baker-Jarvis and Inguva, and Kim. Especially noteworthy as background for derivations presented in later sections of this paper was the work by Abernethy. Abernethy coupled electromagnetic absorption and fluid flow in a one-dimensional radial model of wellbore behavior. He made the simplifying assumption that heat losses to adjacent formations could be neglected at his level of approximation. Later work by McPherson, et al., Hiebert, et al., and Kim accounts for more physical effects, but has a corresponding increase in complexity. Our goal is to present a simple algorithm for estimating the temperature profile of an irradiated reservoir. The algorithm includes heat losses to adjacent formations, and is designed to be a tool for determining the feasibility of heating a reservoir with electromagnetic energy. The EMH process relies on preferential absorption of electromagnetic energy as the means for increasing the temperature of a material. Different materials have different electromagnetic absorption properties. The ability of an electromagnetic wave to transfer energy to a medium depends on the molecular composition of the medium. Suppose a medium contains mobile molecules with a molecular dipole moment (such as water). The passing electromagnetic wave will exert a torque on the polar molecules as their dipole moments try to align with the oscillating electric field of the electromagnetic wave. Interaction of an oscillating polarmolecule with its neighbors generates frictional heat and raises the temperature of the medium. The magnitude of temperature increase of a material depends on the amount of electromagnetic energy absorbed by the irradiated material. Electromagnetic Power attenuation in a porous medium is discussed in Section II. A simple algorithm for estimating the temperature increase associated with reservoir irradiation is given in Section III. Applications of the algorithm in Section IV illustrate typical sources of input data and algorithm results. Some hardware considerations are provided in Section V, and near-wellbore applications are discussed in Section VI. Conclusions are presented in Section VII.
Other Resources

Looking for more?

Some of the OnePetro partner societies have developed subject-specific wikis that may help.

PetroWiki was initially created from the seven volume Petroleum Engineering Handbook (PEH) published by the Society of Petroleum Engineers (SPE).
The SEG Wiki is a useful collection of information for working geophysicists, educators, and students in the field of geophysics. The initial content has been derived from: Robert E. Sheriff's Encyclopedic Dictionary of Applied Geophysics, fourth edition.

The electromagnetic heating for oil recovery is based on the transformation of electric energy into thermal energy. It happens through a direct interaction between the electromagnetic field and the electrically sensitive particles of the medium. There are different types of electromagnetic heating and the choice of the heating type depends on factors such as reservoir depth, geological [Show full abstract] heterogeneities, and electrical characteristics of the reservoir constituents. This study was based on reservoirs with characteristics similar to those found in the sedimentary basins of Electromagnetic heating targets part of the reservoir instead of heating the bulk of the reservoir, which means that the targeted area can be heated up more effectively and with lower heat losses than with other thermal methods. Electromagnetic heating is still relatively new and is not widely used as an alternate or addition to traditional thermal recovery methods. Volume 2013
Electromagnetic heating (EMH) can be used instead. This study presents an oil-gas two-phase linear flow EMH model by COMSOL. The model uses the variation in temperature to update the EM absorption coefficient. Special attention is focused on reservoirs with characteristics for which steam injection is not feasible such as low permeability, thin-zone, and extra-heavy oil reservoirs. In the case of reservoir heating there is a wide range of available frequencies in the electrical spectrum that can be used in diverse heating schemes. In ERH, also known as low frequency heating, the heat source is assumed to be inside the production well using a hot pipe, a constant temperature is assumed at the boundary of the well. Electromagnetic Heating of Heavy Oil and Bitumen: A Review of Experimental Studies and Field Applications. For these types of reservoirs, electromagnetic heating is the recommended solution. Electromagnetic heating targets part of the reservoir instead of heating the bulk of the reservoir, which means that the targeted area can be heated up more effectively and with lower heat losses than with other thermal methods. 1. Introduction High-frequency electromagnetic radiation is a relatively new technique for use in enhanced oil recovery methods. It has been tested by theoretic, laboratories and field trial research in Russia [110], the United States [1117], Canada [1821], and other countries [2234]. Feasibility of Reservoir Heating by Electromagnetic Irradiation. He made the simplifying assumption that heat losses to adjacent formations could be neglected at his level of approximation. Later work by McPherson, et al., Hiebert, et al., and Kim accounts for more physical effects, but has a corresponding increase in complexity. Our goal is to present a simple algorithm for estimating the temperature profile of an irradiated reservoir. The algorithm includes heat losses to adjacent formations, and is designed to be a tool for determining the feasibility of heating a reservoir with electromagnetic energy.