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Skolkovo Institute of Science and Technology

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: Dmitry Eskin

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 thesis is written rather clearly and contains a few interesting results.

Scientific value and industrial relevance of the proposed studies are explained in the 1st Chapter. The Chapter 2 contains the literature review covering major enhanced recovery techniques with a focus on thermal methods, their critical analysis pointing out different advantages and drawbacks. The set of principal objectives was formulated on the basis of the review.

Chapter 3 focuses on hot water flooding experiments, their numerical simulations, and improvement of the model by introducing the "aquathermolysis" kinetic sub-model model previously used only for SAGD/steam injection processes. Chapter 4 is dedicated to studies of water injection under critical parameters on a field scale into the shale reservoir belonging to Bazhenov formation. This studies provide an explanation of importance of detailed specification of Organic Matter saturation, and distribution of organic matter in the target reservoir. Also, this chapter reveals some drawbacks of the existing commercial software.

An attempt undertaken to solve some problems encountered during simulations is also described in the Chapter 4.

Chapter 5 includes experiments (HPRTO, MPCT) and corresponding numerical simulations of the HPAI process. The numerical model of HPCT developed accounts for the major phenomena such as heat and mass transfer, convection, combustion delay and heat losses observed in the experiments conducted under nearly adiabatic conditions. The efficiency of the technique was estimated for the Kirsanovskoe oil field and the problem of upscaling combustion kinetics to field-scale simulations was discussed.

Chapter 6 is dedicated to the analysis of forward and reverse combustion experiments conducted using the HPCT equipment. The conditions, under which reverse combustion can be preferable, are approximately identified.

Concluding remarks are presented in Chapter 7, where the directions for future work are also suggested.

Overall, the topic is relevant to the content. The methods employed are relevant to the dissertation subject. The obtained results are substantial and represent a decent step toward the improvement of existing modeling approaches. Most of the results were obtained in the course of working on projects sponsored by industry. Therefore, the results have a reasonably high practical value. The thesis's results have been published in reputable peer-reviewed journals.

Comments:

1. Page 37, the description of a deep carbonate field.
   Could you describe a general approach for deep carbonate development? Please, formulate approach peculiarities.
2. I suggest to extend the Chapter 2. A comparison between existing recovery techniques against the proposed recovery method (except a financial aspect) should be added.
3. Section 4.1, page 68. A discussion on heat losses to the surrounding formation is needed. A significant amount of injected fluid is required to reproduce experimental results at minimum heat losses. Since the rock is tight, inject of a significant amount of fluid is questionable.
4. Section 4.2.1, 4.2.2. Please clarify the impact of an injected fluid on the pore connectivity after pyrolysis. How does porosity/permeability change during the experiment?
5. In Section 4.1.3, page 74 fix the numbering of Figure 28.
6. Page 93. Please correct the numbering: "2.5.1.1Medium pressure combustion tube numerical model" to 5.3.1.2.
7. Page 93. Please, provide more details on development of the 3D digital model.
8. Page 98. Provide criteria of successful matching.
9. Chapter 5.2. A description of the economic feasibility assessment is needed.
10. Were the original reservoir properties (e.g., original porosity and permeability) preserved in the experiment (see Chapter 6)?

Carbonate reservoirs are known to have vugs and microfractures causing high rock heterogeneity. Because the final goal of the experimental studies is modeling on the field scale, a difference between actual reservoir and experimental parameters can lead to poor model performance on the field scale.

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*