Simposium Jurutera Kimia ke-13, Selangor, 3031 Oct. 2000

LABORATORY INVESTIGATIONS ON MALAYSIAN LOCAL BENTONITE AS A FLUID LOSS AGENT IN OIL- WELL CEMENT SLURRY

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KEYWORDS

Bentonite; fluid loss agent; cement additive; cementing; montmorillonite.

ABSTRACT

This paper presents the result of laboratory works related to the used of Malaysian bentonite as fluid loss control agent in oil-well cement compared with the commercially used, Wyoming bentonite of USA. Lahad Datu and Tawau were Malaysian bentonite sampling areas. Treatments have been carried out to local bentonite to up grade its performance in the cement slurry. Cement sets were tested on filter press tester in two different conditions according to the API Specification 10. In addition characterization analysis and methylene blue tests were carried out for bentonite samples. From laboratory investigations, it is shown that Malaysian bentonite contains impurity materials such as quartz, feldspar, kaolinite and illite, and has CEC value lower than Wyoming bentonite. Malaysian untreated bentonite gives poor fluid loss control than Wyoming bentonite, while after treatment processes, local bentonite shows an improvement as a fluid loss control agent.

INTRODUCTION

Fluid loss is a loss of water phase from the slurry to the formation during slurry placement operation. As the fluid is forced out of the cement slurry, the density of slurry increased, and if a large volume of water is lost, the slurry became too viscous or too dense to be pumpable. Therefore the success of many cementing operations is primarily dependence on the controlling fluid loss rate.

For more than 25 years, fluid loss control agents had been added to the oil- well cement slurries and it is now recognized in industry that the quality of cementing has significantly improved. Indeed, it is clearly acknowledged that a lack of fluid loss control may be responsible for primary cementing failures, due to extensive density increase or annulus bridging and that formation invasion by cement filtrate may has influenced the well productivity.

Bottom static temperature, differential pressure, and formation characteristics are the factors that influenced the fluid-loss rate. Fluid loss often occurs in the high permeability formation or as high-density cement slurry is pumped into the well. Fluid loss test is designed to measure the dehydration and filtrate characteristics of cement slurries during cementing treatment. The API (1990) specifies a standardized 30-minute test at test temperature and a differential pressure of 1000psi. Neat cement has a fluid-loss rate in excess of 100 cubic centimeter per 30 minute (cc/30-min). Varying concentrations of fluid-loss additive will give various fluid-loss rates. In general, fluid-loss rate and their interpretations accepted are good control at 0-200cc/30 min, moderate control at 200-500cc/30 min, fair control at 500-1000cc/30 min and cannot control the fluid loss rate more than 1000cc/30 min. In addition, the typical values of fluid-loss rate for casing cementing is 250-300cc/30min, liner cementing is 50cc/30min, prevention of gas channeling is 20cc/30min and for squeeze cementing is 50-200cc/min (Smith, 1991).

In order to prevent fluid loss and to maintain slurry characteristics, fluid loss control agents (such as bentonite, a sodium montmorillonite) are added to the cement slurry. Bentonite entered the filter cake, lodges between particles and reduced the permeability of the cement filter cake that is deposited on the formation surface when the fluid loss started.

Commercial bentonite quality problems and quality control methods have been studied in the recent years. Therefore, the objective of this paper is to study a possibility of Malaysian bentonite application as a fluid loss agent for oil-well cementing operations.

LABORATORY WORKS

Malaysian bentonite samples were collected from two different areas in Sabah; i.e. Mansuli area (sample M4) at Lahad Datu district, and Andrassy area (sample SA5) at Tawau district. The commercially world -wide Wyoming bentonite of USA was used for comparison and correlation. Sampling has carried out by using, Dormer auger from the required exact depth. The samples were dried in the oven for overnight at 55^0C. then crashed and ground into powder form. The powder was sieved into size of 75μm. This study focuses on blended a G-class cement with dry bentonite at concentration of 2% to 16% by weight of cement (BWOC) and evaluated its fluid loss performance. The cement slurry has been prepared according to API Spec 10 Section 5. In addition, local bentonite has been treated with Na_2Co_3 (dry and wet processes) in order to improve its performance.

More than 145 cement sets were tested on filter press tester to measure the fluid loss filtration according to API Specification 10. In addition, characterizations of bentonite samples have been examined by using XRD & XRF techniques. Using the SIEMEN D-500 X-ray diffract meter unit to determine the mineralogical contents of the bentonite samples has carried the XRD experiment. While automated Phillips PW1480 X-fluorescence spectrometer has been used for XRF technique to determine the chemical contents of the bentonite materials. Moreover methylene blue test was carried out according to API 13B to estimate the cation exchange capacity (CEC).

RESULTS AND DISCUSSIONS

Characterization Analysis

From Table 1 it can be seen that Wyoming bentonite samples (WY-BEN) contains more montmorillonite mineral than the local bentone. In addition, the local bentonite samples contain impurity minerals such as quartz, kaolinite, illite and feldspar.

XRF data in Table 2 shows the amount of SiO_2 is higher in all bentonite samples, which indicated the presence of quartz as previously, discussed. Na_2O amount is higher in Wyoming bentonite than untreated local bentonite, but the Na_2O amounts increased in treated local bentonite, especially in the dry process samples. Fe_2O_3 amount is higher in all local bentonite samples indicating the presence of hematite mineral.

CEC

Table 3 lists the average CEC of various bentonite samples. It shows that untreated local bentonite samples have lesser values of CEC (25 &30 meq/100g) due to the presence of other minerals such as quart, kaolinite, illite and feldspar. CEC values of local bentonite samples after treatment have been improved, that

TABLE 1: Semi- quantitative Mineral Compositions Analysis of Bentonite Samples by X-ray Diffraction XRD

Minerals	Wyoming bentonite (WY-BEN)	Local bentonite before treatment (SA5-BT)	Local bentonite after dry process (SA5-DP)	Local bentonite after wet process (SA5-WP)	Local bentonite before treatment (M4-BT)	Local bentonite after dry process (M4-DP)	Local bentonite after wet process (M4-WP)
Montmril -lonite	* * * *	* *	**	*	*	*	*
Quartz	* *	* * *	***	***	***	***	* * *
Feldspar	Nd	Nd	Tr Orthoclase	* albite	* muscovite	Tr Muscovite	* muscovite
Kaolinite	Tr	*	*	**	*	*	*
Others	Tr Illite	* illite	* illite	Nd	* illite	* illite	* illite

Key :- * * * * : dominant ; * * * : major ; * * : appreciate ; * : minor/ small; Tr: trace ; Nd : not detected

TABLE 2: Chemical Composition of Bentonite Samples by X-ray Fluorescence (XRF)

-	Local bentonite before treatment SA5-BT	Local bentonite after dry process SA5-DP	Local bentonite after wet process SA5-WP	Wyoming bentonite WY-BEN	Local bentonite before treatment M4-BT	Local bentonite after dry process M4-DP	Local bentonite after wet process M4-WP
SiO_2	55.22	48.20	63.06	65.48	63.10	53.86	55.52
TiO_2	0.70	0.60	0.68	0.13	0.71	0.62	0.69
Fe_2O_3	8.35	7.21	7.60	3.79	7.11	6.79	8.14
Al_2O_3	22.21	19.26	16.60	18.77	16.94	16.10	20.59
MnO	0.04	0.03	0.06	0.02	0.07	0.05	0.04
CaO	0.53	0.49	0.20	1.18	0.19	0.27	0.50
MgO	0.55	< 0.01	1.04	1.04	1.12	0.54	0.50
Na_2O	< 0.01	9.96	1.30	2.03	0.29	7.73	2.42
K_2O	0.47	0.46	2.29	0.78	2.35	1.60	0.75
P_2O_5	0.02	0.01	0.03	0.06	0.03	0.02	0.02
L.O.I	11.92	14.61	7.15	6.63	8.12	11.46	10.85
Total %	100.01	100.83	100.01	100.21	100.03	99.04	100.02

due the presence of sodium content in its structural composition during ionic exchange (Ca^{+2} / Mg^{2+} / Al^{+3} replaced by Na^{+}). Tables 3 also shows that the treated local bentonite samples with dry process have higher values of CEC (40 & 45 meq/100g) as compared with the wet process samples (30 & 40 meq/100g) but still lower than Wyoming bentonite.

TABLE 3: Cation Exchange Capacity (CEC) Data

Samples	CEC values for Untreated Bentonite (meq/100g)	After Treatment Processes	
		CEC values for Dry Process (meq/100g)	CEC values for Wet Process (meq/100g)
SA5-Local Bentonite	30	45	35
M4-Local Bentonite	25	40	30
WY-BEN-Wyoming Bentonite	70	-	-

Fluid Loss Performance

As clearly shown in Figure 1 that the fluid loss of cement slurry decreases with higher amount of Wyoming bentonite added to the cement slurry. This is understandable since Wyoming bentonite of sodium montmorillonite clays (as previously discussed) has highest swelling capacity, which is responsible for viscosity build up and formation of low permeability filter-cake. Figure 1 also shows that fluid loss increases with higher percentage of untreated local bentonite samples added to the cement slurry. This is because the local bentonite contains a lot of impurities, which could effect the capability to build up filter cake of low permeability and also having low swelling capacity.

On other hand, it was shown in the Figure 2 that the fluid loss of local bentonite samples has been improved after treatment processes. It shown in Figure 2 that the higher amount of treated local bentonite added to the cement slurry, the less would be that the fluid loss content of cement slurry provided the amount is less than 2% BWOC. If the amount of bentonite added is more than 2% BWOC, the fluid loss increases up to 8% BWOC of treated local is added, after which the fluid loss decreased with increases amount of bentonite added.

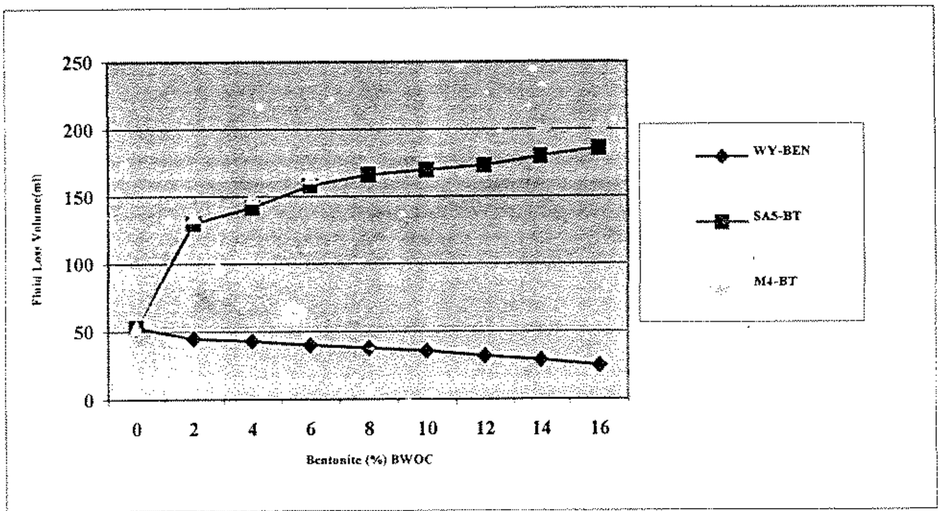

FIGURE 1: Fluid Loss of Cement Slurry with Various Amount of Untreated Bentonite at Room Condition

As shown in Figure 2 and Figure 3 the dry process local bentonite samples had better control of fluid loss compared to wet process samples, but not as good as Wyoming bentonite.

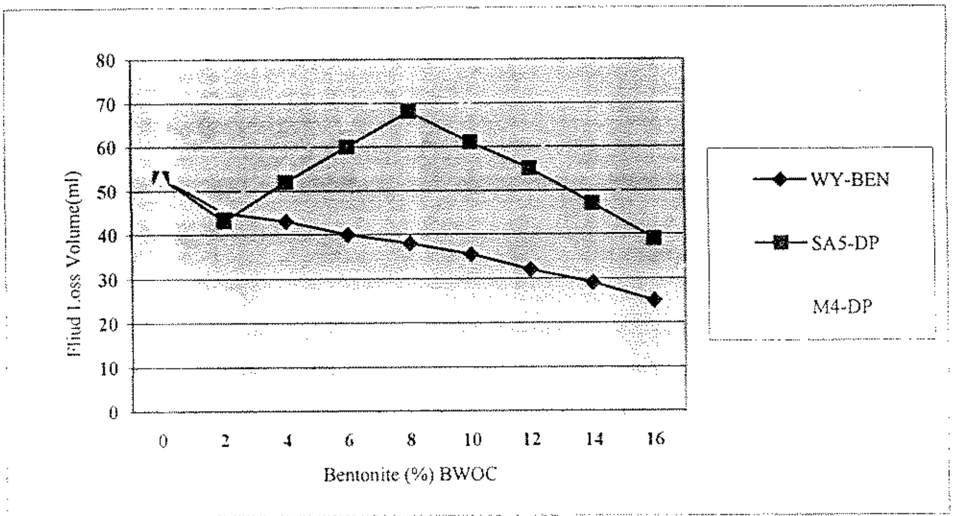

FIGURE 2: Fluid Loss of Cement Slurry with Various Amount of Bentonite After Dry Process at Room Condition

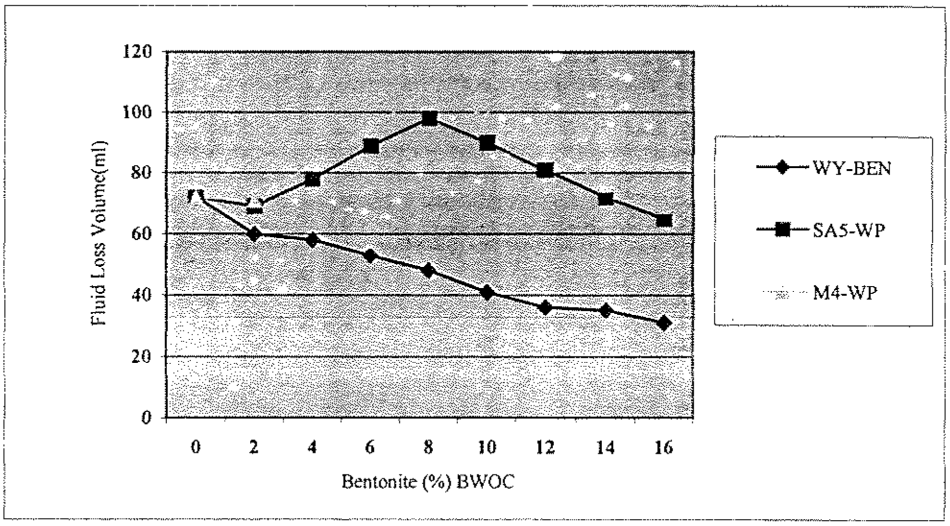

FIGURE 3: Fluid Loss of Cement Slurry with Various Amount of Bentonite After Wet Process at Room Condition

CONCLUSIONS

From the laboratory investigation, it can be concluded that:

1) Local bentonite samples contain less amount of montmorillonite mineral and more impurities materials such as kaolinite, illite, quartz and feldspar, while Wyoming bentonite is considered as high- quality bentonite because it contains more montmorillonite mineral.

2) Performance of untreated local bentonite as a fluid loss agent is not as good as a Wyoming bentonite, since the local bentonite contains less Na^+ and more impurities than Wyoming bentonite, and less CEC value.

3) Performance of Malaysian bentonite as a fluid loss agent can be improved through dry / wet treatment processes if the amount used is not more than 2% BWOC.

NOTATION

API = American Petroleum Institute.
BWOC = By weight of cement (all bentonite concentrations are BWOC).
CEC = Cation Exchange Capacity.
BT = Before treatment.
DP = After dry process.
WP = After wet process.
WY-BEN = Wyoming bentonite sample.
XRD = X-ray diffraction.
XRF = X-ray fluorescence.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Petroleum Engineering, Faculty of Chemical and Natural Resources Engineering (UTM) for all facilities to carry out the experimental works.

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