Utilization of Sugarcane Bagasse Ash as Filtration Loss Control Agent in Water Based Drilling Muds

Arada Saengdee* Bantita Terakulsatit
School of Geotechnology, Institute of Engineering,
Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand
Tel: 0-4422-4441 E-mail: kang_saengdee@hotmail.com

Abstract

The objective of this work is to experimental assessment of the suitability of sugarcane bagasse ash (SCBA) as a filtration loss agent in water based drilling mud formulation. The drilling mud was mixed with concentration of various SCBA at 1, 3 and 5% weight by weight, and is conducted at temperatures at 25, 50 and 80°C according to API RP13B-1 standard. The chemical properties are determined by using X-ray fluorescence, X-ray diffraction and field emission scanning electron microscope. The major oxide observed in SCBA is SiO2 (88.379%). Meanwhile, the major minerals of SCBA with predominance of quartz (73.123%) and shows the amorphous silica formation. The particle shape of SCBA has an irregular shape with rough surfaces and small porous textures. The drilling mud mixed with 1% w/w of SCBA exhibited the best filtration control characteristics with minimal filtrate volume and thinner and consistent mud filter cakes. Physical examination of the filtrate volume indicates that filtrate volume and filter cake thickness increases by a percentage of SCBA and temperature increasing. Thus, SCBA has proved to possess good filtration (fluid) loss control properties.

Keywords: water based drilling mud, filtration loss, sugarcane bagasse ash, additive

1. Introduction

A successful drilling procedure depends on the appropriate mixture and supervision of the drilling mud. The immense mass of petroleum explorations is majorly accomplished by applying water based drilling mud. Drilling mud, which represents about one fifth (15-18%) of the total cost of petroleum well drilling, must generally comply with three important requirements - they should be easy to use, not too expensive and environmentally friendly. The complex drilling mud plays several functions simultaneously. They are intended to clean the well, hold the cuttings in suspension, prevent caving, ensure the tightness of the well wall and form an impermeable cake near the wellbore area [1]. The significant factors in distinguishing the assets of a drilling mud are gel strength, viscosity (apparent and plastic viscosity), explicit weight, pH, thermal stability and the filtration function [2].

Many researches have studied using locally available materials as additives mixed with drilling mud as a fluid loss control agent such as fly ash, cassava derivative, periwinkle shell ash (PSA). These materials are effective in the fluid loss control in various concentrations and temperature, which has studied with Korsinwattana and Terakulsatit [3], Samavati et al. [4], and Igwe and Kinate [5].

Sugarcane is one of the foremost crops grown in all over countries and its entire production is over 1,500 million tons. After the extraction of all economical sugar from sugarcane, about 40-45% fibrous residue is obtained, this is reused in the same industry as fuel in boilers for heat generation leaving behind 8-10% ash as waste, known as sugarcane bagasse ash (SCBA) depending on the quality and type of the boiler [6]. The disposal of this material is already causing environmental problems around the sugar factories. While the quantity of the SCBA is increasing annually, but the utilization of the SCBA is minimal and unmanageable, and causing environmental problems.

Most technical applications of SCBA have been in the area of civil engineering, using SCBA as partial replacement of cement in concrete (Chusilp et al. [7], Srinivasan and Sathiya [8], Abbasi and Zargar [9]). The successful application of SCBA in concrete should encourage research on its applicability in other areas of engineering. However, this material was never applied to use in the drilling mud. Therefore, this work intends to use SCBA as the filtration control additive in water based drilling mud. Some more objectives are comprised of determining the physical and chemical properties of SCBA and water based drilling mud mixed with SCBA and study the effects of temperature and mixed ratio on the fluid loss properties of drilling mud mixed with additive.

2. Materials and Methods

2.1 Materials

The materials used in this work are barite, bentonite, and SCBA. The barite was assisted by Gloden Lime Public Co., Ltd. The bentonite was supported from Thai Nippon Chemical Industry Co., Ltd. The SCBA was collected during the cleaning operation of a boiler operating in Prachuap Sugar Industry Co., Ltd., located in the city of Kanchanaburi, Thailand.

2.2 Sample Preparation and Analysis

The SCBA was air dried and then crushed to fine particles. The ensuring ash was then sieved sizes to less than 75 micrometers (mesh No.200) before storing in zip lock bags. The materials are divided into two parts for chemical properties test and physical properties test.

Mud samples were prepared with varying amount of the various concentrations of SCBA at 1, 3 and 5% weight by weight. The composition of the various mud samples is presented in Table 1. Briefly, using 60 grams of bentonite per 1,000 milliliters of water, 100 grams of barite and amount of concentrations of SCBA were mixed together for 15 minutes by using the high-speed mixture. During mixed, the SCBA is added slowly to agitate the base fluid to avoid a lump occurring within mud system.

Table 1 Composition of mud samples

Mud composition	Water (ml)	Barite (g)	Bentonite (g)	SCBA (g)
Based mud	1,000	100	60	-
Based+ 1% SCBA	1,000	100	60	11.60
Based+ 3% SCBA	1,000	100	60	34.80
Based+ 5% SCBA	1,000	100	60	58.00

2.3 Chemical Properties Analysis

X-ray Fluorescence (ED-XRF, Horiba XGT-5200) was used to determine the samples chemical composition. Mineralogical analysis was performed via X-ray Diffraction (XRD) using a Bruker-D2 Phaser. In addition, evaluate the texture and particle shapes of the samples were observed by Field Emission Scanning Electron Microscope (FE-SEM), using a model Carl Zeiss, AURIGA. These chemical properties of additives are determined both before and after mixed with drilling mud.

2.4 Physical Property Analysis

Determination of mud density

The mud balance is used to determine the density of the drilling mud. The instrument consists of a constant volume cup with a lever arm and rider calibrated to read directly the density of the fluid. Before testing densities of drilling mud samples, mud balance must first be calibrated by using water as the sample. The density of water is 1 gm/cc. After measuring density of mud samples, the true density is calculated.

Measurement of mud filtration loss

Static filtration test was carried by using an API filter press. API RP 13B-1 [10] was strictly followed during the experiment. The filtration test was conducted for 30 minutes of filtration. Filtration control characteristics of the mud samples were demonstrated by the filtrate volume and the thickness and consistency of the filter cake (the residue) deposited on the filter paper after 30 minutes of filtration. The filtrate volume and filter cake characteristics for each of the samples tested were measured and recorded accordingly. The mud filter cake thickness is measured to the nearest millimeter.

Hydrogen ion tests

API RP 13B-1 [10] recommended method for the hydrogen ion (pH) measurement of drilling mud is with a glass electrode pH meter. This method is accurate and gives reliable pH values, being free of interference if a high quality electrode system is used with a properly designed instrument. The pH measurements of the fluids are conducted using the OAKTON pH 700 model electrode pH meters. The instrument determines the pH of an aqueous solution by measuring the electro potential generated between a glass electrode and a reference electrode. Measurement of drilling mud (or filtrate) pH and adjustments to the pH are fundamental to drilling fluid control. Clay interactions, solubility of various components and contaminants, and effectiveness of additives are all dependent on pH, as is the control of acidic and sulfide corrosion processes.

3. Results and Discussion

Assessments on application of SCBA as fluid loss control agent in water based drilling mud on API standard requirement were investigated. The results on density, fluid loss, and pH obtained when the SCBA muds subjected to the temperature of various at 25, 50 and 80°C, emulating drilling well conditions and compared with water based drilling mud using SCBA as additive with various concentrations in 1, 3 and 5% w/w.

3.1 Chemical Properties Analysis

The chemical composition of SCBA was determined using X-ray Fluorescence (XRF), the result is given in Table 2. The major oxide observed in SCBA is silicon dioxide (SiO_2), which is about 88.379%. The main chemical components of drilling mud after mixed with 5% w/w of SCBA in three temperatures has the cognate components dominantly are SiO_2, Al_2O_3, MgO, and Fe_2O_3. However, the chemical compositions of drilling mud depend on the amount of bentonite, barite, and concentrations of SCBA.

The XRD pattern of the SCBA is shown in Fig. 1 and Table 3 presents the major minerals of SCBA. The following crystalline phases were found: barite, quartz, calcite, anorthite, kaolinite, and gypsum with predominance of quartz (SiO_2). The analysis of the SCBA shows the amorphous silica formation with traces of low quartz [11]. The SCBA samples chemical compositions provided by Table 2. According to said data, the SCBA sample contains a large amount of silica (88.379%). This result is consistent with the X-ray Diffraction pattern Fig. 1.

The major minerals of drilling mud after mixed with 5% w/w of SCBA included barite, quartz, gypsum, kaolinite, calcite, rutile, and tobermorite (Table 3 and Fig. 2). A significant amount of tobermorite is formed leading to a denser and more stable structure of the samples [12]. Thus, the amount of tobermorite advocate to increase strength of drilling mud, which effect to the rheology properties.

SCBA and mud filter cake by Field Emission Scanning Electron Microscopy (FE-SEM) are shown in Fig. 3 and Fig. 4. It reveals that the particle shape of SCBA has an irregular shape with rough surfaces and small porous textures (Fig. 3a-b).

Fig. 4(a) shows that the surface mud filter cake of the based mud is shows uneven, thin sheet of bentonite clay larger and smaller particles of barite. Fig. 4(b) shown that after mixed with 5%w/w of SCBA, mud filter cakes are dense on their surfaces and distribution of particles SCBA into pores of mud filter cakes in tight connection, with no big pores and filtrate loss is less.

The results of chemical and mineral analysis found that the temperature in the study is 25, 50 and 80°C, which not change the structure of chemical and mineral of drilling mud presents. Hence, the drilling mud after mixed with SCBA change the content of chemical and minerals that depended on the mixed ratio.

Table 2 Chemical compositions of various materials

Compounds	Chemical compositions (weight %)							
	Bentonite	SCBA	Based 25°C	Based 50°C	Based 80°C	Based+ 5% SCBA 25°C	Based+ 5% SCBA 50°C	Based+ 5% SCBA 80°C
MgO	4.941	1.283	4.914	4.651	5.248	4.750	3.965	3.288
Al_2O_3	16.276	-	14.694	15.278	14.992	12.380	11.572	12.228
SiO_2	55.619	88.379	66.527	65.774	67.560	69.874	70.429	71.460
K_2O	0.634	3.712	0.561	0.526	0.514	1.447	1.362	1.425
CaO	4.485	2.034	2.852	3.740	3.064	2.671	1.937	2.586
Fe_2O_3	14.195	2.848	4.774	5.951	5.931	4.711	4.249	4.474
SrO	0.049	-	0.343	0.457	0.370	0.123	0.123	0.121
Rh_2O_3	0.111	0.103	0.262	0.370	0.292	0.326	0.381	0.343
BaO	-	-	5.073	3.253	2.029	3.718	5.982	4.075
Others	3.690	1.641	-	-	-	-	-	-
Total	100	100	100	100	100	100	100	100

Table 3 Mineral compositions of various materials

Compounds	Mineral content (weight %)							
	Bentonite	SCBA	Based 25°C	Based 50°C	Based 80°C	Based+ 5% SCBA 25°C	Based+ 5% SCBA 50°C	Based+ 5% SCBA 80°C
Barite	-	0.299	48.731	55.515	53.515	48.842	45.004	47.774
Quartz	0.113	73.123	14.518	8.894	11.716	15.849	17.778	14.105
Calcite	18.627	1.851	5.214	1.666	5.601	3.166	2.893	3.234
Anorthite	1.651	6.005	2.722	0.103	1.471	2.942	3.692	2.203
Kaolinite (Bish)	14.726	13.038	2.679	3.868	4.727	6.567	5.241	7.192
Gypsum	0.962	5.684	0.809	2.080	0.917	1.805	1.322	1.792
Chromite	2.057	-	0.252	0.800	0.172	-	-	-
Silica lebail	11.947	-	-	0.002	0.341	-	-	-
Talc	28.508	-	17.271	20.519	14.293	1.733	3.729	4.554
Nacrite	2.069	-	1.568	2.650	2.674	2.948	3.182	2.424
Microcline intermediate1	13.553	-	5.051	3.113	3.647	-	-	-
Hematite	5.787	-	1.185	0.790	0.926	0.836	0.675	0.883
Periclase	-	-	-	-	-	0.061	0.900	0.079
Rutile	-	-	-	-	-	3.013	3.241	3.428
Tobermorite	-	-	-	-	-	12.238	12.343	12.332
Total	100	100	100	100	100	100	100	100

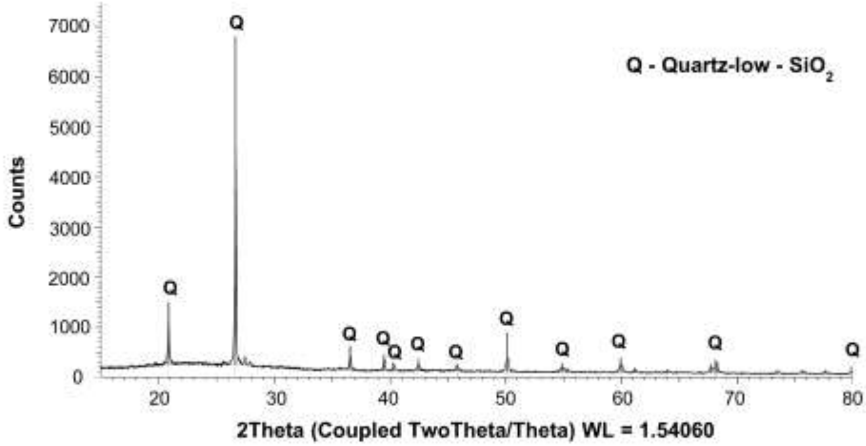


Fig. 1 XRD pattern of SCBA

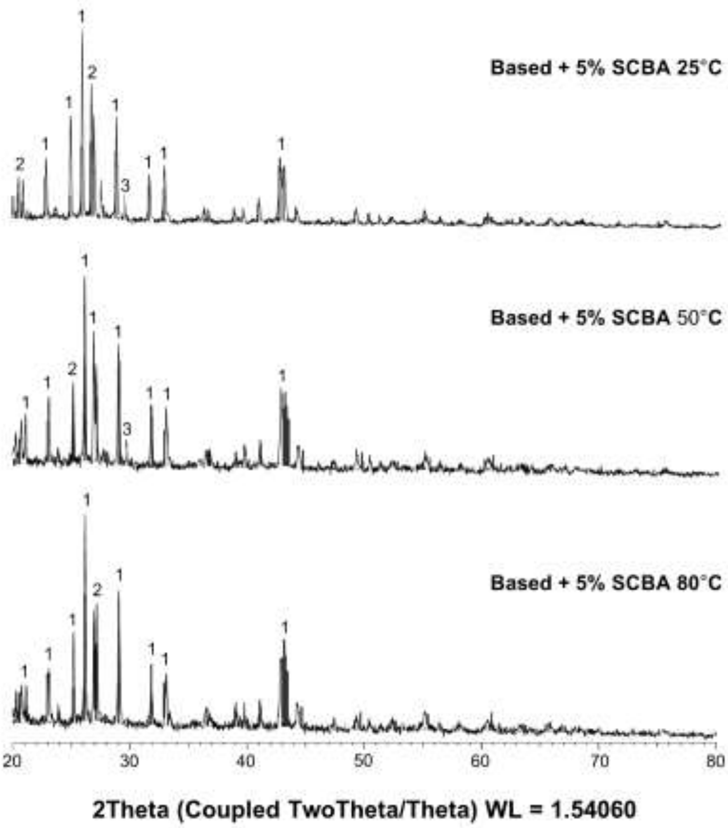
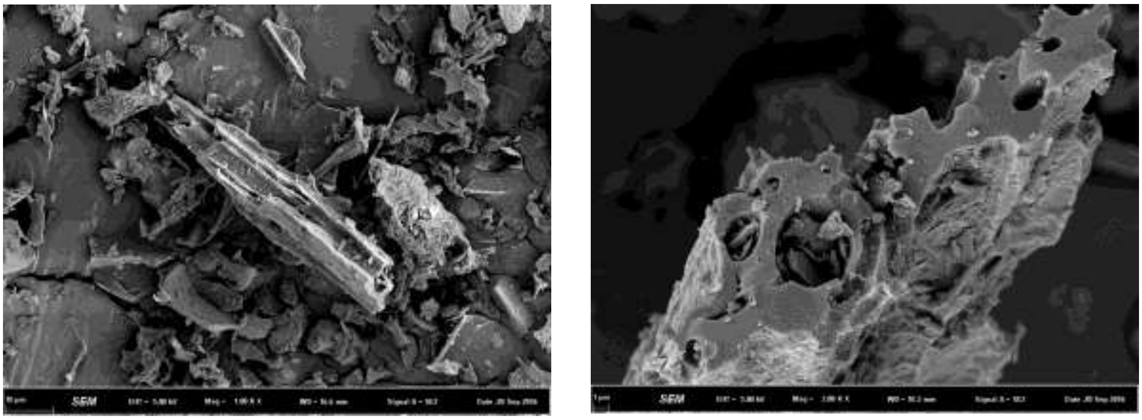
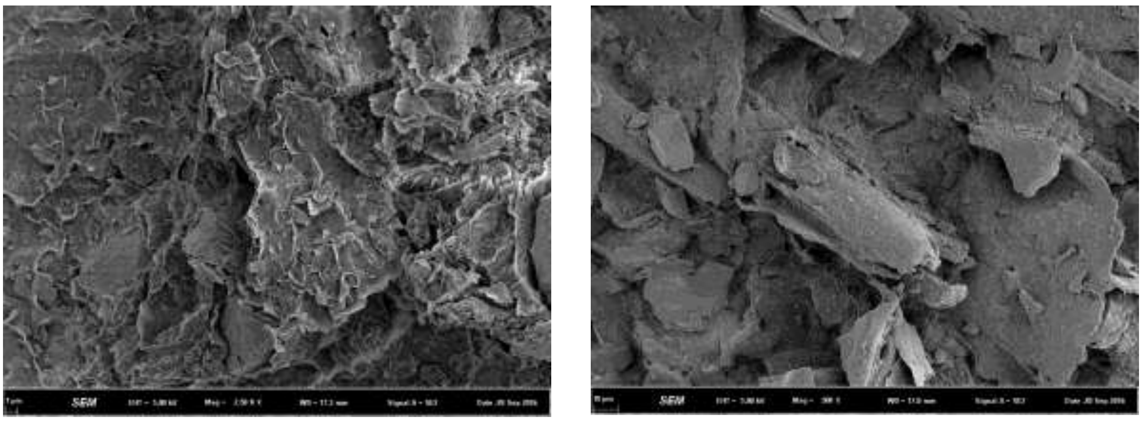


Fig. 2 XRD pattern of drilling mud mixed with SCBA 5% w/w at 25°C (1 = barite; 2 = quartz; 3 = calcite)



(a) (b)

Fig.3 SEM images of SCBA



(a) (b)

Fig. 4 SEM images of (a) mud filter cake formed by based mud and (b) mud filter cake formed by based mud+ 5%w/w SCBA (both of the mud filter cake at temperature 25°C).

3.2 The effect of SCBA on density

The relative of density, temperature and SCBA content are presented in Fig. 5. Mud density slightly decreased with increasing temperature, but the density of drilling mud is increased by adding SCBA content with increasing. Meanwhile, the density of drilling mud using SCBA as additive in 1 and 3% w/w has the same value in all temperatures.

.

3.3 The effect of SCBA on filtration loss

Investigation of the filtration loss properties was carried out using an API low pressure, low temperature filter press (LPLT) manufactured by Baroid (model series 300). The working pressure is 100 psig and pressurized nitrogen gas cylinders is used to measure the discharged filtrate

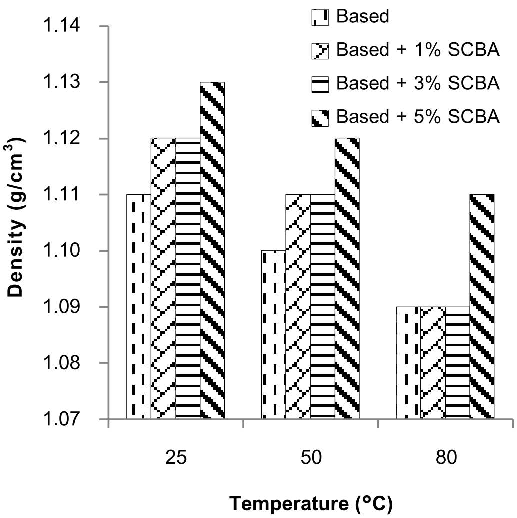
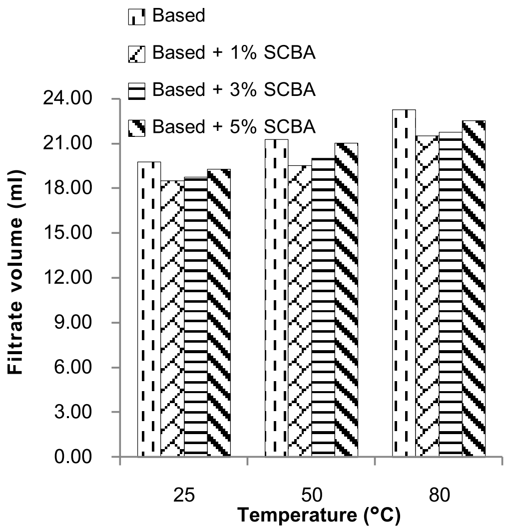


Fig. 5 The density of drilling muds mixed with SCBA

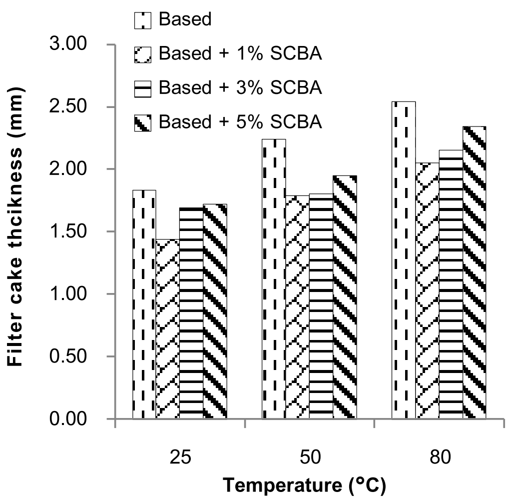
The result of the filtration volume and filter cake thickness experiment of each drilling mud after 30 minutes are presented in Table 4 and shown graphically in Fig. 6. Physical examination of the filtrate volume indicates that filtrate volume increases as the time and temperature increase (Fig. 7). The filter cake of based mixed with 1% SCBA at 25, 50 and 80°C was thinner (1.44 mm, 1.79 mm, and 2.05 mm thickness, respectively). From Table 4, shows the filtration volume of based mud mixed with various SCBA concentrations at 25, 50 and 80°C, which produced the least filtrate volume, demonstrated better filtration control characteristics than based mud. However, from FE-SEM image, Fig. 4(a) the mud filter cake formed is of a poor, causing to form a high permeability mud filter cake. While, Fig. 4(b) shows the mud filter cake are distributed of particles SCBA into pores of mud filter cakes in tight connection. It represents that adding a quantity particle SCBA reacts more effectively with water based to result in seal a porous layer, lower filtration loss and prevents the filtrate in the drilling mud leaking to formation.

Table 4 Filtrate volume from the various drilling mud

Drilling mud	Temperature at		
	25 °C	**50 °C**	**80 °C**
	Filtrate volume (ml)		
Based	19.75	21.25	23.25
Based+ 1% SCBA	18.50	19.50	21.50
Based+ 3% SCBA	18.75	20.00	21.75
Based+ 5% SCBA	19.25	21.00	22.50
Drilling mud	Filter cake thickness (mm)		
Based	1.83	2.24	2.54
Based+ 1% SCBA	1.44	1.79	2.05
Based+ 3% SCBA	1.69	1.80	2.15
Based+ 5% SCBA	1.72	1.95	2.34



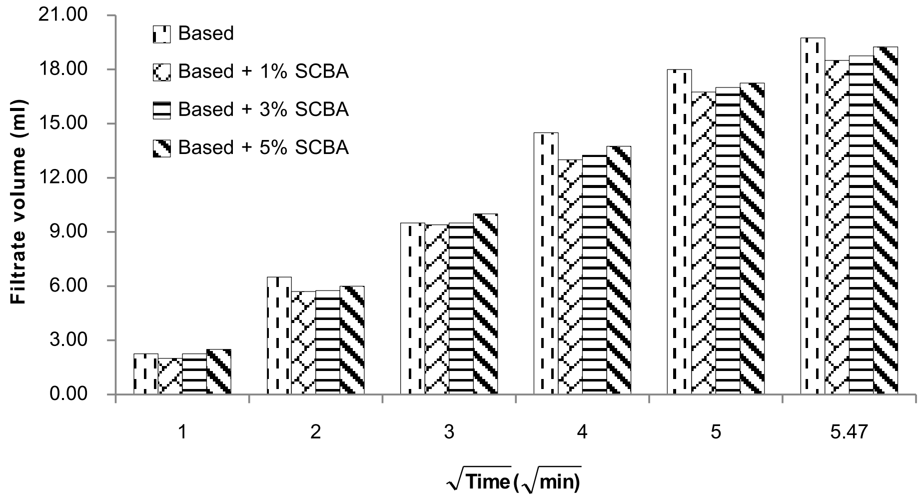
(a)



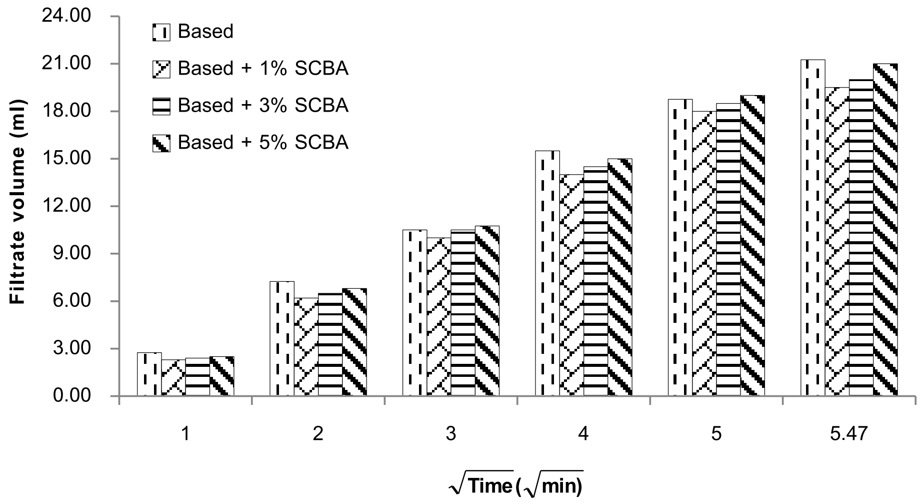
(b)

Fig. 6 The filtration volume evaluation of drilling mud mixed with SCBA (a) filtrate volume and (b) filter cake thickness

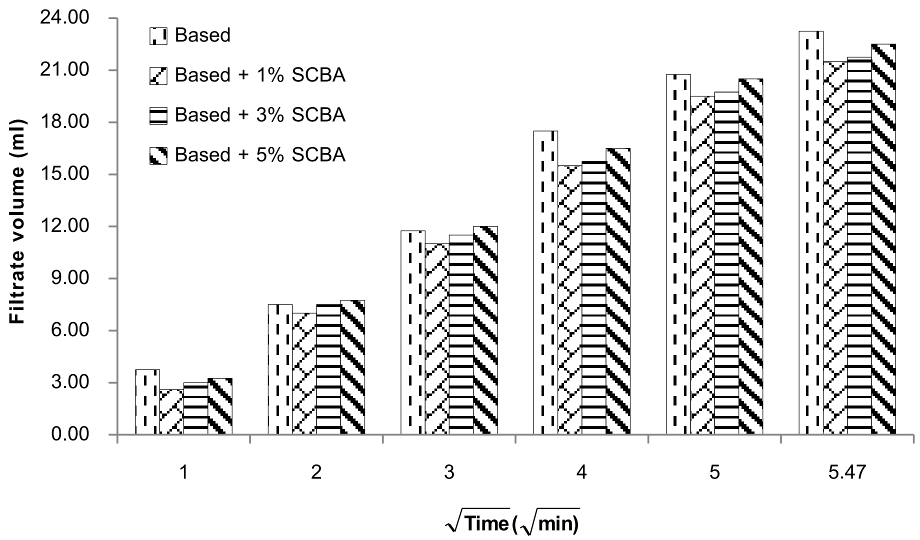
Hence, SCBA have proved to possess good filtration control properties which were major responsible for the thinner filter cake and minimal filtrate volume produced is based mixed with 1% SCBA, but increasing the concentration of SCBA to 3% and 5% did not result to better filtration characteristics.



(a)



(b)



(c)

Fig. 7 The filtration volume evaluation of drilling mud mixed with SCBA at temperature (a) 25°C, (b) 50°C, and (c) 80°C

3.4 The effect of SCBA on pH

The result presented in Fig. 8 revealed that all drilling mud was in a moderate alkaline state (pH more than 7-8). Meanwhile, the pH of drilling mud mixed with SCBA was found to be higher than that of the based mud. However, the pH decreased as the effect of temperature increased. It is implied that the more of SCBA concentration, the reduced mud alkalinity. Although, corrosion rate decreases as pH increases, but the pH decreased as the SCBA concentration increased.

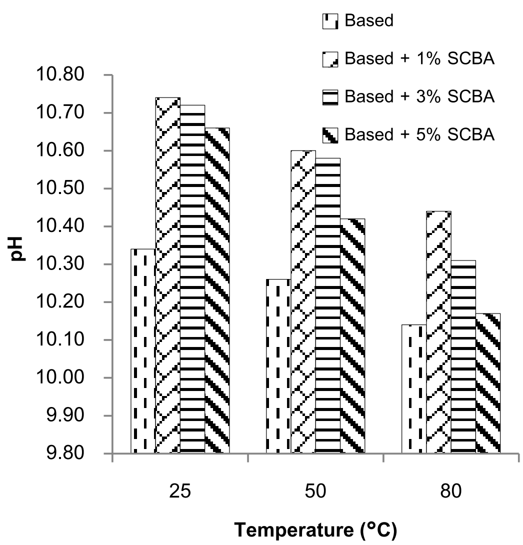


Fig. 8 The pH evaluation of drilling mud mixed with SCBA

4. Conclusions

The result of filtration test indicated the fluid loss and filter cake thickness of drilling mud mixed with SCBA in 1, 3 and 5% w/w at temperature 25, 50 and 80°C were better than based mud. Physical examination of the filtrate volume indicates that filtrate volume and filter cake thickness increases as the concentration of SCBA and temperature increasing. The drilling mud mixed with 1% w/w of SCBA exhibited the best filtration control characteristics with minimal filtrate volume and thinner and consistent mud filter cakes. But increasing the quantity of SCBA to 3 and 5% did not result to better filtration characteristics. The major oxide observed in SCBA is SiO_2 (88.379%). Meanwhile, the major minerals of SCBA with predominance of quartz (73.123%) and shows the amorphous silica formation. The results of chemical and mineral analysis found that the temperature, which does not change the structure of chemical and mineral of drilling mud. However, the drilling mud after mixed with SCBA was changed the content of chemical and minerals that depended on the mixed ratio.

Acknowledgments

This work is supported by Suranaree University of Technology and by Higher Education Research Promotion and National Research University of Thailand, Office of the Higher Education Commission. Permission to publish this paper is gratefully acknowledged. The author is also thankful to all the staff of Suranaree University of Technology laboratory for allowing using analyzes equipment and their advice.

References

[1] Khodja, M., Khodja-Saber, M., Canselier, J.P., Cohaut, N. and Bergaya, F. 2010. Drilling fluid technology: performances and environmental considerations. In: Products and Services; from R&D to Final Solutions. Füerstner, I. (ed). Sciyo, Rijeka, Croatia.

[2] Caenn, R., Darley, H.C.H. and Gray, G.R. 2011. Composition and properties of drilling and completion fluids. 6th edition, Gulf Professional, Boston.

[3] Korsinwattana, P. and Terakulsatit, B. 2014. Efficiency enhancement of drilling mud by using fly ash as an additive. Proceedings of International Conference on Advances in Civil Engineering for Sustainable Development,

Suranaree University of Technology, Nakhon Ratchasima, Thailand, Aug. 27-29, 2014: 531-536.

[4] Samavati, R., Abdullah, N., Tahmasbi Nowtarki, K., Hussain, S.A. and Awang Biak, D.R. 2014. The prospect of utilizing a cassava derivative (fufu) as a fluid loss agent in water based drilling muds. International Journal of Chemical Engineering and Applications, 5(2): 161-169.

[5] Igwe, I. and Kinate, B.B. 2015. The use of periwinkle shell ash as filtration loss control agent in water-based drilling mud. International Journal of Engineering Research and General Science, 3(6): 375-381.

[6] Modani, P.O. and Vyawahare, M.R. 2013. Utilization of bagasse ash as a partial replacement of fine aggregate in concrete. Procedia Engineering, 51: 25-29.

[7] Chusilp, N., Jaturapitakkul, C. and Kiattikomol, K. 2009. Utilization of bagasse ash as a pozzolanic material in concrete. Construction and Building Materials, 23(11): 3352-3358.

[8] Srinivasan, R. and Sathiya, K. 2010. Experimental study on bagasse ash in concrete. International Journal for Service Learning in Engineering, 5(2): 60-66.

[9] Abbasi, A. and Zargar, A. 2013. Using baggase ash in concrete as pozzolan. Middle-East Journal of Scientific Research, 13(6): 716-719.

[10] API RP 13B-1. 1997. API recommended practice standard procedure for field testing water-based drilling fluids. API Standard API RP 13B-1. American Petroleum Institute, Washington, D.C.

[11] Hussein, A.A.E., Shafiq, N., Nuruddin, M.F. and Menon, F.A. 2014. Compressive strength and microstructure of sugar cane bagasse ash concrete. Research Journal of Applied Sciences, Engineering and Technology, 7(12): 2569-2577.

[12] Kolias, S., Kasselouri-Rigopoulou, V. and Karahalios, A. 2005. Stabilisation of clayey soils with high calcium fly ash and cement. Cement and Concrete Composites, 27(2): 301–313.