Possibility Studies Of Using Local Cement In Oil And Gas Wells Cementing Operations In Malaysia

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ABSTRACT

Portland cement, which is primarily a construction material, is used extensively in oil and gas wells. To justify its ability to be used in the oil wells cementing operations, portland cement must comply with the standards set by the American Petroleum Institute (API) interms of their chemistry and physical properties requirements. Therefore, to determine the suitability of our locally produced portland cement and pulverize fly ash cement; compressive strength, thickening time, fluid loss and free water test were carried out closely followed the API Specification 10. Generally, locally produced cement proved to comply to the API Specification and has the possibility to be used in cementing operations.

INTRODUCTION

Portland cement is a hydraulic product made by burning and grinding a mixture of calcareous and argillaceous materials, such as limestone and clay, limestone and shale, limestone and marl, chalk or limestone and iron blast furnace slag and sometimes, portland cement itself being blend with fly ashes to obtain blended cement. Although to most of us, portland cement is primarily known as a construction cement but it is also being used extensively in oil-well cementing operations which helps to seal the annulus between the wall of the wellbore and the casing, to provide zonal isolation, to protect the casing against aggressive wellbore fluids and to protect the casing against collape by rock creeping in on the wellbore.

In order to be able to be used as an oil well cement, portland cement or blended portland cement must comply in terms of their chemistry and physical properties to the standards set by the American Petroleum Institute (API) [1].

The purpose of this paper are to present the laboratory data on the comparison studies done on class G portland cement, ordinary portland cement (Opc) and pulverize fly ash cement (pfa).

LABORATORY WORK

All conducted experiments were closely followed the Specification for Materials and Testing for Well Cements (API Specification 10, Fifth Edition, July 1,1991)[1]. The test conducted were: 1) the fluid loss, thickeniing time, and compressive strength tested at simulated reservoir condition for class G , pfa and opc cement., 2) the fluid loss with 100 psi differential pressure, thickening time at simulated reservoir condition and free water for class G and pfa cement added with different percentage of additive. Different percentage of additives used were based on by weight of cement (BWOC). Four runs were conducted for each test and the average value is recorded.

FILUID LOSS TEST

In the high pressure and high temperature fluid loss test, slurry is prepared according to Section 5, and immediately placed in the preheating atmospheric pressure consistometer and stirred for 20 minutes. The slurry is then poured into the preheated high pressure filter press and maintained at the final temperature of the schedule for the duration of the test.
For the 100 psi differential pressure fluid loss test, prepared slurry is immediately place in the atmospheric pressure consistometer and stirred for 20 minutes. The slurry is then placed in the filter press as quickly as convenient handling will allow and filtrate reading is taken at 1/4, 1/2, 1, 2, and 5 minutes interval, until 30 minutes have elapsed.

COMPRESSIVE STRENGTH TEST

In compressive strength test, again slurry is prepared according to section 5, and immediately poured in the prepared molds in a layer equal to 1/2 of the mold depth and puddled for 25 times per specimen with a puddling rod. After puddling the layer, the remaining slurry is stirred to eliminate segregation and the molds are filled to overflowing and puddled as before. The prepared molds are then placed in the high pressure high temperature curing chamber and cured according to schedule 5g, Well Simulation Test Schedules for Curing Compressive Strength Specimens for a period of 8 hours, 24 hours, 3 days and 7 days and then removed and crushed with the compressive strength machine.

THICKENING TIME TEST

In the thickening time test, prepared slurry is immediately poured into the consistometer container and while the slurry is being stirred, the temperature and pressure is increased according to schedule 5 , Specification Test For Classes G and H. Stiring is then continued until the slurry reaches a consistency of 100 Bc, and the same procedures are followed when tested cements with additive.

FREE WATER TEST

For the free water test, prepared slurry is immediately place in the atmospheric pressure consistometer and stirred for 20 minutes. The slurry is then remixed for an additional 35 seconds and followed by pouring it into a 250 ml graduated cylinder. The mouth of the cylinder is sealed and then is placed on a vibration free surface and allowed to stand undisturbed for 2 hours. The volume of water removed from the top of the slurry is recorded as the amount of free water content.

RESULTS AND DISCUSSIONS

FLUID LOSS ANALYSIS

Table 1 shows the amount of fluid loss of each cement tested at 52 degree Celcius circulating temperature, and it was found that pfa-cement released less water as compared to the class G and opc cement. It proves that, during the cement reaction and with the existing of water, fine particles of fly ash will react with the excess calcium oxide and calcium hydroxide produce during the early reaction to form additional cementitious material of tricalcium silicate hydrates which filled the existing voids and thus will reduce the number of voids, and consequently will reduce the permeability of the cement. With higher content of tricalcium aluminate in opc, it will react at a faster rate during hydration and means less water is released compared to class G cement.

Results on fluid loss test at 100 differential pressure when adding with different percentage of fluid loss additive are shown in Table 2 When the content of fluid loss additive is low (0.2 %), pfa cement show a better control in fluid loss as compared to class G cement. However, when the content of fluid loss additive is being increased from 0.2 % to 0.5 %, 1.5 % and 2 %, the class G cement exhibit better control in fluid loss as compared to pfa cement . In the first case; with the help of little fluid loss additive which will adsorped themselves on the formed tricalcium silicate hydrate , they will create an impermeable bonding between the cement grains. and with the fly ash plays its role in reacting with calcium hydroxide to form extra cementitious material, tricalcium silicate hydrate and filled the voids, and as a consequences, these effects will reduced the permeability of the cement. In the other cases, the less content of tricalcium aluminate in class G cement composition helps the cement to react thoroughly during the hydration period and will formed well developed cystals of tricalcium silicate hydrate and with the helped from the adsorped fluid loss additive which filled the pores between the cement grains; this hydrate will create an effective impermeable bonding. In addition, "fluid loss additive is very sensitive to the amount of tricalcium aluminate compound present in the cement composition"[2].

The clear profile of the fluid loss is shown in Figure 1 and 2.

THICKENING TIME ANALYSIS

Table 3 shows the results of the thickening time of each cement tested at 8000 feet and 52 degree celcius. It was found that Opc cement will set at a shorter period, followed by pfa-cement and then class G cement. With the difference in the content of fast reacting substance; that is tricalcium aluminate explains why each cement will set at different time. Chemically, opc cement has the highest amount of tricalcium aluminate (7.85 %) and therefore, will have a very high rate of reaction during hydration period and therefore, will set at a faster time. Pfa-cement which has about 6.28 % of tricalcium aluminate will take a little longer period to set compared to opc cement and of course the class G cement which has about 1.48 % of tricalcium aluminate will have a longer time to set compared to the others.

Table 4 shows the results obtained when the class G and pfa cement are added with different percentage of fluid loss additive. In all cases, the class G cement has higher pumping time compared to the pfa cement. The amount of tricalcium aluminate present in the cement composition has an influence on the setting time of the cement and the amount of fluid loss added also helped to delay the thickening time in the class G cement by delaying the contact of cement grains with water to undergo the hydration process.

COMPRESSIVE STRENGTH TEST ANALYSIS

Results of the compressive strength test cured for different period are shown in table 5. At the 8 hours curing period, opc cement has the higher strength, followed by pfa cement and then class G cement. With high pressure and temperature, high content of tricalcium aluminate, a very fast rate of reaction during hydration and a very fast setting time explains why it has higher strength compared to others. Pfa cement which comes second in setting time has higher strength compared to class G cement.

For 1 day period, opc cement still has the highest strength, followed by class G cement and then pfa cement. Surprisingly the class G cement has higher strength than pfa cement. With low content in tricalcium aluminate; at this period, the hydration process of G cement produce more tricalcium silicate hydrate, the strength substance as compared to pfa cement and therefore its explain why its sterength is higher compared to pfa cement.

The result for 3 days period curing period showed that. opc cement still has the highest strength followed by pfa cement and then class G cement. At this period pfa cement has shown an increased in strength development and it is believed that fly ash has played an important role in providing the strength to the cement with the forming of extras cementitious material of tricalcium silicate hydrate.

The strength development progess for each type of the cement is clearly shown in Figure 3.

FREE WATER ANALYSIS

The results of free water between class G and pfa cement when added with the additive and when mixing with difference percentage of both additives are shown in Table 6through 11. Cenerally, with different percentage of fluid loss additive and retarder and with the mixing proportion of additives, pfa cement prove to have less free water produced compared to the class G cement until when the mixing of fluid loss additive comes to 1.5 %, and 2 %, where by there is no free water for both cement. At this level, both cement were not set. The fly ash content in the pfa cement consume some of the water during its reaction with calcium hydroxide and produce cementitious material and make the cement to set with less free water.

CONCLUSION

In terms of fluid loss, thickening time, compressive strength and free water tested at atmospheric temperature and pressure and simulated reservoir condition , locally produced cement esspecially the pulverize fly ash cement proved to have the properties suitable for the application in the oilwell cementing operations. However, further testings have to be done on adding and mixing with additives to the cement, mixing with sea water and a few others to exactly verify the justification and these are the steps that will be taken for the continuation of this project.

REFERENCE

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Table 1

Fluid-loss tested at 52 deg. C
and 1000 differential pressure.

SAMPLE	FLUID LOSS (ml)
G-CEMENT	340
PFA-CEMENT	314
OP CEMENT	324

Table 2

Fluid loss of cement sample + different percentage of fluid loss additive added and tested at room temperature with 100 psi differential pressure.

Time min.	Percent Fluid Loss Additive Added							
	0.50%		1.00%		1.50%		2.00%	
	G ml	pfa ml	G ml	pfa ml	G ml	pfa ml	G ml	pfa ml
0.25	28	24	4	5	0	0	0	0
0.5	40	34	6.8	8.5	1	1	0	1
1	60	50	11	13.5	1.8	3	1.4	2
2	89	71	18	21	2.8	4	1.2	3
5	125	97	20	37.5	6	7	3	4.5
10	137	107	45	59.5	9.8	11	5.2	7
15	141	114	59	78	12.6	14	7	10
20	143	118	71	88	14.2	17	8.4	11.5
25	144	120	83	100	16.4	19.6	9.6	13
30	145	121	93	103	18.2	22	10.8	15

Table 3

Thickening time of cement sample according to schedule no. 5 API Specification 10

Sample	Time taken to reach 100 Bc
G cement	114
pfa cement	105
op cement	93

Table 4

Thickening time of sample + different percentage of fluid loss additive tested according to schedule no. 5 API Specification 10

	Percent Fluid Loss Additive Added					
	0.50%		1.00%		1.50%	
Consistency bc	G min.	pfa min.	G min.	pfa min.	G min.	pfa min.
40	112	86	154	152	215	158
70	142	116	175	169	230	177
100	169	144	192	184	238	190

Table 5

Compressive strength cured at differen period according to schedule 5 g Api Specification 10

Sample	8 hours Strength psi	1 Day strength psi	3 Days strength psi
G cement	1798	3056	3265
pfa cement	1843	2975	3925
op cement	2715	3156	4125

Table 6

Free water of sample + Fluid loss additive

Additive percent	G cement ml	Pfa cement ml
0	1.3	0.5
0.5	1.8	2.1
1	0.6	0.2
1.5	0.1	0
2	0	0

Table 7

Free water of sample + retarder

Additive percent	G cement ml	Pfa cement ml
0	1.3	0.5
0.2	1.5	1.1
0.5	3.8	2
0.7	1.8	2.2
1	0.9	1.4

Table 8

Free water of sample + different percentage of retarder + 0.5 percent fluid loss additive

Additive percent	G cement ml	Pfa cement ml
0.2 R + 0.5 FL	1.3	1
0.5 R + 0.5 FL	0.85	0.8
0.7 R + 0.5 FL	0.7	0.6
1.0 R + 0.5 FL	0.35	0.2

Table 9

Free water of sample + different percentage of retarder + 1.0 percent fluid loss additive

Additive percent	G cement ml	Pfa cement ml
0.2 R + 1.0 FL	0.25	0.2
0.5 R + 1.0 FL	0	0
0.7 R + 1.0 FL	0	0
1.0 R + 1.0 FL	0	0

Table 10

Free water of sample + different percentage of retarder + 1.5 percent fluid loss additive

Additive percent	G cement ml	Pfa cement ml
0.2 R + 1.5 FL	0	0
0.5 R + 1.5 FL	0	0
0.7 R + 1.5 FL	0	0
1.0 R + 1.5 FL	0	0

Table 11

Free water of sample + different percentage of retarder + 2.0 percent fluid loss additive

percent	G cement ml	Pfa cement ml
0.2 R + 2.0 FL	0	0
0.5 R + 2.0 FL	0	0
0.7 R + 2.0 FL	0	0
1.0 R + 2.0 FL	0	0

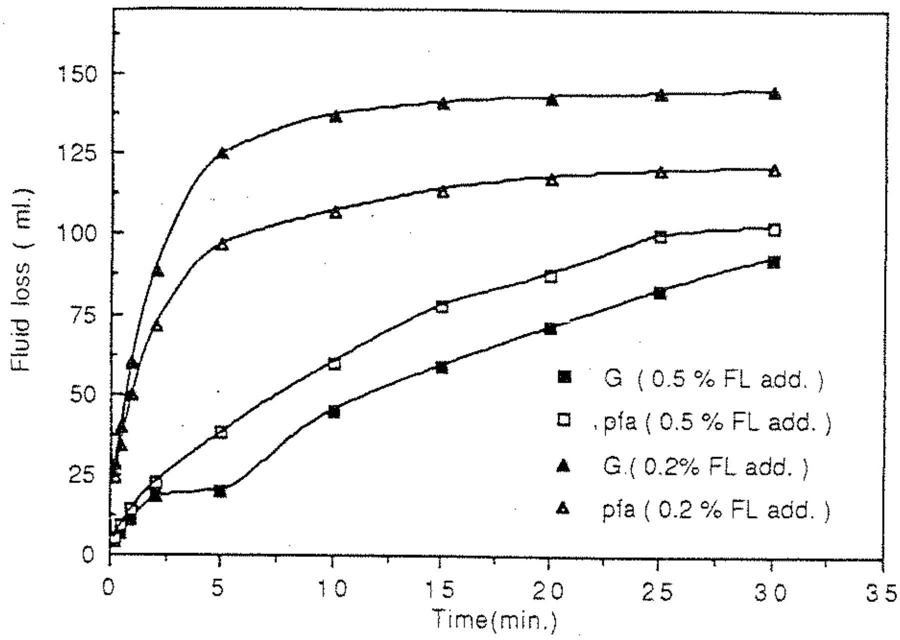

Figure 1. Fluid loss profile tested with 100 psi differential pressure with different percentage of additive.

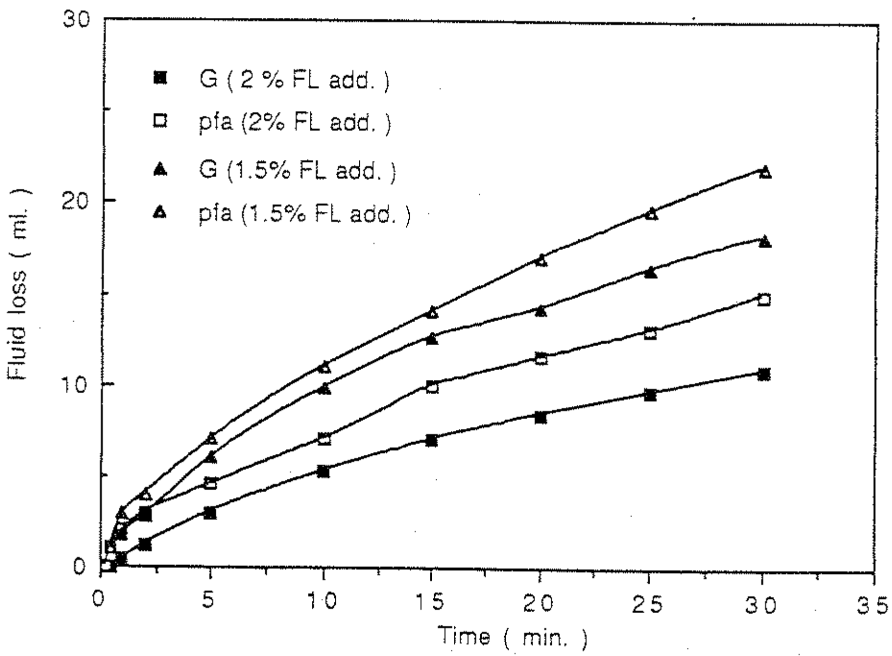

Figure 2. Fluid loss profile tested with 100 psi differential pressure with different percentage of additive.

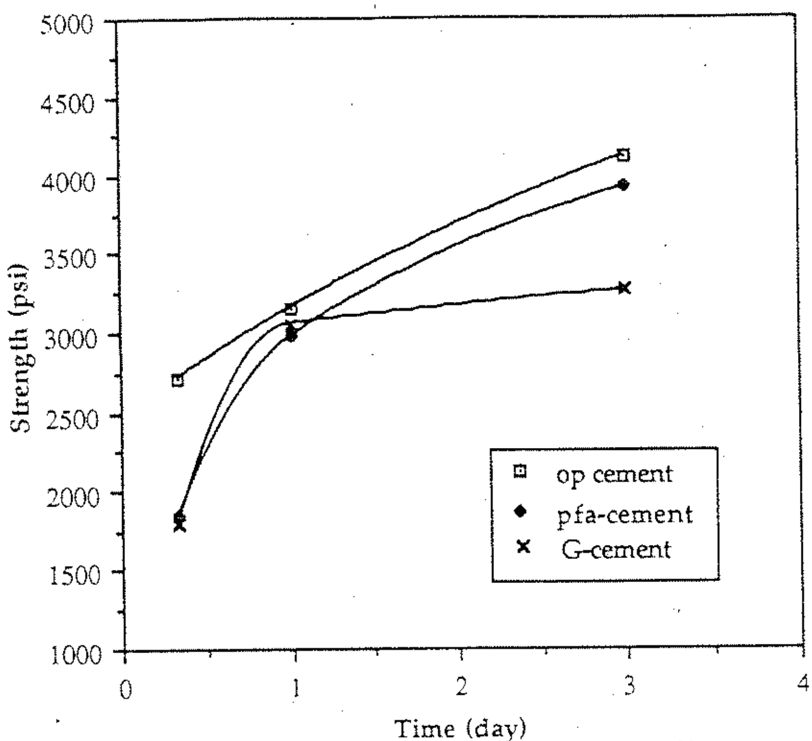

Figure 3 : Strength profile cured according to schedule 5g API Specification 10.