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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Aysylu Askarova

PhD Program: Petroleum Engineering

Title of Thesis: Physical and numerical modeling of thermal methods of EOR and improvements of oil recovery

Supervisor: Associate Professor Alexey Cheremisin

Name of the Reviewer: Dr. Mikhail A. Varfolomeev

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 09-11-2020**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The PhD thesis of Aysylu Askarova is devoted to the physical and numerical modeling of thermal methods. Author has evaluated three types of thermal methods in this work which include a hot water injection (HWI), in-situ combustion (ISC), and HPAI. The huge volume of experiments and calculations was done by Aysylu. If usually in a certain dissertation one method is studied. Here she could overcome three of them.

This work is very important nowadays due to decrease of conventional oil reserves and increasing the share of unconventional resources like heavy oil, tight reservoirs and etc. Also many of current conventional light oil reservoirs are on the last stage of development and effective enhanced oil recovery techniques are required to improve oil production. Thermal methods can be a good solution for them.

Huge volume of work done is not only one advantage of this work. It should be noted that the thesis successfully combines developments and important results of experimental research with a large amount of work in the field of simulation of thermal methods. This is very important for the further successful application of thermal methods and the results of this work in the field. The developments obtained using simulation methods and proposed methodological approaches can be successfully applied both for quick screening and for assessing the efficiency of hot water and air injection in specific oilfields.

Aysylu could get several new and practically important results in her study.

In the part devoted to the hot water injection author has proposed a new kinetic model for simulation of HWI taken into account the aquathermolysis process. May be the chosen reactions are not included all the possible steps of this process however it is very important contribution to the evaluation of efficiency of hot water injection. It has been shown that HWI at temperatures more than 250 ^{0}C cannot be simulated correctly without taken into account chemical reaction of crude oil components. Also author proposed a technique for laboratory screening of HWI on consolidated core models using self-designed cementation technology.

In second part of the thesis devoted to subcritical water injection methodological approach for the enhancement of in-situ upgrading process simulation was proposed which is based on consistent experimental studies of kinetic mechanisms of organic matter transformations and their accurate reproduction in the numerical simulator.

In third part HPAI recovery technique feasibility for the target field was evaluated. Aysylu has done experimental part on HPRTO and MPCT and their 3D numerical modeling based on validated kinetic model. Full-field simulations of HPAI were carried out using adapted fluid model, relative permeability, kinetic model, and operational parameters. Practical recommendations for application of HPAI on the studied reservoir were proposed. These results confirmed the practical importance of the thesis.

In the last part new findings about forward and reverse combustion methods were obtained experimentally and analyzed including simulation part. It should be noted that if forward combustion is more or less studied in the literature and applied in a large number of oilfields, the information about oxidation and recovery processes in reverse combustion is limited.

It should be noted that most of the results were obtained for carbonate reservoirs, which are complex development objects and are attracting more and more attention both of oil companies in Russia and abroad.

Author showed strong competencies and knowledge in petroleum engineering, kinetics of chemical reactions, and numerical simulations.

Main results of this work were published in 4 papers in well-known peer-reviewed journals. This fact confirms the novelty of obtained results and their reliability.

Generally, thesis is well written in English and good organized. There are only few errors in the text. Author presented detailed literature review with the focus on laboratory testing and field applications of hot water and air injection. Less attention was paid on the analysis of papers about oxidation behavior and kinetics of crude oils and some recent works in this area were missed.

Like any work devoted to the study of a wide range of methods and objects, it contains less detailed description of specific processes and their stages. For example it is not very clear from HWI part why in some experiments aquathermolysis processes were observed and in some not. Also, author did not describe in details how each kinetic model was proposed and kinetic parameters were determined. There is no information about reasons for choosing ignition temperature in HPAI and ISC experiments. However, this does not affect the results obtained in this work.

In all I consider this PhD thesis worth the diploma. The author has proved herself to be a highly qualified and knowledgeable specialist who can conduct research independently. She deserves to get PhD degree in Petroleum Engineering.

Provisional Recommendation

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*