

Preface

The research of reasonable well patterns in the oil and gas field development has received significant attention in recent history. In the 1940s, M. Muskat made studies on the flow of homogeneous fluids through porous media. Several authors in literature advanced theories about the relationship between reservoir sweep efficiency and injection models, i.e., well patterns, when the reservoir is homogeneous and the mobility ratio is 1. Subsequently, in the 1950s, researches clarified the changes of reservoir sweep efficiency after water-breakthrough in the water-flooding process under the condition of random mobility ratios. However, in the late 1950s, the method of oil production with sparse well pattern and great differential pressure was proposed by some other researchers and widely applied, but their application failed in practice. In the late 1960s, V.N. Shelkachev in former Soviet Union developed an empirical formula for the determination of final oil recovery and well spacing density. Similarly, some scholars of Daqing Oilfield suggested that the well pattern deployment should be based on the size of reservoir sand and that the relationship of water drive control and well pattern is determined by the oil sand map. In the early 1980s, Tong Xianzhang proposed a method to optimize the well pattern leading to the realization of maximum production. In the early 1990s, Qi Yufeng presented the well pattern system theory. Moreover, Lang Zhaoxin and others initiated the research on the production of horizontal well patterns. In 2003, Liu Dehua proposed the concept of the vector well pattern and corresponding well spacing methodologies and has ever since been working on them. In 2005, Liu Yuetian from China University of Petroleum studied the water injection methods and well arrangement theories of anisotropic reservoir.

With the continuous development of well pattern research, understanding of the well patterns has also been in progress. Since the well pattern is very important in the production of oil and gas fields, the production scale, the life of production, and the economic benefits of oil and gas fields are determined by the selection, deployment, and adjustment of well patterns to a large extent. Moreover, the onshore oil and gas fields in China are mostly heterogeneous reservoirs. The optimization of well patterns is particularly important. Therefore, the establishment

of well pattern optimal control theory plays an important guiding role in improving the oilfield development.

With the development of oil and gas fields and constant change of drive modes, the development system becomes increasingly complex. This creates much demand for further and detailed research on the well pattern or well pattern efficiency. From the perspective of system, the well pattern system which consists of individual wells is a subsystem of oil and gas field development system. Consequently, in order to better handle the challenge of well patterns, it is ideal to optimize the well pattern holistically through the combined optimization of individual wells. This involves the combined evaluation of all the major inputs such as drainage radius of single wells, multi-well interference and injection-production balance, and the position and function of well patterns in the system of oil and gas field development, taking the problem as a socially complex giant system. For the optimization of well patterns, the approach should involve the principle of a minimum number of wells, the largest controlled drainage area, a higher hydrocarbon recovery rate, a satisfactory or an acceptable oil and gas production rate, the flexibility of the well pattern, the lowest managerial cost of ground facilities and so forth.

The author has been engaged in the research on oilfield development theory and application, especially in the systematic research on the well pattern. Combined with the oilfield development practice, he has made a number of significant proposals toward the well pattern optimal control theory.

This book introduced in detail the geological foundation of well pattern optimal control, reservoir direction characteristics and their evaluation methods, the concept of the vector well pattern and corresponding well pattern deployment methods, well pattern control principles and the determination methods of well spacing density in different development phases, the optimization of horizontal wells and the design principles and requirements of mixed well pattern of the horizontal and vector wells, etc. This research finding laid the theoretical foundation for the effective development and secondary development of heterogeneous sandstone reservoirs and proposed a number of effective methods and measures to significantly improve the water-flooding effect.

The book derives its usefulness from the author's various research findings. As the first edition, it is likely for readers to come across a few mistakes. Therefore, the author is open to and welcomes all corrections and constructive suggestions.

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