RGNZ/MGPB

A Review on Glycerol-Based Drilling Fluids and Glycerine as a Drilling Fluid Additive

Rudarsko-geološko-naftni zbornik
(The Mining-Geology-Petroleum Engineering Bulletin)
UDC: 622.3:553.9
DOI: 10.17794/rgn.2024.1.8

Review scientific paper

A. Momeni [1], S. Sh. Tabatabaee Moradi [*,2], S. A. Tabatabaei Nejad [3]

[1] *Faculty of Petroleum and Natural Gas Engineering, Sahand Oil and Gas Research institute, Sahand University of Technology, Tabriz, Iran, ORCID: 0000-0001-7789-1217*

[2] *Faculty of Petroleum and Natural Gas Engineering, Sahand Oil and Gas Research institute, Sahand University of Technology, Tabriz, Iran, ORCID: 0000-0002-1484-6926*

[3] *Faculty of Petroleum and Natural Gas Engineering, Sahand Oil and Gas Research institute, Sahand University of Technology, Tabriz, Iran*

Abstract

A significant increase of energy demands all over the world and production decline from available oil and gas reservoirs have led the industry to invest in major offshore petroleum resources. However, drilling operations in offshore environments are usually restricted by environmental constraints. Therefore, recent studies are devoted to the development of environmentally compatible fluids with adequate technical properties. Glycerine is a non-toxic, lubricating, colorless, odorless substance with a higher density than water. Due to the properties of glycerine, it can be used as the base of drilling fluid to formulate synthetic-based fluids. This research aimed to review the studies on the applications of glycerine in the composition of drilling fluid. Based on the results, glycerine-based fluids can be considered as an environmentally compatible fluid with sufficient technical properties to replace other drilling fluids. However, there is a lack of experimental studies on the glycerine fluid properties for a reliable decision. For the application of glycerine fluids, an economic feasibility study is mandatory for both pure and crude glycerine. Also, the thermal stability of glycerine fluids is an important aspect, which should be covered in future research studies.

Keywords:
glycerine; drilling fluid; offshore drilling; synthetic based mud; drilling fluid properties; lubricity

1. Introduction

Drilling fluids are used in the construction of oil and gas wells to control subsurface formation pressure, provide wellbore stability, clean the hole from drilled rock cuttings, cool the bit, transform fluid hydraulic power to the bit, and lubricate the drill string. Based on the type of continuous phase, drilling fluids are usually classified as water-based fluids (WBF), oil-based fluids (OBF), synthetic-based fluids (SBF) and pneumatic drilling fluid systems (**Caenn & Chillingar, 1996; Choupani et al., 2022; Khodja et al., 2010**).

A major challenge in the drilling industry is to design an optimal drilling fluid composition to meet the geological and technical requirements (**Bloemendal, 1978**). The design of drilling fluid composition is based on the standard screening and testing procedures, where many factors such as formation rock type, bottom-hole pressure and temperature, well path trajectory, economic limits and environmental constraints are considered. Optimization of drilling fluid composition is a significant task in the well planning phase, as many drilling problems, such as stuck pipe, wellbore instability, lost circulation, formation damage, decreased rate of penetration and clay swelling are directly or indirectly related to the composition and properties of the drilling fluid (**Jiao & Sharma, 1994; Sharma & Wunderlich, 1987**).

WBFs are the mostly used fluid in the industry, as they are cheaper, non-toxic and non-harming to the environment (**Choupani et al., 2022**). However, the application of WBFs is limited at high-pressure, high-temperature (HPHT) conditions, in shale formations with swellable clay content and in wells with complex trajectories, where extreme lubricating ability of fluids are required (**Gandelman et al., 2007; Lijuan et al., 2020; Martins et al., 2007**). At HPHT conditions, WBFs are instable and may have insufficient technical properties for a successful drilling operation. In shale formations or any other formation with high clay content, clay swells in contact with water. This leads to further instability problems at the wellbore wall. In directional and horizontal wells, where a complex geometry is expected, fluids with high lubrication ability is required, where WBFs may not be the most promising choice. In these cases, one may suggest the application of OBFs, which are

Corresponding author: S. Sh. Tabatabaee Moradi
e-mail address: s.sh.tabatabaee@gmail.com

thermally stable, inherently lubricant and inhibitive of clay swelling. However, due to the presence of dispersed oils, aromatics, alkyl phenols, normal-olefins, and heavy metals, OBFs are toxic and may cause significant adverse effects on the environment, which restrict their applications (**Amanullah et al., 2016; Li et al., 2016; Yang et al., 2017**).

In this regard, the industry requires the development of environmentally compatible fluids with technical advantageous of OBFs to meet the higher technical requirements of drilling in hostile environments (**Friedheim et al., 2001; Rae & Di Lullo, 2001**). SBFs have been developed as a response to the industry's demand and to combine the benefits of OBFs and WBFs (**Daya et al., 2016; Young et al., 2012**). SBFs are prepared based on vegetable oils, ester-based oils, synthetic paraffins, polyalpha-hydrocarbons, isomerized olefins, and linear alpha olefins. However, these fluids are usually costly compared to WBFs and OBFs. Therefore, their application may be significantly dependent on the results of economic feasibility studies (**Benjumea et al., 2008; Burrows et al., 2001; Lin, 1997; Marbun, Hutapea, et al., 2013; Mueller et al., 1990; Setyawan et al., 2011; Sulaimon et al., 2017**).

Attempts have been made to develop drilling fluids based on other economically feasible materials that have promising technological characteristics (**Ahmed et al., 2021; Chai et al., 2015; Medhi et al., 2019; Sharma et al., 2012; Vryzas & Kelessidis, 2017**).

One of the materials that has been considered for use in recent years as the basis of a drilling fluid is glycerine. Glycerine is a non-toxic, lubricating, odorless, colorless and environmentally safe substance with a higher density than water (**Mahrova et al., 2015; Ondul & Dizge, 2014; Singhabhandhu & Tezuka, 2010**).

In this paper, a summary of the latest studies on drilling fluid compositions with glycerine content are presented to reveal the possible strengths and weaknesses of these compositions in the drilling process. The literature review is divided into two parts. In the first section, the application of glycerine as the drilling fluid additive is investigated. Then, in the second section, glycerine-based drilling fluids (GBFs) are reviewed, where glycerine is applied as the continuous phase of the drilling fluid.

2. Glycerine

Glycerine (1,2,3-propantriol) is an odorless, colorless, sweet-tasting viscous liquid, which can be obtained from natural and petrochemical raw materials. The name "glycerol" is derived from the Greek word sweet. The expressions glycerine, glycerin, and glycerol are used interchangeably in the literature. In fact, glycerine or glycerin is a commercial solution of glycerol and water with glycerol as the main component. The purity of crude glycerol is between 70-80%, reaching to 95.5-99% for commercial sale (**Garcia et al., 2008; Meher et al., 2006; Pagliaro & Rossi, 2008**).

Glycerol is a by-product of the vegetable oil (triglyceride) process for biodiesel production (see **Figure 1**). After transesterification, glycerol is separated due to the density difference (**Soomro et al., 2020**). **Table 1** presents the physicochemical properties of glycerol at 20°C, which is known as a standard reference temperature in scientific studies to ensure the consistency and comparability of data (**Pagliaro & Rossi, 2008**).

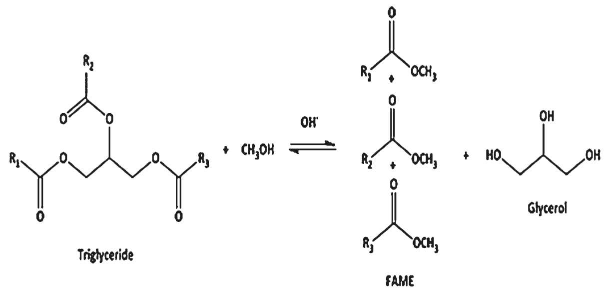

Figure 1: Transesterification of triglycerides with methanol for biodiesel production (**Mota et al., 2017**).

Glycerine has been found to have several applications in the oil and gas industry, including but not limited to the dehydration of carbon dioxide, production of methane and hydrogen with steam gasification of glycerine, hydraulic fracturing, well cementing operations, completion fluid applications, and enhanced oil recovery (EOR) applications. EOR methods are usually applied to provide additional energy for more petroleum production, when primary and secondary methods fall short. (**Ahmad et al., 2021; AlTammar et al., 2020; Curbelo et al., 2018; Ferreira et al., 2018; Román Suero et al., 2015; Toczek et al., 2023; Wallace et al., 2010; Wu et al., 2008**).

Table 1: Physico-chemical properties of glycerol at 20°C (**Pagliaro & Rossi, 2008**).

Chemical formula	$C_3H_5(OH)_3$
Density	1.261 g/cm^3
Molecular mass	92.09382 g/mol
Surface tension	64.00 mN/m
Viscosity	1.5 Pa.s
Flashpoint	160°C
Melting point	18.2°C
Boiling point	290°C
Food energy	4.32 kcal/g

3. Application of Glycerine in Drilling Fluid

A survey on glycerine applications in drilling fluids reveals that glycerine has been used in experimental and

Copyright held(s) by author(s), publishing rights belongs to publisher, pp. 87-99, DOI: 10.17794/rgn.2024.1.8

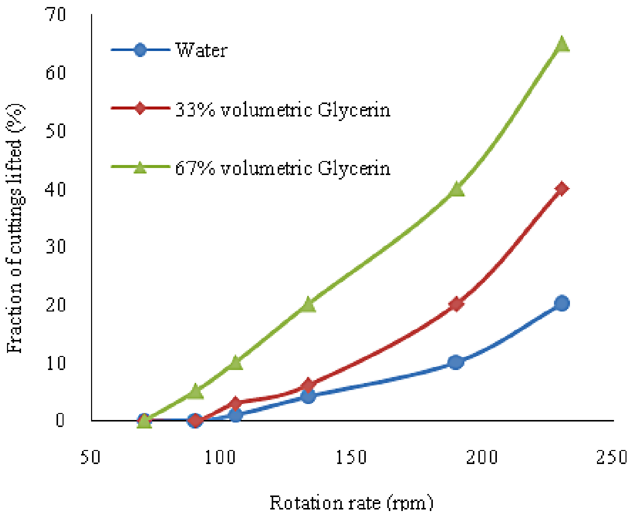

Figure 2: Effect of glycerine addition on cutting lifting capacity (**Philip et al., 1998**).

field studies in two ways as: 1) an additive to a drilling fluid to enhance the technical performance, 2) the base of drilling fluid to replace OBFs. In following sections, a comprehensive literature review on these two applications are presented.

3.1. Application of Glycerine as an Additive to Drilling Fluids

In 1964, Cheatham et al. conducted research on the cutting transport of water and water/glycerine drilling fluids. In their experimental research, the authors tried to investigate the effects of cutting size, flow rate, nozzle size and fluid viscosity on the cutting transport. Glycerine was used to develop fluids with different viscosities and finally investigate the effect of viscosity on the cutting transport process. Since the viscosities of water and glycerine are different, changing the water/glycerin ratio

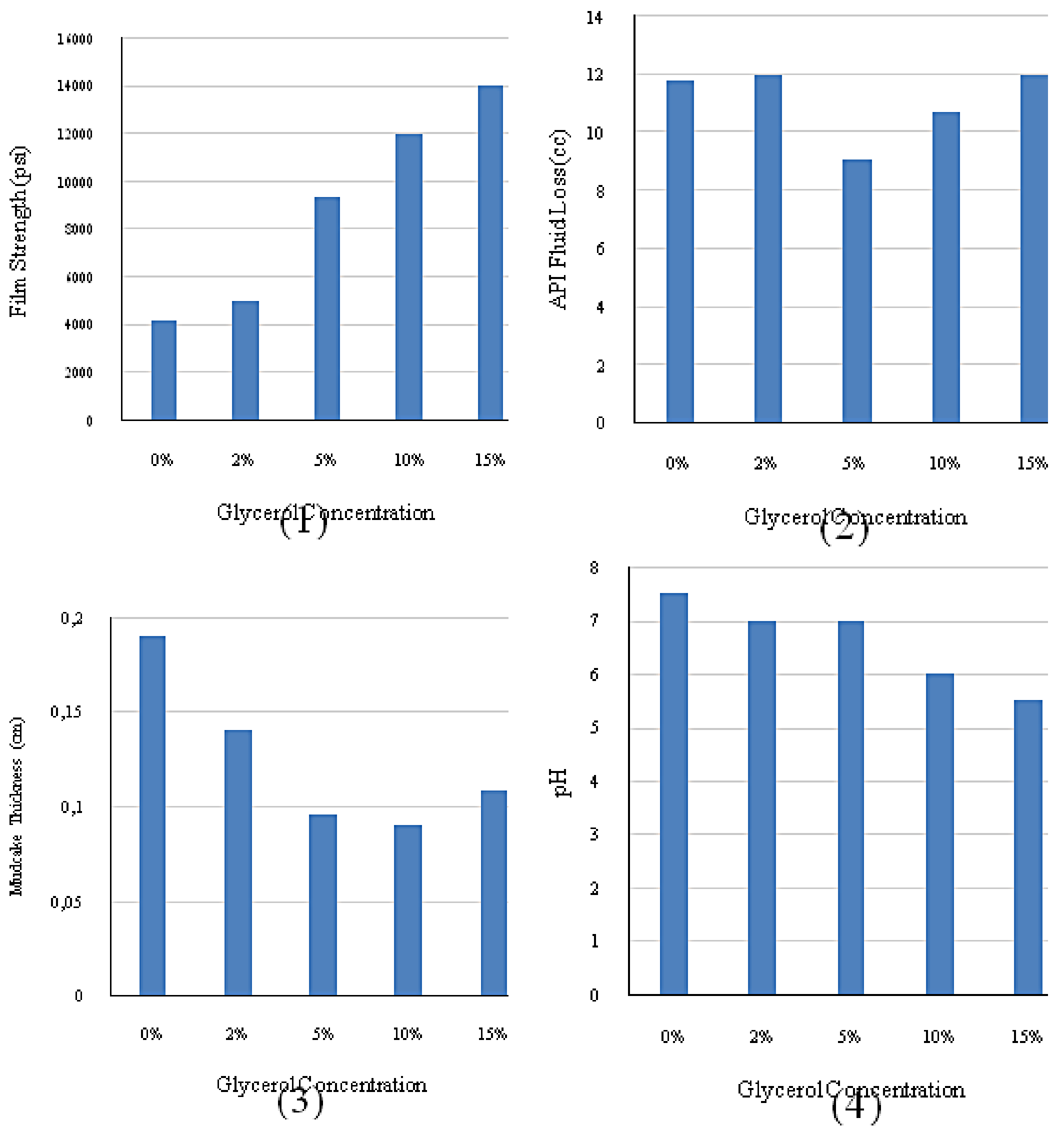

Figure 3: The effect of glycerine as an additive on the drilling fluid properties (1) lubrication properties (2) API fluid loss (3) mud cake thickness (4) pH according to **Marbun et al. (2013)**.

Copyright held(s) by author(s), publishing rights belongs to publisher, pp. 87-99, DOI: 10.17794/rgn.2024.1.8

in the mixture results in viscosity changes of the mixture. Furthermore, viscosity is a critical parameter affecting cutting transport efficiency. In the study by Cheatham et al., it is mentioned that glycerin was mixed with water to modify the viscosity for some tests. However, the study did not specifically investigate how the viscosity was altered as a result of the glycerin addition (**Cheatham Jr & Yarbrough, 1964**).

In the paper of Chenevert, it was stated that the use of glycerine as a drilling fluid additive in WBFs prevents the swelling of shale formations. The author noted that the drilling fluid with glycerine is environmentally friendly (**Chenevert, 1989**).

In 1998, Philip et al. applied the theory of Taylor's vortices to investigate the efficiency of cutting transport in the annular space. In their experiments, they used water, polymer and glycerine to develop different drilling fluid compositions. The results of experiments on glycerine-water solutions confirmed their more efficient cutting transport in comparison with water and polymer fluids. **Figure 2** presents the fraction of lifted cuttings versus rotational speeds, where vortices were formed, for water and glycerine-water fluids. As can be seen, an increase in glycerine volumetric concentration leads to a more efficient cutting transport (**Philip et al., 1998**).

In an experimental study by **Marbun et al. (2013)**, glycerine was added in different concentrations from 0 to 15%, to the drilling fluid and the main properties of WBFs were investigated. The results showed that glycerine could significantly improve lubricating properties, however, the use of this substance reduced the pH of drilling fluid which is undesirable and subsequently may lead to the poor rheological performance of the fluid. The detailed results about the glycerine effect on drilling fluid properties can be seen in **Figure 3** (**Nickdel Teymoori & Ghasem Alaskari, 2007**).

In 2018, Malgaresi et al. proposed a new composition of drilling fluid by replacing 50% of the water in the WBF with raw glycerine. In the conclusions, the authors claimed that the new GBF had advantages over the customary WBM, such as less filtration volume (see **Figure 4**) (**Malgaresi et al., 2018**).

Ribeiro Filho et al. (2020) described glycerine as a suitable additive in the compositions of WBFs due to its non-toxicity and solubility in water. In the experimental tests, the performance of a common drilling fluid composition applied in Brazilian oilfield was compared with WBFs having a glycerine additive (see **Table 2**). The effect of glycerine on drilling fluid properties is shown in

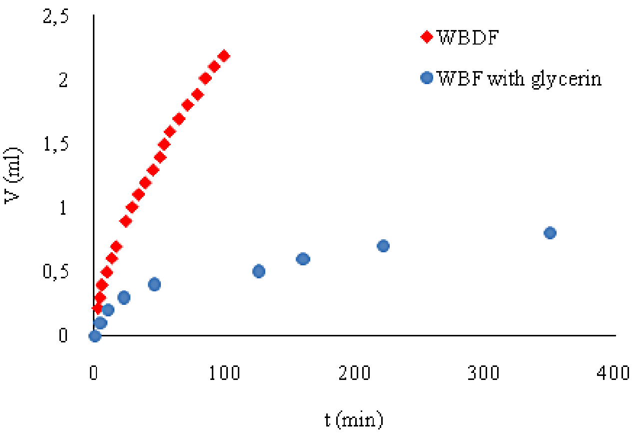

Figure 4: Dynamic filtration volume of WBF (Red) and WBF with glycerine (Blue) (**Malgaresi et al., 2018**).

Table 2: Composition of proposed drilling fluids according to **Ribeiro Filho et al. (2020)**

Substances	Function	Base fluid	Adding glycerine to base fluid			
			5 %	10%	15%	20 %
Water, v/v%	Continuous phase	49	44	39	34	29
Bi-distilled glycerine, v/v%	Continuous phase	0	5	10	15	20
Saturated sodium chloride brine, v/v%	Continuous phase	40	40	40	40	40
Sodium bicarbonate, g/L	Hardness removal	0.57	0.57	0.57	0.57	0.57
Polydimethylsiloxane, g/L	Defoamer	0.57	0.57	0.57	0.57	0.57
Xanthan gum, g/L	Viscosifier	2.28	1.43	1.43	1.43	1.43; 1.71
Polyanionic cellulose - low Viscosity,g/L	Filtration control agent	5.70	5.70	5.70	5.70	5.70
Hydroxypropyl starch, g/L	Filtration control agent	11.41	11.41	11.41	11.41	11.41
Magnesium oxide, g/L	Alkaline agent	1.42	1.42	1.42	1.42	1.42
Potassium chloride, g/L	Shale inhibitor	42.80	42.80	42.80	42.80	42.80
Polyamine, g/L	Swelling agent	17.12	17.12	17.12	17.12	17.12
Glutaraldehyde, g/L	Biocide	0.85	0.85	0.85	0.85	0.85
Calcium carbonate, g/L	Weighting / bridging agent	114.12	114.12	99.86	85.59	71.32
Polyol ester oil, g/L	Bit balling preventer	0.85	0.85	0.85	0.85	0.85
Polyethylene glycol oleate, g/L	Lubricant	14.26	14.26	14.26	14.26	14.26
Sodium silicate, g/L	Corrosion inhibitor	2.28	2.28	2.28	2.28	2.28

Table 3: Comparison of target values and values obtained from experiments according to **Ribeiro Filho et al. (2020)**

Properties	Reference values*	Base Fluid	Adding glycerine to base fluid				
			5%	10%	15%	20% + 1.43 g/l XG	20% + 1.71 g/l XG
Plastic Viscosity cP	15-40	26	21	26	27	29	34
Yield Point lb/100ft^2	15-40	29	17	26	27	28	33
Gel Strength (10s) lb/100ft^2	7-15	6	2	4	4	5	6
Gel Strength (10min) lb/100ft^2	8-25	7	4	6	5	6	7
L3, rpm	7-10	6	3	5	4	4	6
Fluid Density, ppg	9.8 -10.2	9.8	9.9	10	10.2	10.1	10.1

* According to fluid used in operation

Table 4: Summary of studies on glycerine as an additive.

Authors	Year	Studied parameters	Results
Cheatham et al. [43]	1964	- Cutting transport was investigated. - Water and water/glycerine mixture used as drilling fluids in the experiments. - Effect of cutting size, flow rate, jet size, and fluid viscosity was investigated.	Glycerine used as an additive to modify the viscosity.
Chenevert [44]	1989	- Glycerine as a clay swelling inhibitor was investigated.	Glycerine could improve inhibition properties of the drilling fluid. Drilling fluid with glycerine is environmentally friendly. Limitation: The cost of glycerine may limit its application.
Philip et al. [45]	1998	- Investigation of Taylor's vortices effect on cutting transport efficiency. - 33% glycerine in water and 67% glycerine in water fluids with Newtonian rheological behaviour was developed.	Cutting transport efficiency increased with an increase in viscosity.
Marbun et al. [47]	2013	- Effect of glycerol on drilling fluid properties was investigated. - Studied parameters: lubricity, plastic viscosity, yield point, gel strength, density, filtration, and acidity.	Glycerine addition resulted in: - improvement of lubricity and filtration properties - reduction of PV and YP - pH reduction.
Malgaresi et al. [49]	2018	- A new drilling fluid was developed by replacing half of the water with glycerine. - Core floods were performed to test the new drilling fluid.	Glycerine addition resulted in: - Less filtrate volume. - Less time for the filter-cake buildup.
Ribeiro et al. [50]	2020	- The performance of a common drilling fluid composition was compared with WBFs having glycerine additive.	Glycerine addition resulted in the improvement of plastic viscosity, yield point, and gel strength
Zhao et al. [51]	2022	- Different type of lubricants for environmentally friendly WBF.	Glycerol and polyglycerol are not only effective in the lubrication properties of WBF, but also lead to the improvement of wellbore stability.
Celino et al. [52]	2022	- Introduction of a new formula for the inverse emulsion of glycerine in olefin. - The rheological properties of new mud formulation such as PV, YP, and thixotropy was investigated. - Experimental tests were performed in a variety of pressure and temperature conditions.	In a variety of tested pressure and temperature conditions, glycerine preserves the common NaCl rheological properties.

Table 3. Based on the results, the authors claimed that in most properties, the performance of new formulations, were better than conventional drilling fluid.

In 2022, Zhao et al. published a review paper on various types of environmentally friendly lubricants. In their paper, it is mentioned that glycerol and polyglycerol as additives to the drilling fluid composition are effective in the improvement of WBF lubrication properties and the wellbore wall stability (**Zhao et al., 2022**).

Celino et al. (2022) proposed a new formula for the inverse emulsion of glycerine in olefin. They investigated the rheological properties, i.e. plastic viscosity, yield stress, and thixotropy of their olefin-based fluids at different temperatures and pressures. The results showed that fluids with a crude glycerine additive had satisfactory rheological properties at different temperatures and NaCl concentrations.

Table 4 summarizes the main studies on the drilling fluids with a glycerine additive.

3.2. Application of Glycerol as the Base of Drilling Fluid

The earliest application of glycerine as the fluid base in drilling fluid dates back to 1951, where Williams and his co-worker studied the cutting transport ability of different drilling fluids. Conducting both laboratory and field tests, the authors tried to establish the minimum flow rate of water and glycerine drilling fluids for an efficient cutting transport. In laboratory tests, glass balls and metal discs were used as drilling cuttings. The results showed that in the case of glycerine drilling fluids, cutting behaviour was independent of its dimension, while for WBFs, a behaviour similar to leaf falling was reported (**Williams & Bruce, 1951**).

In 1992, Oakley et al. referring to the possible environmental threats of OBFs in the drilling operations, proposed a GBF as a candidate replacement with no adverse effect on the environment. The authors also showed that the inhibitive characteristics of GBFs for drilling clay-rich formations is comparable to OBFs and traditional inhibitive KCl fluids (**Oakley et al., 1992**).

Ismail et al. (2001) investigated the effects of flow rate, annular fluid velocity, fluid viscosity and cuttings geometry on the cutting transport ability of drilling fluid in directional wells. The authors suggested the use of glycerine instead of actual drilling fluid since the viscosity of glycerine solutions could be easily adjusted during experiments. Although this research is not exactly about the GBFs, however, the results can be used as a guidance for further studies. For example, the results showed that an increase in the plastic viscosity of GBF from 25 to 138 cp, leads to less efficient cutting transport. The laboratory rig, used in the study, is presented in **Figure 5**.

In the research of **Waldmann et al. (2005)** a GBF with Newtonian rheological behaviour was developed to study the fluid filtration properties, i.e. filtrate volume

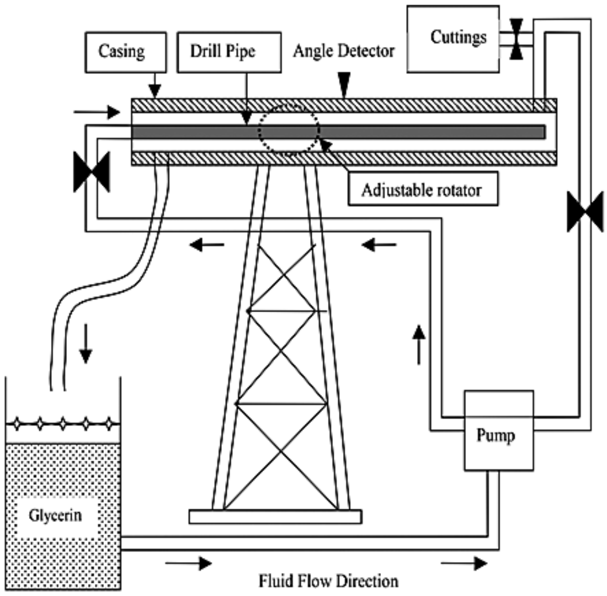

Figure 5: Laboratory rig used for the investigation of cutting transport OF GBF (**Ismail et al., 2001**).

and invasion depth. The fluid was composed of 80% glycerine and 20% water. In the conclusions, the authors emphasize the significant role of mud cake permeability in filtrate invasion control. This research is not exactly about GBFs. The authors used glycerine to ensure a Newtonian rheological behaviour. Despite the fact that only Newtonian fluids were investigated in this research, there are other rheological models such as Herschel-Bulkley, Bingham, Hahn-Eyring, and Vom-Berg that could be fitted to the experimental results (**Wiśniowski et al., 2022**).

In 2013, Marbun et al. stated that glycerine could be used as an SBM with certain additives. In their experimental study, they used additives such as an emulsifier (primary and secondary), filtration control additive, viscosifying agent, KCl, and lime for the formulation of GBF. **Table 5** presents the composition of developed GBFs in the study (**Marbun, Aristya, et al., 2013**).

The authors showed that due to the high solubility of glycerol in water, the viscosity of the GBF is low and a viscosifying agent is required. On the other hand, the

Table 5: Composition of GBF according to **Marbun, Aristya, et al. (2013)**.

Mud Components	Glycerol
Base Fluid (ml)	273
Primary Emulsifier (ml)	3
Secondary Emulsifier (ml)	2
Duratone (ppb)	4
Lime (ppb)	5
KC1 (ppb)	17
Water (ml)	70
Geltone (ppb)	6

 pp. 87-99, DOI: 10.17794/rgn.2024.1.8

experimental results indicated low gel strength, which may lead to a low suspension capacity of the cuttings in the system. In this type of drilling fluid, hot rolling leads to a decrease in viscosity, while according to the studies of Marbun et al., this factor improves the gel strength and suspension properties of a mud system. **Table 6** summarizes the rheological measurements on the GBF before and after hot rolling. **Marbun et al. (2013)** also investigated the effect of glycerol as an additive to WBFs. The results of their research were presented in the previous section.

Table 6: Rheological properties of GBF before and after hot rolling **(Marbun, Aristya, et al., 2013)**.

Parameters	Glycerol	
	BHR	AHR
Viscometer dial reading at 600 rpm	42	25
Viscometer dial reading at 300 rpm	24	20
Viscometer dial reading at 200 rpm	16	17
Viscometer dial reading at 100 rpm	9	10
Viscometer dial reading at 6 rpm	2	5
Viscometer dial reading at 3 rpm	2	3
10 sec, lb/100sqft	2	8
10 min, lb/100sqft	4	11
PV, cp	18	5
YP, lb/l00 sqft	6	15

In 2019, Pacheco et al. investigated operational problems in the drilling of salt layers. The authors stated that salt dissolution may severely alter drilling fluid properties, which in turn leads to costly operational challenges. Therefore, in their study, the kinetics of NaCl dissolution in drilling fluids containing crude and pure glycerine were investigated. The compositions of the investigated drilling fluids are presented in **Table 7** (**Pacheco et al., 2019**).

Table 7: Composition of GBF according to **Pacheco et al. (2019)**.

	1	2	3[a]	4	5	6	7	8	9	10[a]
Glycerine (mL)	0	200	200	240	280	320	360	380	400	400
Deionized Water (mL)	400	200	200	160	120	80	40	20	0	0
Glycerine/water Ratio	0:100	50:50	50:50	60:40	70:30	80:20	90:10	95:05	100:0	100:0

[a] Fluids prepared with crude glycerine

The authors performed dissolution kinetic tests to study the effect of glycerine on the NaCl solubility. The results showed that in fluids with pure glycerine, a faster reduction of the NaCl mean diameter was observed, which indicates a faster salt dissolution. However, in the case of crude glycerine, the dissolution was slower due to the presence of impurities (see **Figure 6**) **(Pacheco et al., 2019)**.

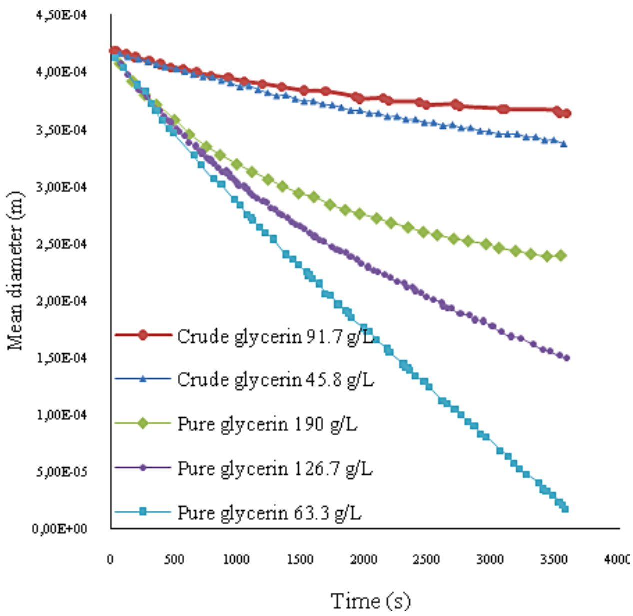

Figure 6: Comparison of mean diameter for fluids formulated with pure and crude glycerine **(Pacheco et al., 2019)**.

Soares et al. (2020) developed two types of drilling fluids: WBFs and GBFs with calcium carbonate ($CaCO_3$) and a glass sphere as a lost circulation material (LCM). They proposed a methodology for the determination of mud cake properties (porosity and permeability) in static filtration tests to evaluate the effects of fluid composition, LCM type, LCM size and concentration on the filtration properties of the drilling fluids. The compositions of GBFs are presented in **Table 8**.

Table 9 shows the filtration volume of GBFs in the static filtration tests. As can be seen, in the case of glass spheres, the filtration volume is almost the same. The authors related this result with fluidity of the glycerine, where glycerine dragged the spheres together with the filtrate. The results also show that fluids with $CaCO_3$ had lower filtration volume, as $CaCO_3$ particles are usually uneven, leading to the creation of blockages between the edges and faces, creating greater resistance to flow (**Ali et al., 2022; Soares et al., 2020**).

Duarte et al. (2021) experimentally investigated the solubility of gas in GBFs. The authors highlighted that gas solubility in synthetic and oil-based fluids is a major problem in well control, where kick detection becomes a challenge. Their experimental study included the investigation of rheological and PVT properties to analyze methane saturation pressure, density variation (see **Figure 7**) and the fluid formation volume factor at different

Table 8: Formulation of GBFs (**Soares et al., 2020**).

Fluid	Glycerine: Water (L)	LCM Additive		
		Type	Size (µm)	Amount (g)
Fluid 1	0.475: 0.025	Glass spheres	15 < Dp < 75	145.83
Fluid 2	0.475: 0.025	Glass spheres	180 < Dp < 300	145.83
Fluid 3	0.475: 0.025	$CaCO_3$	0 < Dp < 53	137.25
Fluid 4	0.475: 0.025	$CaCO_3$	0 < Dp < 106	137.25
Fluid 5	0.475: 0.025	$CaCO_3$	0 < Dp < 150	137.25

Table 9: Static filtration data for GBFs formulation of **Table 7** (**Soares et al., 2020**).

Fluid	Filtrate volume	Pressure (psi)	Time (min)
Fluid 1	113.50 ±0.09	500	00:06
Fluid 2	124.70 ± 0.07	500	00:06
Fluid 3	86.71 ± 0.08	500	00:20
Fluid 4	69.91 ± 0.09	500	00:20
Fluid 5	84.44 ± 0.08	500	00:20

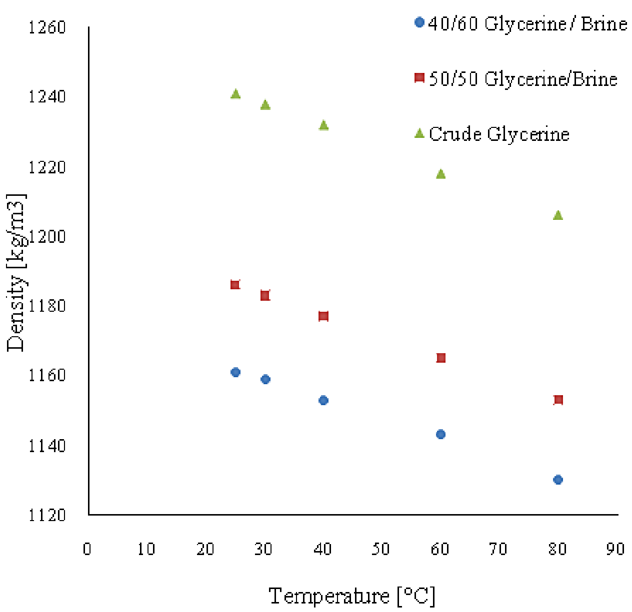

Figure 7: Density vs. temperature for three different GBFs at 1 atm (**Duarte et al., 2021**).

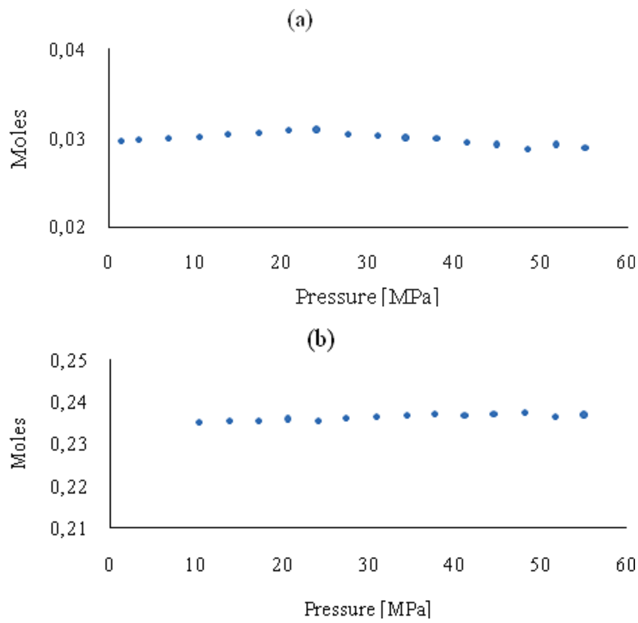

Figure 8: Moles of methane in the mixture with crude glycerine at 20°C: (a) 10% of methane, (b) 50% of methane (**Duarte et al., 2021**).

temperatures. They used crude glycerine, 50% glycerine – 50% brine and 40% glycerine – 60% brine as drilling fluid samples.

Figure 8 shows the moles of methane in the methane-crude glycerine mixture at room temperature. As can be seen, the solubility of the methane in glycerine is minimal and almost is the same at different pressures. With respect to well challenges, especially in slime deep holes, this result is promising (**Duarte et al., 2021**).

In the paper of **Lyu et al. (2021)** the inhibitive characteristic of GBFs with a mix of nano-silica, organic soil, KCl, polymer and surfactant was experimentally studied. Based on the results, the following composition of drilling fluid had the best performance in shale inhibition: 55:45 glycerine water ratio, 0.5% nanosilica, 0.4% xanthan gum and 0.9% Na-CMC.

Issoufou et al. (2021) conducted an experimental study on the estimation of the cuttings settling speed in different drilling fluids. They used water and glycerine with different weight percentages as drilling fluid. Based on the results, the authors developed a new relation for cutting settling velocity prediction for solid-liquid and solid-liquid-gas flows. In their research, glycerine was used with water to develop a drilling fluid with Newtonian rheological behaviour.

In 2023, Rasool et al. (**Rasool, Ahmad, Siddiqui, et al., 2023**) introduced the new environmentally friendly calcium chloride and glycerine based drilling fluid with a ratio of 1:4. In their studies, the rheological properties and shale swelling inhibition of drilling fluids were investigated. The results showed that the developed drilling fluid compositions provided satisfactory gel strength. Also, in other papers they showed that these types of drilling fluids exhibit good inhibition performance in shale formations (**Rasool & Ahmad, 2023; Rasool, Ahmad, Ayoub, et al., 2023**).

Table 10: summarizes the findings of the main studies on GBFs.

Authors	Year	Studied parameters	Results
Williams et al. [53]	1951	Water and glycerine were used as a drilling fluid, glass balls and metal discs were used as drilling cutting. Cutting transport efficiency of drilling fluids were investigated in laboratory and in field.	For GBFs, the cutting transport efficiency was independent of cutting dimensions.
Oakley et al. [54]	1992	Environmental issues of the drilling fluids were investigated.	GBF was more environmentally friendly than OBFs. Clay swelling inhibition properties of GBFs is comparable to OBFs and KCl fluids.
Ismail et al. [55]	2001	Glycerine with plastic viscosity of 25 and 138 centipoise was used as drilling fluid. The effect fluid flow parameters and viscosity, fluid velocity in the annulus, and the geometry of the drilling cuttings at different angles of the well was investigated.	An increase in the viscosity results in a decrease of the cutting carrying capacity due to more laminated fluid flow regime in directional wells.
Waldmann et al. [56]	2005	The amount of filtrate volume and invasion depth of filtrate into the formation were investigated. Laboratory tests included standard and single-phase radial filtration. Tested fluid was 80% glycerine (20% water), as a Newtonian fluid.	Filter cake permeability is the most important parameter that controls the invasion of the filtrate.
Marbun et al. [47]	2013	Comparison of glycerol with other oil-containing muds such as seraline and biodiesel as a drilling fluid base. Parameters studied: plastic viscosity, yield point, gel strength, and lubrication properties.	Viscosity of crude glycerine and refined glycerine is higher than biodiesel and palm oil. Low gel strength. Decrease of viscosity with an increase in temperature.
Pacheco et al. [57]	2019	Investigation of oil-based drilling fluid problems in salt layers. Kinetics of dissolution of NaCl in drilling fluid containing glycerine.	Obtaining the mass transfer coefficients of salt in glycerine.
Soares et al. [58]	2020	Investigation of the drilling fluid filtration in two types of water-based and GBFs. Effect of LCM (glass spheres and CaCO3 in different size) and viscosifiers (CMC and XG) on amount of mud filtrate was investigated.	Mud containing XG and LCMs compared to CMC and LCM leads to a filter cake with a lower thickness, permeability and amount of filtrate the glycerine base fluid with blocking agents exhibit Newtonian behaviour. Poor performance of the glycerine base mud with a large volume of filtrate.
Duarte et al. [60]	2021	Study of glycerol-based muds from the perspective of well control.	Less methane solubility in glycerine in comparison with other SBDF. Better kick detection in glycine-based mud and improvement in well control.
Lyu et al. [61]	2021	Application of Nano-silica as inhibitor of shale swelling agent in GBDF.	The addition of 0.5% nanosilica increases 37% of shale inhibition in this mud system type.
Issoufou et al. [62]	2021	The estimation of the settling speed of drilling cuttings when system contains rising gas bubble air as gas, aluminium discs as drilling cutting, and water and glycerine with different weight percentages as drilling fluid were used.	The collision of the bubble with the drilling cutting reduces the slipping velocity (settlement) by 50-20%. In fluids with high viscosity, the effect of viscosity and density is more dominant than the gas-drilling cutting collision effect.
Rasool et al. [63-65]	2023	The new environmentally friendly calcium chloride based drilling fluid and glycerine with a ratio of 1:4 was introduced. The rheological properties and inhibition of shale were investigated.	Their results showed that the developed mud provided good gel strength. Also, this type of mud exhibited good inhibition performance in shale formations.

4. Summary and Conclusion

Technical performance and environmental compatibility are two main considerations in the design of drilling fluid composition. In several circumstances such as HPHT condition, salt drilling, directional wells, shale formations, the OBFs may be a better choice. However, due to the adverse effect of oils on the environment, their application is limited. In this regard, GBFs, as non-toxic fluids with less environmental impacts are proposed as a possible substitution. This research was aimed to review the main studies, conducted on the applications of glycerine in the composition of drilling fluid. The main conclusions can be listed as follows:

Glycerine in drilling fluids can improve the inhibitive properties of the fluids in shales. However, the mechanisms of inhibition are not clearly known.

In comparison with WBFs, GBFs improved the lubricity, which makes their application possible in highly deviated wellbores, where high torque and drag are expected.

In filtration tests of GBFs, less filtrate volume is reported. Yet, the high-strength mud cake is not desirable as it can significantly decrease the quality of primary cementing.

An efficient cutting transport is reported in GBFs. However, this result should be evaluated more deeply, especially in the case of directional and horizontal drillings, where cutting beds are formed at the lower section of the borehole.

Glycerine is soluble in water and therefore their mixture may not be viscous enough for cutting transport and suspension. In this case, a viscosifying agent is required to modify the rheological properties of GBFs.

In salt drilling, the application of the GBF may be limited due to salt solubility in glycerine.

As can be seen, GBFs have adequate technical properties to replace the OBFs. However, the experimental studies carried up to now, are not sufficient for a reliable decision. There are other main aspects of the GBF application, which are not covered in previous studies in detail. For example, the economic feasibility study is mandatory for both pure and crude glycerine. Thermal stability of GBF is another important aspect, which is not fully covered in previous studies.

5. References

Ahmad, F., Miskimins, J., Liu, X., Singh, A., & Wang, J. (2021). Experimental Investigation of Proppant Placement in Multiple Perforation Clusters for Horizontal Fracturing Applications. SPE/AAPG/SEG Unconventional Resources Technology Conference,

Ahmed, A., Sharifi Haddad, A., Rafati, R., Bashir, A., AlSabagh, A. M., & Aboulrous, A. A. (2021). Developing a thermally stable ester-based drilling fluid for offshore drilling operations by using aluminum oxide nanorods. *Sustainability*, *13*(6), 3399. https://doi.org/10.3390/su13063399

Ali, I., Ahmad, M., & Ganat, T. (2022). Biopolymeric formulations for filtrate control applications in water-based drilling muds: A review. *Journal of Petroleum Science and Engineering*, *210*, 110021. https://doi.org/10.1016/j.petrol.2021.110021

AlTammar, M. J., Gala, D. P., & Sharma, M. M. (2020). Application of different fluid injection methods to reduce breakdown pressure. International Petroleum Technology Conference,

Amanullah, M., Ramasamy, J., Al-Arfaj, M. K., & Aramco, S. (2016). Application of an indigenous eco-friendly raw material as fluid loss additive. *Journal of Petroleum Science and Engineering*, *139*, 191-197. https://doi.org/10.1016/j.petrol.2015.12.023

Benjumea, P., Agudelo, J., & Agudelo, A. (2008). Basic properties of palm oil biodiesel–diesel blends. *Fuel*, *87*(10-11), 2069-2075. https://doi.org/10.1016/j.fuel.2007.11.004

Bloemendal, J. W. (1978). Recent Developments In Drilling Fluid Technology. Offshore South East Asia Conference, Singapore.

Burrows, K., Evans, J., Hall, J., & Kirsner, J. (2001). New low viscosity ester is suitable for drilling fluids in deepwater applications. SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, Texas.

Caenn, R., & Chillingar, G. V. (1996). Drilling fluids: State of the art. *Journal of Petroleum Science and Engineering*, *14*(3-4), 221-230. https://doi.org/10.1016/0920-4105(95)00051-8

Celino, K. N., da Silva Fernandes, R., de Morais, S. C., de Souza, E. A., & de Carvalho Balaban, R. (2022). Emulsion-based drilling fluids: Rheological properties preservation facing changes on the temperature, pressure and dispersed phase. *Journal of Molecular Liquids*, *352*, 118753. https://doi.org/10.1016/j.molliq.2022.118753

Chai, Y. H., Yusup, S., & Chok, V. S. (2015). A review on nanoparticle addition in base fluid for improvement of biodegradable ester-based drilling fluid properties. *Chemical Engineering Transactions*, *45*, 1447-1452. https://doi.org/10.3303/CET1545242

Cheatham Jr, J., & Yarbrough, J. (1964). Chip removal by a hydraulic jet. *Society of Petroleum Engineers Journal*, *4*(01), 21-25. https://doi.org/10.2118/782-PA

Chenevert, M. (1989). Glycerol mud additive provides shale stability. *Oil and Gas Journal;(USA)*, *87*(29).

Choupani, M., Tabatabaee Moradi, S., & Tabatabaei Nejad, S. (2022). Study on Attapulgite as Drilling Fluid Clay Additive in Persian Gulf Seawater. *International Journal of Engineering*, *35*(3), 587-595.

Curbelo, F., Garnica, A., Araújo, E., Paiva, E., Cabral, A., & Freitas, J. (2018). Vegetable oil-based preflush fluid in well cementing. *Journal of Petroleum Science and Engineering*, *170*, 392-399. https://doi.org/10.1016/j.petrol.2018.06.061

Daya, A. A., Sajjadian, M., & Esmaeilpour, M. E. (2016). Experimental investigation of new additive to optimize the properties of synthetic-based drilling fluid. *Journal of*

Mining and Metallurgy A: Mining, *52*(1), 37-43. https://doi.org/10.5937/JMMA1601037D

Duarte, A., Ribeiro, P. R., Kim, N. R., Mendes, J. R. P., Policarpo, N. A., & Vianna, A. (2021). An experimental study of gas solubility in glycerin based drilling fluid applied to well control. *Journal of Petroleum Science and Engineering*, *207*, 109194. https://doi.org/10.1016/j.petrol.2021.109194

Ferreira, G., Souza, D., Lima, R., Lobato, A., Silva, A., & Santos, L. (2018). Novel glycerin-based microemulsion formulation for enhanced oil recovery. *Journal of Petroleum Science and Engineering*, *167*, 674-681. https://doi.org/10.1016/j.petrol.2018.04.048

Friedheim, J. E., Candler, J. E., & Rabke, S. P. (2001). New testing protocols and regulatory guidelines to promote further development of synthetic-based fluid technology. SPE Annual Technical Conference and Exhibition,

Gandelman, R., Leal, R., Gonçalves, J., Aragao, A. F. L., Lomba, R., & Martins, A. L. (2007). Study on gelation and freezing phenomena of synthetic drilling fluids in ultradeepwater environments. SPE/IADC Drilling Conference,

Garcia, E., Laca, M., Pérez, E., Garrido, A., & Peinado, J. (2008). New class of acetal derived from glycerin as a biodiesel fuel component. *Energy & fuels*, *22*(6), 4274-4280. https://doi.org/10.1021/ef800477m

Ismail, A. R., Mansor, M., & Foo, K. S. (2001). Experimental study of cuttings removal rate of inclined wellbore. 6th Mining, Metallurgical and Petroleum Eng. Conference at: Bangkok, Bangkok.

Issoufou, M. K., Song, X., Zhu, Z., Xu, Z., Yu, B., Jing, S., & Duan, S. (2021). Predicting cuttings settling velocity in drilling muds and in rising-bubbles-containing muds. *Journal of Petroleum Science and Engineering*, *204*, 108766. https://doi.org/10.1016/j.petrol.2021.108766

Jiao, D., & Sharma, M. M. (1994). Mechanism of cake buildup in crossflow filtration of colloidal suspensions. *Journal of Colloid and Interface Science*, *162*(2), 454-462. https://doi.org/10.1006/jcis.1994.1060

Khodja, M., Khodja-Saber, M., Canselier, J. P., Cohaut, N., & Bergaya, F. (2010). Drilling fluid technology: performances and environmental considerations. *Products and services; from R&D to final solutions*, 227-256. https://doi.org/10.5772/10393

Li, W., Zhao, X., Ji, Y., Peng, H., Li, Y., Liu, L., & Han, X. (2016). An investigation on environmentally friendly biodiesel-based invert emulsion drilling fluid. *Journal of Petroleum Exploration and Production Technology*, *6*, 505-517. https://doi.org/10.1007/s13202-015-0205-7

Lijuan, P., Xiaoping, L., Wu, L., Fuhao, Z., Tongliang, W., Huang, W., & Fuwei, W. (2020). Study on rheological property control method of “three high” water based drilling fluid. *International Journal of Engineering*, *33*(8), 1687-1695. https://doi.org/10.5829/ije.2020.33.08b.28

Lin, K.-F. (1997). Synthetic paraffinic hydrocarbon drilling fluid. *Journal of Cleaner Production*, *1*(5), 172.

Lyu, C., Hao, S., & Yang, L. (2021). Application of nanosilica in glycerol-based drilling fluid for shale formations. *SPE Drilling & Completion*, *36*(03), 473-482. https://doi.org/10.2118/204238-PA

Mahrova, M., Pagano, F., Pejakovic, V., Valea, A., Kalin, M., Igartua, A., & Tojo, E. (2015). Pyridinium based dicationic ionic liquids as base lubricants or lubricant additives. *Tribology International*, *82*, 245-254. https://doi.org/10.1016/j.triboint.2014.10.018

Malgaresi, G. V., Vaz Jr, A. S., Corrêa, C. C., Cruz, G. F., Lomba, R. F., & Waldmann, A. (2018). A new crude-glycerin-based drilling fluid. *Journal of Petroleum Science and Engineering*, *160*, 401-411. https://doi.org/10.1016/j.petrol.2017.10.039

Marbun, B., Aristya, R., Corina, A., & Hutapea, P. (2013). Innovation of purified glycerol palm oil in drilling fluid system. *American Journal of Oil and Chemical Technologies*, *1*(10), 39-53.

Marbun, B., Hutapea, P., Corina, A., Aristya, R., & Purwandari, S. (2013). Application of glycerol by-product of biodiesel palm oil as potential base drilling fluid. *Am. J. Oil Chem. Technol.*, *1*(10).

Martins, A. L., Leal, R. A. F., Junior, I. J., Lomba, R. F. T., & Aragao, A. F. L. (2007). Minimizing drilling fluid invasion in coring operations. European Formation Damage Conference,

Medhi, S., Chowdhury, S., Sangwai, J. S., & Gupta, D. K. (2019). Effect of Al_2O_3 nanoparticle on viscoelastic and filtration properties of a salt-polymer-based drilling fluid. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-13. https://doi.org/10.1080/15567036.2019.1662140

Meher, L., Sagar, D. V., & Naik, S. (2006). Technical aspects of biodiesel production by transesterification – a review. *Renewable and sustainable energy reviews*, *10*(3), 248-268. https://doi.org/10.1016/j.rser.2004.09.002

Mota, C., Pinto, B. P., Lima, A., & De Glycerol, A. (2017). Versatile Renewable Feedstock for the Chemical Industry. *Cham: Springer*.

Mueller, H., Herold, C.-P., von Tapavicza, S., Grimes, D., Braun, J.-M., & Smith, S. (1990). Use of selected ester oils in drilling fluids and muds.

Nickdel Teymoori, R., & Ghasem Alaskari, M. (2007). Effects of salinity, pH and temperature on CMC polymer and XC polymer performance. *International Journal of Engineering*, *20*(3), 283-290.

Oakley, D. J., Morrison, A., Burdis, I., & Jones, K. G. (1992). Cooperative Research—A Route To Reduce the Environmental Impact of Drilling Fluids. *SPE Drilling Engineering*, *7*(03), 186-190. https://doi.org/10.2118/20885-pa

Ondul, E., & Dizge, N. (2014). Glycerol: a major by-product in the biodiesel manufacturing process. *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *19*(1-2), 75-79.

Pacheco, L. V., de Oliveira Borges, R. F., de Oliveira, B. R., Scheid, C. M., & Calcada, L. A. (2019). Study on the dissolution kinetics of NaCl in environmentally friendly drilling fluids containing glycerin. *Journal of Petroleum Science and Engineering*, *182*, 106165. https://doi.org/10.1016/j.petrol.2019.06.029

Pagliaro, M., & Rossi, M. (2008). *The future of glycerol*. Royal Society of Chemistry.

Philip, Z., Sharma, M. M., & Chenevert, M. E. (1998). The role of taylor vortices in the transport of drill cuttings. SPE India Oil and Gas Conference and Exhibition,

Rae, P., & Di Lullo, G. (2001). Towards environmentally-friendly additives for well completion and stimulation operations. SPE Asia pacific oil and gas conference and exhibition, Jakarta, Indonesia.

Rasool, M. H., & Ahmad, M. (2023). Epsom Salt-Based Natural Deep Eutectic Solvent as a Drilling Fluid Additive: A Game-Changer for Shale Swelling Inhibition. *Molecules*, *28*(15), 5784. https://doi.org/10.3390/molecules28155784

Rasool, M. H., Ahmad, M., Ayoub, M., & Abbas, M. A. (2023). A Novel Ascorbic Acid Based Natural Deep Eutectic Solvent as a Drilling Mud Additive for Shale Stabilization. *Processes*, *11*(4), 1135. https://doi.org/10.3390/pr11041135

Rasool, M. H., Ahmad, M., Siddiqui, N. A., & Junejo, A. Z. (2023). Eco-Friendly Drilling Fluid: Calcium Chloride-Based Natural Deep Eutectic Solvent (NADES) as an All-Rounder Additive. *Energies*, *16*(14), 5533. https://doi.org/10.3390/en16145533

Ribeiro Filho, F. d. A., Mainier, F. B., & Monteiro, L. P. C. (2020). Evaluation of the use of glycerin and sodium silicate in water-based drilling fluid. *International Journal of Research -GRANTHAALAYAH*. https://doi.org/10.29121/granthaalayah.v8.i5.2020.156

Román Suero, S., Ledesma Cano, B., Álvarez-Murillo, A., Al-Kassir, A., & Yusaf, T. (2015). Glycerin, a biodiesel by-product with potentiality to produce hydrogen by steam gasification. *Energies*, *8*(11), 12765-12775. https://doi.org/10.3390/en81112339

Setyawan, W., Ashfahani, A. S., Fajarwati, K., Marbun, B., & Manurung, R. (2011). Alternative use of castor oil for vegetable oil-based mud environmentally friendly potential domestic oil-based mud. Thirty-Fifth Annual Convention & Exhibition, Indonesian Petroleum Association.

Sharma, M., & Wunderlich, R. (1987). The alteration of rock properties due to interactions with drilling-fluid components. *Journal of Petroleum Science and Engineering*, *1*(2), 127-143. https://doi.org/10.1016/0920-4105(87)90004-0

Sharma, M. M., Chenevert, M. E., Guo, Q., Ji, L., Friedheim, J., & Zhang, R. (2012). A new family of nanoparticle based drilling fluids. SPE Annual Technical Conference and Exhibition,

Singhabhandhu, A., & Tezuka, T. (2010). A perspective on incorporation of glycerin purification process in biodiesel plants using waste cooking oil as feedstock. *Energy*, *35*(6), 2493-2504. https://doi.org/10.1016/j.energy.2010.02.047

Soares, A. S. F., Scheid, C. M., Marques, M. R. C., & Calçada, L. A. (2020). Effect of solid particle size on the filtration properties of suspension viscosified with carboxymethylcellulose and xantham gum. *Journal of Petroleum Science and Engineering*, *185*, 106615. https://doi.org/10.1016/j.petrol.2019.106615

Soomro, S. A., Soomro, S. A., & Brohi, K. M. (2020). Effect of synthesized biodiesel on the rheological properties of oil based drilling mud. *Engineering Science and Technology International Research Journal*, *4*(1), 28-33.

Sulaimon, A. A., Adeyemi, B. J., & Rahimi, M. (2017). Performance enhancement of selected vegetable oil as base fluid for drilling HPHT formation. *Journal of Petroleum Science and Engineering*, *152*, 49-59. https://doi.org/10.1016/j.petrol.2017.02.006

Toczek, P., Wisniowski, R., Zlotkowski, A., & Teper, W. (2023). Hydraulic Radial Drilling Using a Rotary Hydraulic Nozzle Aimed at Increasing the Exploitation of Deposits. *Energies*, *16*(23), 7867. https://doi.org/doi.org/10.3390/en16237867

Vryzas, Z., & Kelessidis, V. C. (2017). Nano-based drilling fluids: A review. *Energies*, *10*(4), 540. https://doi.org/10.3390/en10040540

Waldmann, A. T. A., Martins, A. L., Aragão, Á. F. L., & Lomba, R. F. T. (2005). Predicting and monitoring fluid invasion in exploratory drilling. *SPE Drilling & Completion*, *20*(04), 268-275. https://doi.org/10.2118/86497-pa

Wallace, C. B., Holt, R., & Purvis, D. (2010). Use of Glycerol (Glycerin) to Dehydrate CO2 Above the Critical Pressure at Denbury's Mississippi Facilities. *Denbury Onshore LLC*.

Williams, C. E., Jr., & Bruce, G. H. (1951). Carrying capacity of drilling muds. *Journal of Petroleum Technology*, *3*(04), 111-120. https://doi.org/10.2118/951111-g

Wiśniowski, R., Skrzypaszek, K., & Toczek, P. (2022). Vom Berg and Hahn–Eyring Drilling Fluid Rheological Models. *Energies*, *15*(15), 5583. https://doi.org/doi.org/10.3390/en15155583

Wu, H., Golovin, E., Shulkin, Y., Chudnovsky, A., Dudley, J. W., & Wong, G. K. (2008). Observations of hydraulic fracture initiation and propagation in a brittle polymer. The 42nd U.S. Rock Mechanics Symposium (USRMS),

Yang, X., Shang, Z., Liu, H., Cai, J., & Jiang, G. (2017). Environmental-friendly salt water mud with nano-SiO_2 in horizontal drilling for shale gas. *Journal of Petroleum Science and Engineering*, *156*, 408-418. https://doi.org/10.1016/j.petrol.2017.06.022

Young, S., Friedheim, J., Lee, J., & Prebensen, O. I. (2012). A new generation of flat rheology invert drilling fluids. SPE Oil and Gas India Conference and Exhibition,

Zhao, X., Li, D., Zhu, H., Ma, J., & An, Y. (2022). Advanced developments in environmentally friendly lubricants for water-based drilling fluid: A review. *RSC advances*, *12*(35), 22853-22868. https://doi.org/10.1039/D2RA03888A

SAŽETAK

Pregled isplaka na bazi glicerola i upotrebe glicerina kao isplačnoga aditiva

Znatno povećanje potražnje za energijom u cijelome svijetu i pad proizvodnje iz dostupnih ležišta nafte i plina doveli su do povećanja ulaganja naftne industrije u odobalna istraživanja. Međutim, aktivnosti bušenja u odobalju obično su ograničene ekološkim ograničenjima. Stoga su novija istraživanja posvećena razvoju ekološki prihvatljivih fluida s odgovarajućim tehničkim svojstvima. Glicerin je netoksična, podmazujuća tvar bez boje i mirisa, veće gustoće od vode. Zbog svojih svojstava glicerin se može koristiti kao baza sintetičkih isplaka. Cilj je ovoga istraživanja pregled provedenih istraživanja o primjeni glicerina u sastavu isplaka. Na temelju rezultata istraživanja može se zaključiti da se tekućine na bazi glicerina mogu smatrati ekološki prihvatljivim tekućinama s dovoljnim tehničkim svojstvima da zamijene druge fluide koji se koriste kao isplake prilikom bušenja. Međutim, za donošenje pouzdane odluke o primjeni glicerina u isplakama još uvijek nema dovoljno eksperimentalno dobivenih podataka. Za primjenu glicerinskih tekućina (i za čisti i za sirovi glicerin) potrebno je provesti studiju ekonomske izvedivosti. Također, budućim istraživanjima potrebno je obuhvatiti i ispitivanje toplinske stabilnosti glicerinskih tekućina.

Ključne riječi:
glicerin, isplaka, bušenje u odobalju, sintetičke isplake, svojstva isplaka, mazivost

Authors’ contribution

Ali Momeni (1) (PhD student, Petroleum Engineer) conducted the literature review and wrote the manuscript. **S. Sh. Tabatabaee Moradi (2)** (Ass. Prof. Dr., Petroleum Engineer)**, S. A. Tabatabaei Nejad (3)** (Prof. Dr., Petroleum Engineer) supervised the study and provided analyses of the results.