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Professor of Petroleum Engineering

17/11/2022

REVIEW OF THE OFFICIAL REVIEWER

for the dissertation thesis submitted on the Requirements for the Degree of Doctor of Philosophy (Ph.D.) in Petroleum Engineering (8D07202) by Sagyndikov Marat Serikovich titled "Systematic Approach Investigation for Improving Polymer Flood Technology at the Kalamkas field"

№ n/a	Criteria	Compliance with the criteria (it is necessary to mark one of the answer options)	Justification of the official reviewer position
1.	The dissertation title (at the time of its approval) corresponds to the directions of scientific development and/or state programs	1.1 Compliance with priority directions of science development or state programs: 1) the dissertation was completed within the framework of a project or target program funded from the state budget (specify the name and number of the project or program) 2) the dissertation was completed within the framework of another state program (specify the name of the program) 3) <u>the dissertation corresponds to the priority direction of science development approved by the higher scientific and technical commission under the government of the Republic of Kazakhstan (specify the direction)</u>	This Ph.D. thesis aimed to investigate polymer flood at the Kalamkas field to develop a systematic approach for improving technology. Therefore, the title of the dissertation corresponds to the priority directions of development of science and state programs for the development of the Oil and Gas sector of the Republic of Kazakhstan.
2.	Importance to science	The work <u>makes</u> /does not make a significant contribution to science, and its importance is well <u>disclosed</u> / not disclosed	The presented results significantly contribute to the development of polymer flooding technology and improve knowledge in this field. Its importance is well disclosed in the thesis.
3.	The principle of independence	The level of independence: 1) <u>high</u> ; 2) average; 3) low; 4) there is no independence	Based on the presented thesis and my discussion with the student, I confirm that the work represents the doctoral student's personal efforts in all steps (methodology, experiments, modeling, analysis, and conclusion).
4.	The principle of internal unity	4.1 Justification of the dissertation relevance: 1) <u>justified</u> ; 2) partially justified; 3) not justified	Polymer flooding is an important EOR method that is widely used and studied in Kazakhstan. Still, there are many questions regarding the polymer solution preparation and the polymer behavior in the porous media. In this work, the author tried to answer some of these questions, which confirms the relevance of this dissertation.
		4.2 The dissertation content reflects the title of the dissertation: 1) <u>reflects</u> ; 2) partially reflects; 3) does not reflect	The content of the dissertation reflects the topic of the dissertation, and all chapters are related to the main topic.

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		<p>4.3 The purpose and objectives correspond to the title of the dissertation: 1) correspond; 2) partially correspond; 3) do not correspond</p>	<p>The formulation of the goals and objectives corresponds to the topic of the dissertation</p>
		<p>4.4 All sections and hypotheses of the dissertation are logically interrelated: 1) completely interconnected; 2) the relationship is partial; 3) there is no relationship</p>	<p>Dissertation work has an internal unity due to the set goal, setting and solving problems to achieve it. Materials are presented in a logical and systematic manner, the obtained scientific results are substantiated</p>
		<p>4.5 The new solutions proposed by the author (principles, methods) are reasoned and evaluated in comparison with the known solutions: 1) there is a critical analysis; 2) partial analysis; 3) the analysis is not author opinions, but quotes from other authors (citations)</p>	<p>The new solutions proposed by the author are argued and evaluated in comparison with the known solutions. In addition, they are justified by the positive results of the performed research.</p>
5.	The principle of scientific novelty	<p>5.1 Are the scientific results and hypotheses new? 1) completely novel; 2) partially new (25-75% are new); 3) not new (less than 25% are new)</p>	<p>The way that the author analyzed the available literature is new and very interesting. Also, the results about the degradation in the porous media and the importance of fractures add new information to the literature.</p>
		<p>5.2 Are the conclusions of the dissertation novel? 1) completely novel; 2) partially novel (25-75% are new); 3) not novel (less than 25% are new)</p>	<p>The conclusions obtained by the author are supported by the available literature and his experiments/field measurements. Hence, I believe that it is novel.</p>
		<p>5.3 Are technical, technological, economic or managerial decisions novel and justified? 1) completely novel; 2) partially novel (25-75% are novel); 3) not novel (less than 25% are novel)</p>	<p>As the author has experience in the area, he is aware of the technical, technological, and economic directions of the work. Hence, he tried to cover these aspects and I believe that it is novel and justified.</p>
6.	Validity of the main conclusions	<p>All the main conclusions are based/not based on scientifically significant evidence or are sufficiently well-founded (for qualitative research and areas of training in the arts and humanities)</p>	<p>The main conclusions of the thesis are based on valuable evidence obtained by lab/field investigations and analysis.</p>
7.	The main hypotheses submitted for defense	<p>It is necessary to answer the following questions for each hypothesis separately: 7.1 Is the position proved? 1) proved; 2) rather proven; 3) rather not proven; 4) not proven 7.2 Is it trivial? 1) yes; 2) no 7.3 Is it new? 1) yes; 2) no 7.4 Level for application: 1) narrow;</p>	<p>The hypotheses presented for the defense were proved by field, laboratory and theoretical studies. These hypotheses are new and not trivial. The results of the thesis have been published in the press and presented at international conferences. The conclusions of hypotheses can be applied industry-wide, i.e. the level of application is wide. In the first scientific position the author proved that vertical injection wells of HPAM work with fractures, which are necessary for</p>

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		<p>2) average; 3) wide 7.5 Is it proved in the article? 1) yes; 2) no</p>	<p>polymer injection. And these fractures significantly reduced the mechanical degradation of the polymer. In the second scientific position, the author confirmed that dissolved oxygen in the injected polymer solution is rapidly absorbed by the surrounding rock, thereby increasing oxidative (or chemical) stability. The third scientific position is devoted to the proof that in Kalamkas conditions the residual resistant factor (RRF) does not differ significantly from unity, i.e. there is no post effect of polymer flooding. Consequently, polymer injection should be carried out as long as the net present value (NPV) is positive. The fourth scientific proposition proves that polymer flooding under volatile oil prices is a long-term project that extends the profitable life of the field and increases oil recovery.</p>
8.	<p>The principle of reliability</p> <p>The reliability of sources and information provided</p>	<p>8.1 The choice of methodology - is justified or the methodology is described in sufficient detail: 1) yes; 2) no</p>	<p>The choice of methodology is sufficiently described and justified. The conceptual and practical foundations of the methodology were developed by the author and coordinated with scientific consultants.</p>
		<p>8.2 The results of the dissertation work were obtained using modern research methods and methods of data processing and interpretation using computer technology: 1) yes; 2) no</p>	<p>Yes. Modern and up-to-date software was used for the simulation and data analysis. Also, the tools and equipment used in the experimental part are well-known and reliable.</p>
		<p>8.3 Theoretical conclusions, models, identified relationships and patterns are proved and confirmed by experimental research (for areas of training in pedagogical sciences, the results are proved on the basis of pedagogical experiment): 1) yes; 2) no</p>	<p>Generally, I agree. Field experiments on 5 wells and laboratory experiments on core samples from the Kalamkas field were performed, where the developed methodology for studying the degradation of polymer solution was tested</p>
		<p>8.4 Important statements are confirmed/partially confirmed/not confirmed by references to relevant and reliable scientific literature</p>	<p>An interesting and valuable point of the thesis is how the author reviewed, criticized, and used the data in the literature. I believe that it can be a good model for other students.</p>

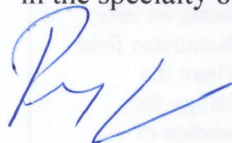
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		8.5 The literature sources used are sufficient /not sufficient for a literary review	Yes, I believe that the main sources in the literature related to the work are covered and analyzed.
9.	The principle of practical value	9.1 The thesis has theoretical significance: 1) yes ; 2) no	One of the main objectives of the thesis is to field demonstration of incorrectness of early theories: 1) that polymer injection wells necessarily operate with fractures and 2) that there is no residual resistance factor. Therefore, the thesis research has theoretical significance.
		9.2 The dissertation is of practical importance and there is a high probability of applying the results obtained in practice: 1) yes ; 2) no	The results presented in this dissertation are of great practical importance for the successful application of polymer flooding technology. There is a high probability of real application of the proposed methodology.
		9.3 Are the suggestions for practice new? 1) completely new ; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	Suggestions are new and can be applied in the fields under polymer flooding or under study for an EOR approach.
10.	Quality of writing and design	Quality of academic writing: 1) high ; 2) average; 3) below average; 4) low.	The thesis is written in acceptable scientific and technical language. I have following minor comments to improve the work: 1) On page 33 present small mistake, the word "more" should be changed to "less". 2) Calculation in Table 4.5 should be checked and corrected. 3) The source of Figure 5.3 fractional flow data should be shown. Is it from the lab or only analytically derived?

Conclusion

Ph.D. student has provided a high level of scientific research that is of high interest and contributes to the collective knowledge of the global community of petroleum engineers. Moreover, the work meets the requirements for the Ph.D. thesis. Therefore, I recommend that the author, Marat Sagyndikov, be allowed to defend his thesis because he deserves the Doctor of Philosophy (Ph.D.) in the specialty 8D07202 – Petroleum Engineering.



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