

***Research on optimizing the content of lost circulation materials for polymer mud system
drilling in the basement of Bach Ho field***

Truong Van Tu^{1,*}, Nguyen Tien Hung¹, Nguyen The Vinh¹

¹ Hanoi University of Mining and Geology, e-mail:truongvantu@humg.edu.vn

Abstract

One of the common technical problems that encountered during drilling through the fractured Basement formation at the Bach Ho field is the loss of drilling fluid. Such technical problems not only result of loss a large volume of drilling fluid but also lead to other technical issues such as: instability of the wellbore, stuck pipe, alteration of the natural permeability characteristics of the formation, etc., consequently increasing operations time and cost, and affecting future production efficiency. While the method of using polymer mud system with LCM additives is more environmentally friendly towards the production formation as it limits the volume of influx drilling fluid, it faces challenges in selection of type and optimal concentration of LCM additives. Therefore, researching the selection of LCM additives as well as their optimal concentration to mitigate drilling fluid loss in the Basement at the Bach Ho field managed by the Vietnam-Russia oil and gas joint venture Vietsovpetro is crucial and necessary. The authors of this study utilized both theoretical research methods and experimental methods in the laboratory to test various additives such as rice husk ash, coconut husk, and calcium carbonate (CaCO_3), followed by determining their suitable concentrations when added to the base drilling fluid. The research results indicate that the new drilling fluid system, after adding the studied additives at the determined concentrations by the authors, effectively mitigates drilling fluid loss. This is demonstrated through the additives' ability to seal fracture and resist fluid loss under differential pressure conditions similar to those encountered in oil fields.

Keywords: Lost circulation, Fractured basement, Tampon, Husk, Coconut fiber and Calcium carbonate.

1. Lost Circulation in Drilling Operations at the Bach Ho Field

Loss of drilling fluid while drilling through the fractured basement reservoir of the Bach Ho field is always noted at the most complex level, causing many consequences not only for the drilling process but also for the subsequent production operations since this is the largest oil reservoir of the field. Loss of drilling fluid occurs when the hydrostatic pressure in the wellbore is greater than the formation pressure, drilling through fractured zones, weak formation. In the Bach Hô filed, the fractured basement formation is located at a depth of 3000 - 5000m, with predicted pressure in the range of 300 - 400 atm., and temperatures between 120 -150°C. In the influence of these factors (especially at high temperatures), the drilling fluid invade tends to become diluted (due to the decomposition of polymers), a flow of drilling fluid into the formation, causing significant fluid loss [5,6].

The basement reservoirs with its characteristic fractures and cavities, currently has a formation pressure in the range of 0.8 to 0.9 times of the hydrostatic pressure, the bottom temperature of about 150°C. When penetrated through the basement formation, the fluid loss occurs in the varying level from partial loss to total loss. Based on the results of previous research, the authors group found that the extent of fluid loss in the fractured basement varies by region, depth, following a certain regulation and being related to geological factors such as lithological composition, tectonic destruction, etc. The level of fluid loss at the Central is much greater than that at the Northern. Specifically, fluid loss has not been occurred mainly in the Northern [2,8].

After over 30 years of production, the reservoir pressure has depleted (reaching only 0.80-0.90 of the hydrostatic pressure), leading to a more severe occurrence of drilling fluid loss in the reservoirs. Therefore, two methods are applied to kill the fluid loss including: no return

drilling methodology with using seawater and pumping lost circulation materials, which are subsequently removed by acid dissolution after drilling.

For the first method, due to the substantial amount of seawater used for no return drilling, this water will directly invade to the reservoir, affecting its natural permeability and reducing future production rates. Hence, this solution is rarely, if ever utilized. The second method, the Vietnam-Russia joint venture (Vietsovpetro) use polymer mud system with a clay content of 100-150 kg/m³ combined with lost circulation materials, such as rice husk with a content of 15-50 kg/m³. However, this method still has some limitations. For instance, the inappropriate content of rice husk may increase the risk of drill string stuck, and the ability to limit fluid loss may not be sufficiently high, with fluid losses of up to 30 thousand cubic meters and lost circulation material volumes of up to 10 thousand cubic meters per year [3,4]. Therefore, it's crucial to determine the appropriate content of lost circulation materials to ensure the required sealing ability, limit fluid loss, reduce the risk of drill string stuck, and enhance fluid loss control capability.

2. Research Methodology

The authoring team conducted material selection and experimentation on Lost Circulation Materials (LCM) as well as single-phase drilling fluid formulations at the Drilling Fluid Laboratory of the Research Institute of Petroleum Industry (NIPI). We utilized LCM test device laboratory equipment to select appropriate fluid loss prevention materials and formulate suitable single-phase drilling fluids.

The base fluid used in this experiment is bentonite, with the main components being bentonite and CMC-HV with a viscosity in the range of 100-120s [7,9]. Bentonite combined with rice husk and CaCO₃ enhances the sealing ability in lost circulation zones due to their different particle sizes and shapes (flakes, granules). The biopolymer CMC-HV possesses thermal stability to minimize clay content. Rice husk, coconut fiber, and calcium carbonate have flexible characteristics, facilitating their movement into various-sized fractures, easy decomposition by microorganisms, acid solubility, and convenience for cleaning the wellbore bottom after completion operations.

The experimental procedure was conducted following the instructions for the LCM and the method for testing drilling fluid loss prevention materials using models of fractures and steel balls [8]. The team conducted experiments with two models: models of various fractures with widths ranging from 1mm to 4mm to assess the sealing ability of the fluid; and hollow models created by steel balls in the casing with diameters of 4.39mm and maximum permeability of K = 200 Darcy, and 14.3mm with maximum permeability of K = 2000 Darcy to evaluate sealing and leakage prevention capabilities.

For the experimental steps involving fractures model, the team varied the concentrations of rice husk as lost circulation materials from 5-40 g/l, and coconut fiber from 5-10 g/l. For the experimental step with hollows model, we varied the concentration and type of CaCO₃ as presented in Table 3. The experiments were conducted at room temperature conditions, with pressure differentials ranging from 0.69 to 6.9 MPa.

3. Results and Discussion

After conducting experiments with fractures model, the team recorded, statistically analyzed, synthesized, and presented the results obtained in figure 1 and figure 2. The results of experiments with fracture model:

- For the 3 fracture model with sizes of 1, 2, and 3mm, with drilling fluid samples containing only rice husk at concentrations ranging from 5-40 g/l, no bridging material formed in the fractures (see Figure 1).

- For the 4 fracture model with sizes of 1, 2, 3, and 4mm, when coconut fiber was added at concentrations ranging from 5-10 g/l while maintaining rice husk concentration at 5 g/l,

bridging materials began to form. However, when the coconut fiber concentration was increased to 10 g/l, no bridging materials were formed (see Figure 1).

- For the 3 fracture model with sizes of 1, 2, and 3mm, when adjusting the rice husk concentration to 10 g/l and coconut fiber concentration to 5 g/l, bridging materials began to form in the fractures under a pressure differential of 0.69 MPa, and completely bridged the fractures under a pressure differential of 6.9 MPa (see Figure 2).

- For the fracture model with a size of 4mm, with rice husk concentration of 10 g/l and coconut fiber concentration of 5 g/l, bridging materials began to form under a pressure differential of 1.5 MPa, but these bridging materials were destroyed under a pressure differential of 4.0 MPa (see Figure 2).

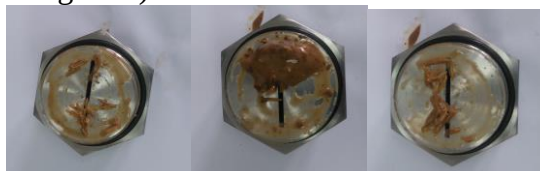


Figure 1. No bridging material formed in the fractures



Figure 2. Bridging material formed in the fractures

The experiments results indicated that, for small fractures ranging from 1 to 3 mm, the bridging materials remained intact under high pressure differentials and high permeability conditions. However, for fractures with a width of 4 mm, these bridging materials were disrupted under high pressure differentials (>4.0 MPa) and high permeability conditions.

Therefore, we conducted additional experiments by adding different types of CaCO_3 (C, M, F) to enhance the sealing ability of the bridging layer, thus increasing the fluid loss prevention capability of the base fluid. By adding these types of CaCO_3 to the above-mentioned fluid, the varied particle sizes (ranging from 10 to 1000 μm) and shapes (granules, flakes) of CaCO_3 increased the bridging and sealing ability of the base fluid in crack networks. The results of the experiments testing the sealing ability of the fluid after the addition of various types of CaCO_3 are presented in figure 3. The results of experiments with hollow models created by steel balls indicate:

- For the hollow model created by steel balls with a diameter of $D = 4.39$ mm, no bridging materials were formed and the sealing capability was low for drilling fluid samples containing only coconut fiber and rice husk.

- When various types of CaCO_3 were added at different concentrations, the formation of bridging materials and increased sealing capability were observed (Figure 3) when coconut fiber and CaCO_3 were added at precise concentrations: 60 g/l of type M CaCO_3 , 40 g/l of type C CaCO_3 , and 20 g/l of coconut fiber.

- For the hollow model built by steel balls with a diameter of $D = 14.3$ mm, equivalent to a permeability of 500 Darcy, no bridging materials were formed, and the sealing capability was very low even after various concentrations of bridging materials were added.



Figure 3. Modeling using steel balls with a diameter of 4.39 mm

Therefore, based on the results of the two experiments, the authors observed that the environments have porosity with widths in the range of 1 mm to 4 mm, permeability ranging from 35 to 140 Darcy, to enhance the waterproofing and sealing capability, only adding rice husk and coconut fiber with concentrations of: 10 g/l rice husk and 5 g/l coconut fiber is necessary. For reservoir have porosity with permeability ranging from 200 to 500 Darcy, to increase the waterproofing capability of the drilling fluid, it is necessary to additionally add coconut fiber with a concentration of 20 g/l and various types of CaCO_3 with concentrations: Type M CaCO_3 60 g/l, Type C CaCO_3 40 g/l.

4. Conclusion and Recommendations

Based on the analyses and experimental results, the authors propose the following conclusions and recommendations:

- For fracture zones with crack widths ranging from 1 to 4 mm and permeability from 35 to 140 Darcy, the authors suggest using a polymer bentonite solution containing LCM with the following concentrations and types: 10 g/l rice husk and 5 g/l coconut fiber.
- For fracture zones with permeability ranging from 200-500 Darcy, the recommended solution is a polymer bentonite solution containing LCM with the following concentrations and types: 60 g/l Type M CaCO_3 , 40 g/l Type C CaCO_3 , and 20 g/l coconut fiber.
- For fracture zones with permeability above 500 Darcy, using a polymer bentonite solution containing LCM is deemed unfeasible and ineffective. The authors propose researching alternative modern drilling methods that do not compromise the natural permeability characteristics of the formation.

References

1. Report on technology diagram for adjusting exploitation and construction of Bach Ho field, 2013. Volume I, III, Vietnam - Russia oil and gas joint venture.
2. Nguyen Lam Anh, Tran Xuan Dao, 2018. *Oil and gas exploration and exploitation in basement rock of Bach Ho field - Volume 2 Drilling technology and Exploitation technology*, Ho Chi Minh City National University Publishing House, 347 pp.
3. Tran Xuan Dao, Nguyen Thanh Truong, Nguyen Quoc Phong, Vu Van Hung, 2008. *Summary report on drilling work in fractured basement rock of Bach Ho field- Vietsopetro*, Vung Tau.
4. Nguyen Van Khuong, 2015. *Research to perfect drilling technology for wells in Bach Ho field fracture foundation using drill bits smaller than 7 inches*, Doctoral thesis.
5. Конесев Г.В., Мавлютов М.Р., Спивак А.И., Мулюков Р.А., 1993. *Смазочное действие сред в буровой технологии*. Недра, Москва, -272 с.
6. Рязанов Я.А., 2005. *Энциклопедия по буровым растворам*. Оренбург: «Летопись», -664 с.
7. VSP-000-PK-637, 2016. *Регламент буровых растворов при проводке скважин на месторождениях СП Вьетсовпетро*.
8. Отчёт о научно-исследовательской работе тема IV.1, 2017. *Совершенствование существующих и внедрение новых технологий строительства и КРС*, Вунгтау, VSP.
9. РД VSP-000-PK-650, 2017. *Технические требования к качеству и основные методики проведения лабораторных испытаний химических реагентов и материалов для бурения, капитального ремонта и кислотной ОПЗ скважин в СП Вьетсовпетро*.