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Research Article

Impact of Quartz/Argillaceous Sandstone and Siliceous/Kaolinitic Claystone Contamination of Drilling Fluid and Filter Cake Properties

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The drilling fluid must be designed through a comprehensive process to select the right additives, and then must passed through different API standard evaluation processes to ensure the quality. However, the contamination of the drilling fluid with the drilled cuttings caused a significant alteration in the drilling fluid and sealing properties of the drilling fluid. Therefore, many studies have been conducted to identify the effect of different cuttings on the drilling fluid properties. The current work emphasized on the impact of four different cuttings (quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone). The utilized cuttings in this work were selected carefully from different sandstone types to have varied clay content ranged from 0 to 70%. The selected cuttings were prepared and then characterized in term of their mineral composition and particle size distribution. In order to accomplish the objective of this work, the base mud contains zero cutting concentration, after that, an additional four drilling fluid samples were prepared by adding the prepared cuttings in two different concentrations include 5 wt.% and 10 wt.%. Several indispensable tests were conducted to investigate the impact of the added cutting on the rheological properties, filtration performance, filter cake properties, and other primary properties such as the drilling fluid density and pH. The results exhibited that the fluctuation of fluid properties was governed by two factors, one was the cutting concentation and the other was the clay content. Filter cake thickness showed high sensitivity at the low cutting concentration while the other properties were mostly in the acceptable range. On the other hand, at higher concentration, the results fall down into two clusters: cuttings with clay content ranging from 0 to 50% (quartz sandstone cuttings, Argillaceous sandstone, and Siliceous claystone) and cuttings with clay content higher than 50% (Kaolinitic claystone) as shown in details in the result section of this work. This works highlight the important of considering the cutting impact on the drilling fluid properties which ultimately impact the whole drilling operations.

1. Introduction

Drilling in the oil and gas industry is the process of creating a passage to the subground with the objective of producing hydrocarbon. This process involves many systems such as hosting, rotating, and circulating. Each system plays key role in reaching to the hydrocarbon reservoir in the most economical and efficient way possible. An important element in the circulating system is the drilling fluid, its importance can be seen in its various functions. Functions like controlling the subsurface pressure, cooling the bit, protecting the formation damage, removing the drilling cutting, etc. The drilling fluid performance can be evaluated based on how these functions are achieved [1, 2].

There are a lot of factors including the type of the drilling fluid additives, well condition, and formation properties that were encountered during the drilling operation which might cause adverse impact on the performance of the drilling fluid and the well condition. This issue is directly associated with the thermal stability of many additives, which leads to improper properties by altering the performance of the designed drilling fluid additives [3–8]. In addition, the alteration in the physical properties of the drilling additives as the particle size is directly affected by the viscosity and the packing of the solids in mud and filter cake layer [9]. Moreover, the contamination of the drilling with different materials has a major impact on the drilling fluid properties.

Monitoring the contamination degree is a key factor to ensure effective drilling performance [10–12]. Many approaches have been used to minimize the impact of the contamination such as utilizing the saltwater to drill salt formations to avoid contamination from different ions like magnesium (Mg^{2+}) and calcium (Ca^{2+}) which are harmful to the water based mud [12, 13]. Such cations may also alter the pH of the drilling fluid, having a significant impact on the rheology performance of both polymers and bentonite drilling fluid [13, 14]. Other source of contamination is the formation cutting that mix with the drilling fluid during the drilling process. The solid contamination (cuttings) are usually separated through the different solid removal equipment such as shale shaker and mud cleaner for the large size particles, while the smaller particles could be removed through the desander, desilter, and centrifuge [15].

The contamination of the drilling fluid with the fine drilled cuttings, if not separated through the solid removal equipment, has several effects on the drilling fluid and filter cake properties, and the cutting's chemical and physical properties are the main factors [16–18]. Accordingly, several studies have been conducted to identify the impact of different cutting types. However, some might look at the effect of the cutting which forms a wide range window as sand content or any other type, it was observed that heterogeneity of the sandstone formation exhibited different behaviors. The sandstone cuttings as calcareous, Argillaceous, and ferruginous varied performance of the drilling fluid after they are added compared to quartz rich (i.e., arenite) cutting [19]. Moreover, the cuttings with different mechanical properties such as compressive strength (UCS) and Young's modulus (E) presented flocculating behavior when they are added to the based drilling fluid [20]. Therefore, this study can effectively make much progress in studying particular sandstone types such as Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone that contain different clay concentration and then compared the obtained results with quartz rich cutting (quartz sandstone; almost zero clay). The impact of these cuttings on the drilling fluid and filter cake properties was evaluated in this work. The studied sandstones and claystones include quartz-rich sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone. All rock samples were collected from Saudi sandstone formations. The quartz-rich sandstone is mainly formed within a beach depositional setting with quartz type of minerals. Claystone on the other hand is mainly formed from clay minerals and clay size of particles that are deposited in low-energy depositional environment such as coastal flood plains. The change in mineral composition of the sandstone and claystone is due to the mineral composition of the source rocks, weathering, and depositional processes.

The diagram as shown in Figure 1 describes the phases that were followed to achieve this work. Firstly, the drilling fluid and the cuttings were prepared. In the second phase, the varied types of cutting were added to the drilling fluid to evaluate the effect of cutting type and concentration. In the last phase, the properties of the drilling fluid including the rheological properties, filtration performance, filter cake properties, and other primary properties such as the drilling fluid density and pH were investigated. The following subsections illustrate the details for each element in this diagram in term of cutting characterization, mud preparation, and the experimental procedures.

2. Materials and Experimental

2.1. Rock/Cutting Samples. Four rock core samples were collected from Saudi Arabian sandstone formations. These samples are characterized by a wide range of mineral and element compositions. The four rock samples are quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone. Drilling cuttings from the four core samples were obtained by crushing the samples to fine powder in sufficient quantities for experimentation. The fact is that the produced cuttings during the drilling operation have varies sizes, however, the large size cuttings (>74 μm) are removed through the solid removal equipment's such as shale shaker and mud cleaner [2]. In this work, the goal was to evaluate the effect of the fine cuttings (<74 μm) which might have the chance, if not removed, to be an integral part of the drilling and recirculated during the mud circulation. Thus, the crushed samples were sieved using 90-micron mish. After that, the cuttings were characterized in term of their chemical and physical properties.

2.2. Mineralogical and Elemental Characterization. Several equipment was utilized to characterize the cutting composition and particles shape including:

(i) *X-Ray Powder Diffraction* (XRD): core rock samples were grounded into powder and analyzed for mineralogical composition using a Panalytical Empyrean diffractometer. The powder samples were scanned with a 2-theta angle from 4° to 70° and at a rate of 0.04°/second. Then, mineral peaks were identified via a peak matching approach considering potential minerals such as quartz, kaolinite, calcite, heavy minerals, and evaporative minerals

(ii) *Powder X-Ray Fluorescence* (XRF): 10 grams from each sample were analyzed for element composition using Energy Dispersive X-ray Fluorescence Spectrometer (JSX-1000S X-ray fluorescence spectrometer

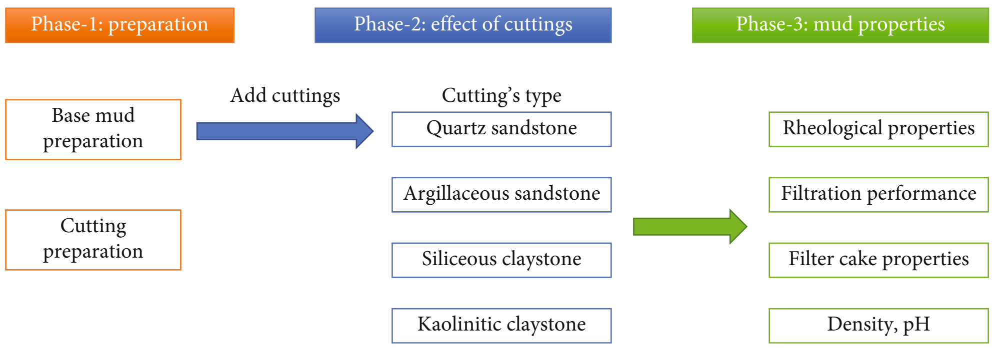


FIGURE 1: Mineral composition of four core samples (perspective 1).

(XRF)). The powder samples were mounted in sample white plastic tube with transparent cover as holder and scanned by the X-ray tube with 30 Kv voltage and 0.030 mA current. The EDXRF analysis was operated for 5 minutes acquis ion time for each sample. The element peaks were automatically picked using solution application provided with EDXRF

(iii) *Scanning Electron Microscopy* (SEM): the powder samples (cuttings) were analyzed using Joel 7000 desktop scanning electron microscopy with 2 nm gold coating layer

2.3. Mineral and Elemental Composition of Rock/Cutting Samples. The mineral composition of the four rock samples is illustrated in Figure 2. Quartz account for 100%, 95%, 36.50%, and 22.6% of the bulk mineral composition of the quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone samples, respectively. On the other side, kaolinite mineral form 4%, 51.8%, and 71.4% of the bulk mineral composition of Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone samples, respectively. The accessories of minerals, including calcite and heavy minerals, comprised 1%, 11.7%, and 6% of the entire mineral composition of Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone samples, respectively.

From the elemental composition perspective, silicon and aluminum are the main elements presented in the studied core samples, with traces of iron in Kaolinitic claystone sample (Figure 3). Silicon occurred with a mass percentage of 96.52%, 87.80%, 56.39%, and 49.52% in quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone samples. Aluminum comprised 2.67%, 11.09%, 41.93, and 44.90% of the bulk elemental composition of quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone samples. In addition, the iron element was presented in the Kaolinitic claystone sample with a mass percentage of 2.50%.

The mineral composition of the studied rock samples was also investigated via scanning electronic microscopy (SEM). According to surface texture and morphology of the mineral grains, the quartz, kaolinite, and heavy minerals (hematite) were identified as shown in Figure 4.

2.4. Drilling Fluid. Barite water-based drilling fluid as shown in Table 1 was used to formulate the reference drilling (base mud). In order to accomplish the objective of this work, the base mud was prepared with zero cutting concentration. After that, an additional four drilling fluid samples were prepared by adding the prepared cuttings in two different concentrations, 5 wt.% and 10 wt.%. Thus, base mud will be referred as the zero-cutting concentration (reference sample) and the other drilling fluid samples will be referred to as MC1, MC2, MC3, and MC4 to distinguish the cutting containing drilling fluid. Table 2 displayed the drilling fluid label via the cutting type and concentration.

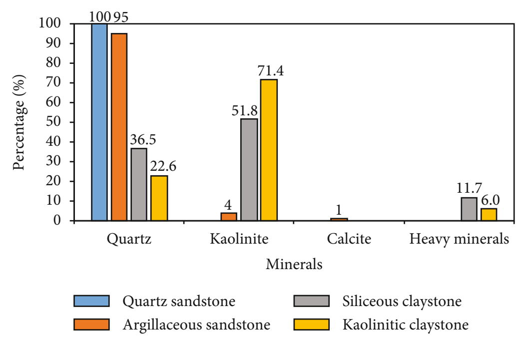


FIGURE 2: Mineral composition of four core samples.

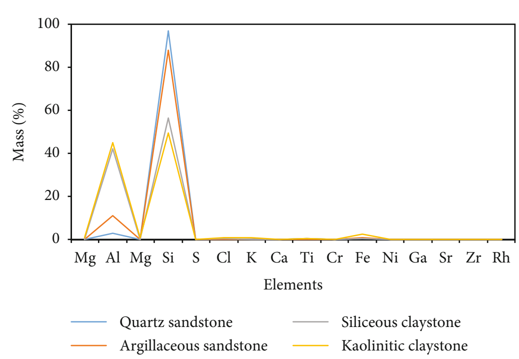
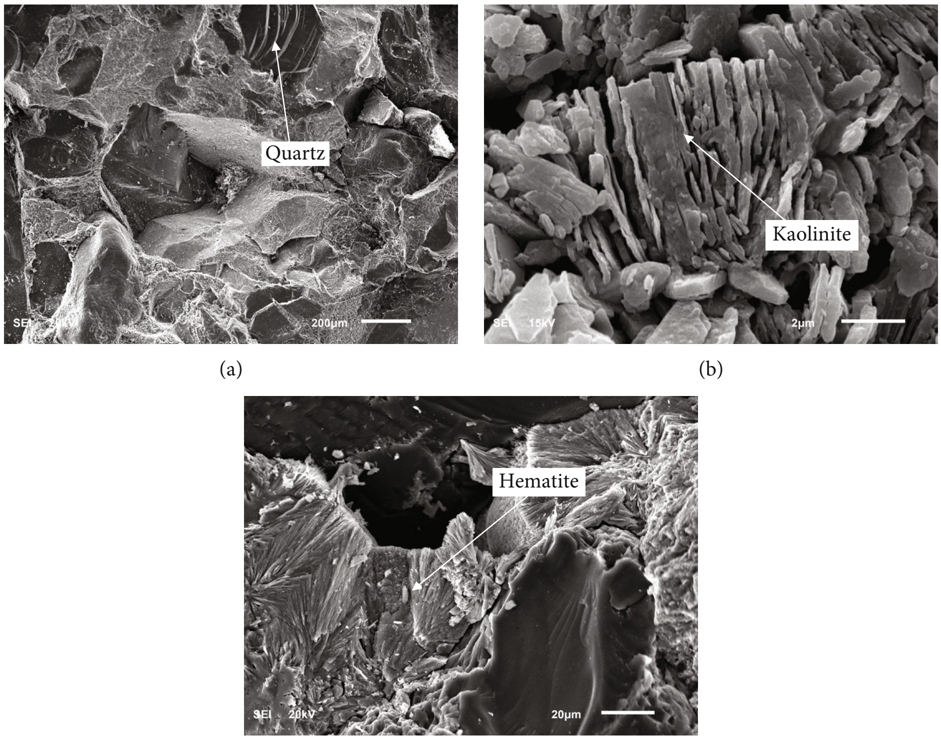


FIGURE 3: Elemental composition of the tested rock samples (perspective 1).

2.5. Solid Particle Size Distribution (PSD). The PSD for the four cutting samples was examined using a wet dispersion unit ANALYSETTE 22 NanoTec plus. In addition, the PSD of the weighting agent (barite) was also determined. The



(a) (b) (c)

Figure 4: SEM microphotographs of the rock samples showing the dominant minerals, (a) quartz, (b) Kaolinite, and (c) hematite.

Table 1: Base mud formulation.

Component (unit)	Value
Water (ml)	245
Defoamer (g)	0.08
Soda ash (g)	0.5
XC-polymer (g)	0.5
Starch (g)	6
Bentonite (g)	4
Potassium hydroxide (g)	0.5
PAC-R (g)	1
Potassium chloride (g)	20
Calcium carbonate (g)	5
Barite (g)	250

Table 2: Map for preparing the drilling fluids.

	Cuttings	
Mud label	Concentration	Type
Base mud	Zero	—
5% MC1	5 wt.%	Quartz sandstone
10% MC1	10 wt. %	
5% MC2	5 wt.%	Argillaceous sandstone
10% MC2	10 wt.%	
5% MC3	5 wt.%	Siliceous claystone
10% MC3	10 wt.%	
5% MC4	5 wt.%	Kaolinitic claystone
10% MC4	10 wt.%	

PSD for the utilized cuttings and the barite is shown in Figure 5. Although an equal amount of the cutting samples was crushed at the same time, the PSD varied which might be influenced by the essential rock properties such as the rock strength. This variation would be the actual case in the reality if these rocks were drilled at the same time. However, the part of the fine cutting range between the D_{10} and D_{50} was mostly very close for the four samples as shown in Figure 5.

2.6. Methodology. The properties of the prepared drilling fluids were measured and then compared with the base mud properties in order to identify the effect of the added cuttings. The effect of cutting was evaluated in terms of the change of the following indexes: drilling fluid density, pH as essential properties using the mud balance, and the pH meter, respectively. In addition, the rheological properties were examined before and after adding the cuttings using six-speed FANN viscometer at 120°F. The rheological indexes were determined using the Equations (1), (2), and (3) [20], whereas the gel strengths were obtained from the direct reading of the dial at 3 RPM at two times 10 second and 10 minutes.

$$\text{Apparent viscosity}(\text{AV}) = \frac{\varnothing_{600}}{2}, \tag{1}$$

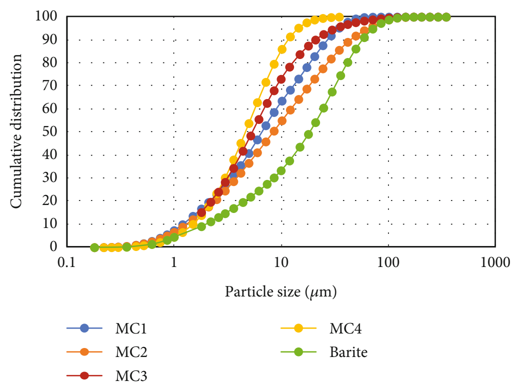


Figure 5: Particle size distribution for the cuttings and weighting material (barite).

$$\text{Plastic viscosity}(\text{PV}) = \varnothing_{600} - \varnothing_{300}, \quad (2)$$

$$\text{Yield point}(\text{YP}) = \varnothing_{300} - PV. \quad (3)$$

Moreover, API filtration test was conducted using the drilling fluid formulation shown in Table 2 as function of addition the cuttings to evaluate the impact of the added cuttings on the filtration volume, filter cake thickness, and filter cake sealing properties. The test was carried out using API filter press FANN apparatus at ambient temperature and 100 psi differential pressure.

The permeability for the formed filter cake before and after the filter cake addition (k_{fc} in mD) was calculated based on the filtration rate q (the slope per unit area obtained from the filtration volume and time plot in cm/s) using the formulas [21]:

$$K_{fc} = 14700 \frac{q * \text{Th}_{fc} * \mu}{p_{fc}}, \quad (4)$$

where Th_{fc} is filter cake thickness (cm), and μ is viscosity which is assumed to be 1 cP as the base for the preparation was water. The differential pressure (p_{fc}) across the filtration medium was 100 psi.

3. Results and Discussion

Initially, the properties of the base mud as a reference point were estimated. Then, the fluid properties were evaluated as a function of adding different sand cuttings (quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone) as shown in detail in the characterization section. The drilling fluid was prepared with two different cutting concentrations as shown in Table 2. The effect of cuttings was evaluated through the drilling fluid density, pH, rheological, and filtration properties.

The results in Table 3 clearly illustrate the densities of the prepared drilling fluid as function of adding the varied cuttings in 5% and 10% concentrations to the base mud (zero content cutting drilling fluid). The density of the base mud was 14 ppg. As the cutting's concentration increased from 5% to 10%, there was an indication of an increase in the density of the drilling fluid with almost 1 ppg (±0.2). Meanwhile, the difference in drilling density according to the change in the cutting type could be ignored because these type of sandstone rocks mostly have similar grain densities in the range of 2.2 SG. Likewise, the increment in the drilling fluid density as a function of adding 5% of these cutting could be negligible. This is because the SG of the added cutting was in the range of 2.2, which is lower than the barite 4.1 SG. Also, the weight of the barite in the drilling fluid was 250 g, as shown in Table 1, whereas the dosage for the 5% cutting was 17.5 g.

The second property was the pH of the prepared drilling fluid. Based on the experimental results, the pH of the base mud was 10.5 and loading the drilling fluid with the four cuttings (i.e., quartz sandstone, Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone) showed an insignificant impact on the drilling fluid pH values. It is known that the viscosifier agent, either polymeric or natural clays, is extremely sensitive to the salinity and acidity of pH [22]. Thus, it can be stated that the change in the other examined drilling fluid (rheological) as a function of adding different cuttings was not due to alternating the performance of the viscosifier agent as the pH of the drilling fluid was not influenced by these cuttings.

After preparing the barite weighted drilling fluid (base mud) and then adding the different type of cuttings in varied concentrations, the impact of cuttings on rheological properties was investigated. The present unweighted (before adding the weighting agent) base mud formulation, as shown in Table 1, is a typical mud formulation utilizing the polymeric and natural additives as XC polymer PAC-R, starch, and bentonite to obtain the favorable rheology and filtration properties based on the mutual physicochemical interference between these additives and the charged clay (bentonite) [22]. In addition, after adding the weighting agent (barite), the barite characteristics including the PSD and concentration influenced the rheological behavior of the prepared mud by changing the particle packing [6]. Thus, in this case, adding cuttings might stimulate the interaction between these additives and change the mud properties, which depend on the chemical and physical properties of the cuttings.

Figures 6 and 7 showed the rheological properties and gel strengths of the drilling fluid as a function of adding 5% of different cuttings. The drilling fluid AV, PV, and YP were not highly influenced by adding low concentration of different cuttings (5 wt.%) with comparison to the base mud rheological indexes. Moreover, at this level of cutting concentration, the properties of the drilling fluid did not experience clay-induced effect. This was obvious through comparing the results of the quartz sandstone cuttings (zero clay content cuttings; MC1 sample) with other samples where the clay content reached up to 70% in the cuttings as per sample MC4. Even so, the gelation indexes for a long period (30 minutes) showed relatively higher resistance to shear for the drilling fluid prepared with higher clay content (MC3 and MC4). Other than this, the properties of the drilling fluid showed insignificant fluctuation by adding 5% of different cuttings.

On the other hand, increasing the cutting concentration in the fluid formulation to 10% showed a clear change in the

Table 3: The density of the drilling fluids.

	Base mud	5% MC1	5% MC2	5% MC3	5% MC4
Density (ppg)	14	14.3	14.2	14.1	14.1
	Base mud	10% MC1	10% MC2	10% MC2	10% MC4
Density (ppg)	14	15.2	14.9	14.8	15

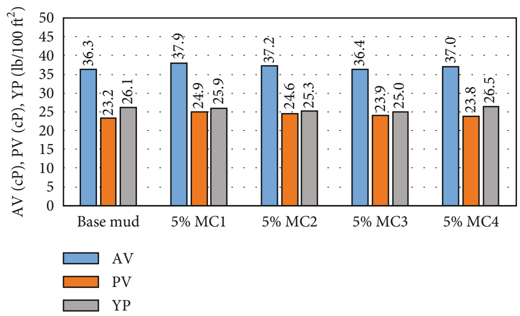


Figure 6: Rheological properties as function of adding 5% of different cuttings to the base mud.

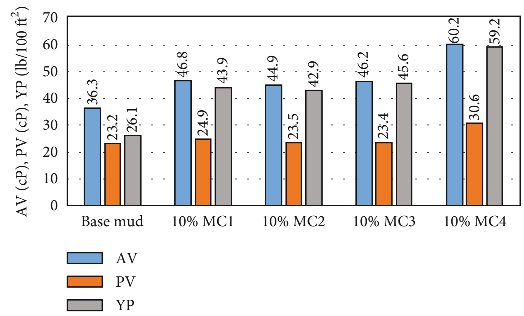


Figure 8: Rheological properties as function of adding 10% of different cuttings to the base mud.

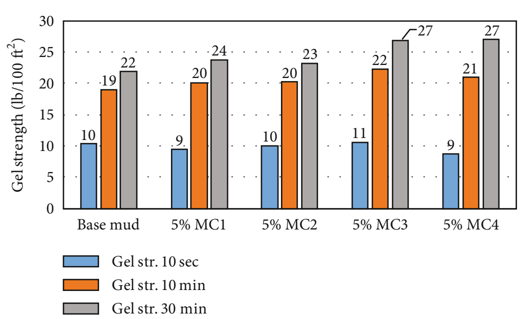


Figure 7: Gel strengths as function of adding 5% of different cuttings to the base mud.

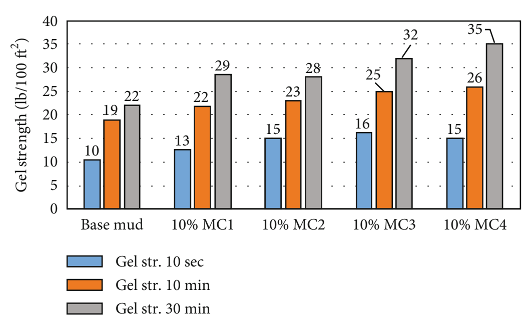


Figure 9: Gel strengths as function of adding 10% of different cuttings to the base mud.

drilling fluid rheological properties. Simultaneously, the effect of changing the cutting type on the fluid properties was also explicit, as shown in Figures 8 and 9. Increasing the clay content above 50% as sample MC 4 (Kaolinitic claystone cuttings) yielded additional increment in the yield point (YP), which might indicate the effect of chemical interaction between the polymer and clay, this might led to adsorbed the polymer on the surface of the clay and accordingly produced viscous mud [22]. The increment in the plastic viscosity (PV) for the three samples MC1, MC2, and MC3 was insignificant compared to the last sample MC4 which could attribute to the same justification. Among these properties (AV, PV, YP), increasing the cutting concentration to 10% caused an increment in the YP, meanwhile, the produced mud viscosity is dominant by the clay content for as the clay content is reached higher than 50% in the cutting. The same observation was concluded for the gel strengths. Mostly the MC2, and MC3, MC4 showed same behavior, while MC4 (higher clay cuttings) displayed higher resistance to the share. However, it was expected according to the PSD that the samples MC2 and MC1 would produce higher viscosity indexes due to the relatively higher particle size comparing with MC4 and MC1 based on to what called inertial effect [22, 23].

The filtration behavior of the prepared drilling fluid as a function of adding different cutting types in varied concentrations was assessed via the fluid loss test. The filter cake thickness is the essential indicator. The results showed that as the base mud was contaminated with the cuttings, there was an increment in the filter cake thickness as shown in Figure 10. The base mud was designed to have a lower filter cake thickness, however, adding 5% of the cuttings caused an increment in the filter cake thickness from 0.82 mm to an average of 1.3-1.4 mm. The results displayed that the increment in the filter cake thickness was almost within this average value regardless of the cutting type and concentration except for the last sample (MC4) in which the thickness reached up to 1.85 mm. This indicates that the high concentration of the high clay content cutting caused a significant increment in the filter cake thickness.

Figure 11 shows filtrate volume (V_f) at the end of the filtration test (30 minutes) for the prepared drilling fluid with different cuttings at the investigated concentrations. Firstly, the results illustrated that there was no effect on the filtrate

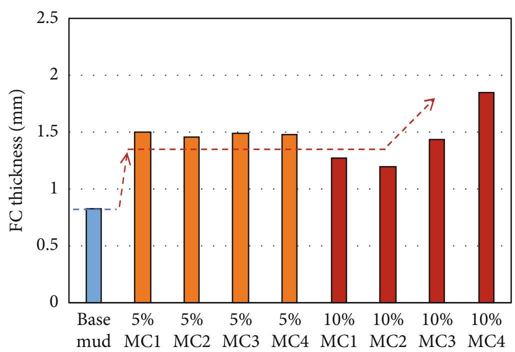


Figure 10: Filter cake thickness as function of adding different cuttings to the base mud.

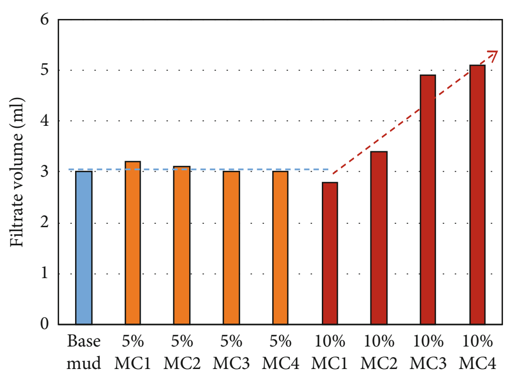


Figure 11: Filtrate volume as function of adding different cuttings to the base mud.

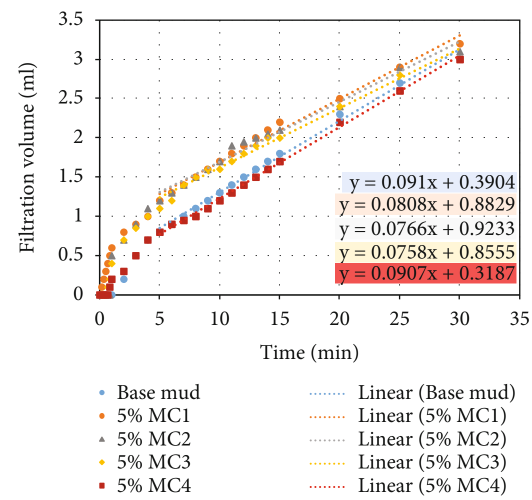


Figure 12: Filtrate volume vs. time for the base mud and as function adding different cuttings in 5% concentration.

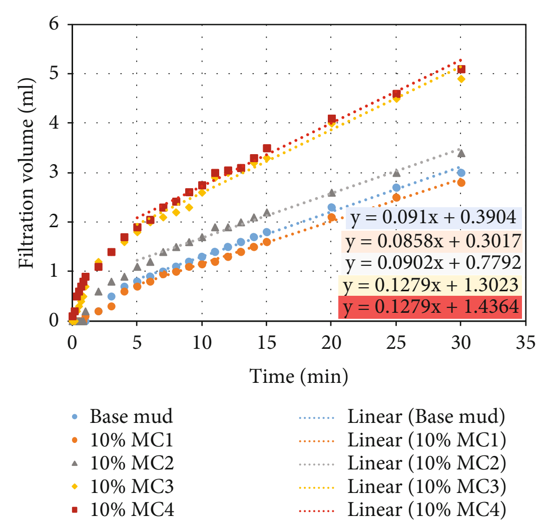


Figure 13: Filtrate volume vs time for the base mud and as function adding different cuttings in 10% concentration.

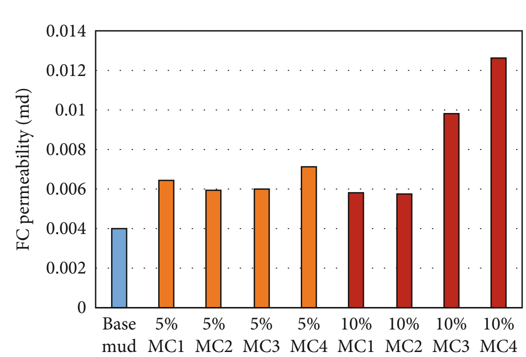


Figure 14: Filter cake permeability as function of adding different cuttings to the base mud.

volume by adding 5% of different cuttings. However, by adding 10% of the same cuttings, the filtration volume increased by increasing the clay content in the added cuttings. Sample MC1 (zero clay content) almost demonstrated the same value as the base mud, while the other sample at 10% cutting concentration produced a higher filtrate volume.

The drilling fluid filtrate volume was measured versus time during the filtration test. Figures 12 and 13 presented the filtration curves of base mud in comparison to the cutting containing drilling fluid in 5% and 10%, respectively. In order to calculate the filter cake permeability for each sample based on the filtration data, the fitting trend was plotted for the stabilized zone at late time period after 5 min. To distinguish the samples, the data point, dotted trend line, and the fitting equation for each sample were presented in the same color mode. For example, the blue color was representing the base mud. The addition of MC1, MC2, MC3, and MC4 cuttings into barite drilling fluid in 5% concentration showed a trivial effect on the filtration performance as shown in Figure 12. However, the calculated filter cake permeabilities of cutting containing samples using Equation (4) exhibited higher values as shown in Figure 14. The permeability of formed filter cake increased from 0.004 mD (for the base mud) to an average of 0.006 mD (for samples 5%MC1, 5%MC2, 5%MC3, and 5%MC4). This was reflected in the higher filter cake thickness of these samples as per Figure 10 which is a direct input in the filter cake permeability calculation (Equation (4)). The additional increment in the permeability of sample 5%MC4 was due to the slight augmentation in the filtration rate (0.0907 ml/min, as obtained from the slope of the fitting trend line, Figure 12) compared to other samples. This indicated that increasing the clay content in the cutting produced permeable filter cake in accordance to the samples containing the same concentration of the cutting with less clay content. This observation was obvious at higher cutting concertation. As the cutting concertation increased from 5% to 10%, the filtration rate increased for the drilling fluid samples that contain rich clay content cuttings (10%MC3 and 10%MC4) as obtained from the slope of the fitting trend lines in Figure 13. Accordingly, the increment in filter cake permeability for these samples (10%MC3 and 10%MC4) was significant as shown Figure 14.

To sum up, the impact of cutting can be categorized based on their concentration in the drilling fluid. At low cuttings (5 wt.%), there was no obvious distinct effect based on the cutting type, the four cuttings revealed a relatively close behavior. The filter cake thickness showed high sensitivity to the cutting addition, the average percent increase in filter cake thickness was 80% as a function of 5% of cuttings regardless of the cutting type. However, the impact on other filtration indexes such as filtrate volume and filter cake permeability was insignificant. Moreover, the rheological indexes (AV, PV, and YP) exhibited relatively close performance to the reference mud as a function of adding different cutting types. When the concentration increased to 10 wt.%, there was a significant change in drilling rheological and filtration properties. Moreover, the clay content in the sandstone cuttings played a momentous role in altering the base mud properties. According to the results, the cuttings could be divided into two clusters: cutting with clay content ranging from 0 to 50% (quartz sandstone cuttings, Argillaceous sandstone, and Siliceous claystone) and cuttings with clay content higher than 50% (Kaolinitic claystone). The first clusters showed a moderate impact on the AV and YP with an increment percentage increase by 25% and 70%, respectively. Increasing the clay content (>50%) increased AV by 65% and YP by 130%. While the impact on the other rheological indexed could be insignificant. The filter cake thickness of the first cluster (0-50% clay content cuttings) was not affected by increasing the cutting concentration from 5% to 10%, the thickness revealed relatively close values in the range of 1.3-1.5 mm while the increment percentage in filtrate volume was approximately 70%. This was also observed through the high increment in filter cake permeability.

4. Conclusions

Four different sandstone cuttings were loaded into barite water-based drilling fluid with different concentrations to evaluate their impact on drilling fluid and filter cake properties. The mineralogy of the sand cuttings was selected with verity in clay content (Argillaceous sandstone, Siliceous claystone, and Kaolinitic claystone). The results were investigated with respect to zero clay content cuttings (quartz sandstone cuttings). A laboratory experimental work was conducted to study the properties of cuttings containing drilling fluid in comparison to the base mud (zero cutting content). The clay content in sandstone cuttings played a significant role in fluctuating the drilling fluid properties. The role of the clay content was a function of the contaminated cutting's concentration loaded into the barite drilling fluid. At low concentration, there was no distinctive impact on the drilling fluid properties based on the cutting type, and filter cake thickness was the most impacted parameter. As the cutting concentration increased, the impact of the cutting type can be seen more clearly on the drilling fluid properties. For the cutting with clay content less than 50% (MC1, MC2, and MC3), the impact was moderate on the rheological properties with no significant impact on the filter cake. On the hand, the cutting with clay content more than 50% (MC4) had higher effect on the drilling properties.

Data Availability

All data are available in the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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