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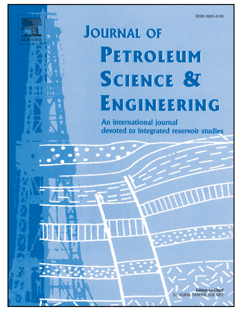

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Development of Scaling Criteria for Enhanced Oil Recovery: A Review

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ABSTRACT

Scaling criteria are used to evaluate the performance of a reservoir by deriving dimensionless groups which affect a specific enhanced oil recovery (EOR) process. The relationships among different process controlling factors are investigated in this approach by comparing the dimensionless numbers. Scaling criteria can capture continuous alteration of rock and fluid properties related to fluid flow through porous media which can be characterized by different dimensionless groups. In this study, a critical review of scaling criteria development is made based on published inspectional and dimensional analyses of fluid flow through porous media for oil-water displacement processes. This paper provides the basic concepts of scaling and dimensionless groups along with the review of recent works on scaling criteria development for EOR processes. This paper discusses how scaling criteria are developed using the existing techniques and reviews both their merits and demerits. The history of dimensional analysis is reviewed, starting with the first notions of dimensions to the powerful methods of recent times. This study reviews briefly some relevant analytical and semi-analytical works which are related to scaled model development for petroleum reservoirs. Understanding the basics of these mechanisms will assist petroleum engineers to analyze, design and evaluate EOR processes. This study will also help in developing dimensionless mathematical models for fluid flow through porous media.

Keywords: Scaling criteria, dimensional analysis, inspectional analysis, dimensionless group, displacement process.

1. Introduction

Scaled physical models have been extensively used in the field of engineering problems to reproduce the behavior of an actual system on a small-scale laboratory for many years (Doscher, 1980). This process is effective to simulate the behavior of a petroleum reservoir and efficient in evaluating the advantages of a recovery process (Purvis and Bentsen, 1988). Their significance has been demonstrated particularly for new processes whose mechanisms are not well understood or a mathematical description is difficult to formulate. The procedure for the development of scaled models will be accepted when dimensionless scaling groups would be known to scale up laboratory results to field conditions. The world has huge natural resources (e.g., fossil fuel). Most of the fossil fuel in the form of heavy oil reserves are found in Canada. These unconventional resources have been deposited in unfavorable conditions. Thus, it needs more efforts, technological advancements and energy to recover the reservoir fluid. In practice, three-dimensional (3D) displacement models can represents an appropriate well configuration. However, their physical limitations make it impossible to duplicate the real reservoirs under some conditions. Therefore, it is essential and of pragmatic significance to create scaling criteria for depicting the fluid behavior in unconventional reservoirs (Zhou, 2015). Although, recent advancements in numerical reservoir simulation processes are significant, however scaled physical models are presently favored because their capacity to capture the physical phenomena that can occur in a specific process. In the petroleum engineering, core flood experiments in the laboratory have been used for many years to understand, and verify the reservoir behavior and numerical findings. The feasibility of EOR techniques are investigated through this process before they are attempted in the field application. Whatever information is obtained from a pore scale model, it should be presented in a way such that it will be appropriate for other systems rather than the one used. As results are described, it is practical to use the outcome of one scale to foresee the behavior of another scale. A series of connection should be developed to verify the approximations between the two configurations which are considered for the analyses. The developed connections between two systems are typically known as similarity laws, similarity requirements, or scaling laws. These scaling laws help to develop the specific EOR process which can affect the physical phenomena.

1.1 Enhanced Oil Recovery

EOR is the implementation of different kinds of secondary and tertiary recovery techniques. It can be employed for increasing the amount of crude oil that can be extracted from an oil field. Different types of technologically

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