

Review of the Scientific Advisor

for the dissertation thesis submitted on the Requirements for the Degree of Doctor of Philosophy (Ph.D.) in Petroleum Engineering (8D07202) Satbayev University

by Sagyndikov Marat Serikovich

titled "Systematic Approach Investigation for Improving Polymer Flood Technology at the Kalamkas field"

The submitted Ph.D. dissertation of Marat Serikovich Sagyndikov titled «Systematic Approach Investigation for Improving Polymer Flood Technology at the Kalamkas field" describes a systematic approach investigation for improving polymer flood technology at the Kalamkas field.

The dissertation relevance. The majority of giant oil fields in Kazakhstan are entering or already in the brownfield development stage, and the Kalamkas oilfield is one of them. The field was discovered in 1976 and developed commercially since 1979 according to the Field Development Project. In view of the low reservoir temperature, elevated mobility ratio, and high formation permeability, it was recognized that there is considerable potential for enhancing oil production by polymer flooding. Furthermore, a recent tertiary polymer flood pilot shows high technical and economic success. Thus, polymer flooding is considered as a perspective EOR technique for the Kalamkas field that requires further development. Although polymer flooding worldwide has been applied ~60 years, and it still requires further investigation to provide improvements. Thus, this dissertation describes a systematic approach investigation for improving polymer flood technology at the Kalamkas field, which proves the relevance of this research.

The objective of this dissertation is investigation of polymer flood at the Kalamkas field to develop a systematic approach for improving technology. Therefore, the research scope of this dissertation was focused on the following aspects: (1) a comprehensive literature review of recent worldwide polymer EOR projects focusing on the Kalamkas field polymer flood aspects; (2) assess polyacrylamide solution chemical and mechanical stability during a polymer flood in the Kalamkas field; (3) develop a novel method for the field assessment of polymer degradation during a polymer flood of an oil reservoir; (4) experimental and numerical studies of the Kalamkas polymer flood technology. Examine the oil recovery at various simulation scenarios; (5) the Kalamkas polymer flood projects feasibility studies and choose most rational scenario for full field deployment.

The scientific novelty is that for the first time conducted and published oil TAN (total acid number) analysis for Kazakhstan fields for ASP flood screening. In Chapter III, Ph.D. student by theoretical, laboratory and field studies proved that the vertical HPAM injection wells contained fractures that were necessary for polymer injection. And this fractures substantially reduced mechanical degradation, and that injected polymer solutions were quickly stripped of dissolved oxygen (thereby promoting oxidative stability). This is the first published report demonstrating that backflowed HPAM samples from an injection well showed no detectable dissolved oxygen. Also, this is the first published report demonstrating that backflowed samples from an injection well showed no HPAM mechanical (or oxidative) degradation. These accomplishments are well documented in his recent peer-approved paper "Field Demonstration of the Impact of Fractures on Hydrolyzed Polyacrylamide Injectivity, Propagation, and Degradation" in USA leading scientific journal, which is cited in Scopus Base Q1 (94 percentile) - SPE Journal. Also, the novel sampling method reported here has been registered by the Patent for a utility model presented in Appendix A, which indicates the scientific novelty of the performed study.

Application and practical value. In Chapter IV dissertation author provided a methodology to assess chemical degradation for the Kalamkas field conditions. This study indicates the possibility of saving 25% of OPEX for the Eductor-type polymer unit, thereby improving project economics. In addition, a novel approach to model polymer flood can be used to optimize polymer injection parameters, thereby improving technology efficiency, which undoubtedly demonstrates the high practical significance of the scientific results.

Personal contribution is demonstrated by the official reports from the field operations, which are presented in the thesis Appendixes.

The completeness of publications. The main hypotheses of the dissertation have been published in 7 works, which include 1 article – in the Scientific Journal cited in the Scopus base (Q1, 94 percentile), 2 articles – in the Scientific Journals listed in the recommended by the Committee for Quality Assurance in the Sphere of Education and Science of the Ministry of Science and Higher Education RoK, 3 articles– International Conferences, 1 – Patent for the utility model (KazPatent). Mr. Sagyndikov is the first author in all publications and affiliation shown as Satbayev University. Thus, Mr. Sagyndikov's work fully meets the requirements of the Satbayev University Dissertation Council.

Dissertation Organization. The dissertation is composed of six chapters. The introduction presents the general overview, relevance, objectives, hypotheses, and dissertation organization. Chapter I provides the Kalamkas oilfield geological properties and reservoir dynamics features. Chapters II, III, IV, and V are based on published papers, of which I am the first author, about topics of the Kalamkas

polymer flood key aspects and EOR technology optimization. Chapter VI is conclusions. The total volume is 165 pages, including 55 figures, 27 tables, references of 168 titles, and 6 appendices.

In conclusion, by its relevance, the scientific and practical value dissertation work of Marat Serikovich Sagyndikov titled "Systematic Approach Investigation for Improving Polymer Flood Technology at the Kalamkas field" meets the requirements of the Committee for Supervision and Certification in Education and Science of the Ministry of Science and Higher Education. Therefore, the dissertation author deserves the Doctor of Philosophy (Ph.D.) in the specialty 8D07202 - Petroleum Engineering.

Scientific Advisor,
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«31» August 2022

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A handwritten signature in blue ink, appearing to be the signature of S. E. Kudaibergenov.