Comparative studies on the effect of Synthesized and the imported retarder on the Thickening time of Cement Slurry

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Abstract

This study was carried out using API recommended practice 13B-2 in a cement laboratory, and the essence was to compare the performance of the synthesized cement retarder and the imported retarder at various concentrations of 0.01gal/sk, 0.04 gal/sk, 0.07 gal/sk and 0.10 gal/sk on the setting time of the cement slurry. The test results obtained at various concentrations showed that thickening time at 100BC was 3:06 hrs, 4:06 hrs, 5:28 hrs 8:18 hrs while the imported retarder thickening time was as follows: 4:02 hrs, 5:13hrs, 6:53 hrs, 9:20 hrs for the respective increase in concentration. The study, therefore, shows that synthesized cement retarder can compare favorably with the imported cement retarder.

Keywords: *Thickening time, Synthesized, Rheology.*

I. INTRODUCTION

Cementing operation is the placing of oil well cement slurry in between the formation and casing to achieve adequate zonal isolation of the well. The objectives of the operation is to prevent the formation fluid-like gas and water from communicating from one zone to another in the well, to support the casing, to prevent casing from corrosion, to prevent casing from shock loads while drilling, to prevent blowouts, to achieve seal off lost circulation or thief zones and for well abandonment. Well cementing is seen as one of major operations that must be carried out in the process of oil well construction of a wellbore (Looten, 2004) therefore, cement slurry of high grade is needed to achieve economically and safely crude oil production over the lifetime period of the well (Ridha et al, 2010) and to secure the extended durability of wellbore by providing a high-quality casing (Pourafshary et al, 2009; Ershadi et al, 2011). When complete zonal isolation is not achieved and there is a weak bond between the cement and the casing and the cement with the formation it may cause the well not to produce to its full potential as there will be oil spills (Calvert, 2006). In well cementing, poor cement slurry design and poor cementing operation can adversely affect the production of crude oil. Some of the effects of poor cementing operation and poor slurry design lead to oil spills which have an environmental effect (Lootens, 2004) that causes death to aquatic lives and land pollution causing low production of agricultural produce, making the environment inhabitable to humans as it causes some respiratory diseases and is also responsible for loss of world oil reserves.

A. Chemistry of Portland cement slurry reaction

The predominantly used cement in cementing oil well is Portland cement. The four more important clinker phases found in Portland cement are dicalcium silicate (C_2S), tricalcium silicate (C_3S), and tetra calcium aluminoferrite (C_4AF), tricalcium aluminate (C_3A),; the clinker is mixed with gypsum (CH_2). The formulae above C represent CaO, S represents SiO2, A represents Al_2O_3, F represents Fe_2O_3 and H represents H_2O in chemistry abbreviations,(Young and Hansen, 1987).

The chemical reactions that result between water and cement are complex. Each part of the Portland cement undergoes the hydration process by unique chemical reaction route and at different reaction rate. The chemical reactions, nonetheless, depend on one another due to the chemistry of the cement and the closeness of the parts. When these reactions take place it usually results in energy being giving out or producing heat.

Five principal chemical reactions occur instantly between water and cement in a mixture once they are in contact, dissolution of parts of the clinker sulphates and dissolution of parts of the gypsum, generating a basic or an alkaline solution that is rich in sulphates. Immediately when mixing is over, the Tricalcium aluminate (C_3A) component-the one that reacts most among the components undergo a chemical reaction with the water to develop a gel-like solution that is rich in aluminate. The gel undergoes reactions with sulphate produced in the mixture to form a minute rod-like structure of ettringite. The Tricalcium aluminate (C_3A) hydration process is usually a heat evolution process that lasts for a few periods. And it is immediately taken over by few hours of comparably low energy production. This period is known as the induction period. The early stage of the induction period lasts for hours which will be enough time for the cementing operation. As the induction time continues, the slurry turns very hard to be pumpable. After the induction time, the

C_3S and C_2S in the portland begin to undergo hydration, with the building up of calcium hydroxide and calcium silicate hydrate. At the same time, the strength of the cement is developing too. The cement particles begin its reaction within the surface insides and cause the anhydrous cement grains to turn smaller. The tricalcium aluminate (C_3A) hydration at the same time progresses, as new crystals are easily reachable to water. The time of highest energy evolution happens usually on average of 15hours from when it was intermingled and slowly dies off. In a mixture having cement particles as major cementitious particles, the main strength development attained happens usually within 30days. Ferrite hydration begins immediately water is introduced, and gradually reduces thereafter, and this could be because of the formation of a film gel of iron hydroxide, covering the iron and behaving as a hindrance for any other future chemical reaction. Oil well cement is made up of four major compounds: tricalcium silicate (C_3S), dicalcium silicate (C_2S), aluminate (C_3A) and an iron component. (C_4AF) (Joel, 2009). The rate of reaction between water and cement particles can be altered by additions of chemicals known as additives (Lu, et al, 1993).

B. Cement additives

There are over 100 cement additives in the oil and gas industries, these additives are classified into eight (8) categories namely: Retarder, accelerator, Fluid loss, lost circulation material, weighting Agent, Extender, Dispersant and special Additives such as Antifoams.

a) Retarder as an Additive.

The chemical Additives which helps to slow down the setting time of the cement slurry is known as a retarder, the predominantly used additives as cement retarder in the oil industries are Cellulose, lignosulphonates, and sugar extracts, The most abundant retarders are gotten from wood pulp. They comprise Calcium and sodium salts of lignosulphonic acids and contain some saccharides. They are believed to attach onto the initial layer of C-S-H gel, causing it to be hydrophobic and prolonging the induction period. Added in concentrations 0.1 to 1.5 percent BWOC, they retard hydration at temperatures up to 122^oC (250^oF). When treated with other chemicals such as borax, lignosulphonates can be used up to 315^oC (600^oF).

Hydroxycarboxylic acids, such as glucoheptonate and gluconate salts, also retard hydration but are not used when the bottom-hole temperature is below 93^oC (200^oF). Cellulose sources like carboxymethyl hydroxyethyl cellulose (CMHEC) have been used for many years as cement retarder. To achieve good cementing operations several cement slurry designs are carried out, however, this study tends to compare the performance of the locally synthesized cement retarder and the imported cement retarder on the thickening time of 15.8ppg cement slurry at different concentration of both.

II. Materials and Methodology.

A series of tests were performed at different concentrations to evaluate the comparative performance of the synthesized cement retarder and the imported retarder on thickening time. All tests were conducted in line with the specification for materials and testing for Well Cements (Anon,1997 and 2013). The testing conditions are specified in (Table 1).

a) Slurry preparation

The slurries were prepared according to the API specification 10A standard, and the thickening time test was carried out at the various concentrations of the synthesized cement retarder.

b) Thickening time Test

The thickening time test indicates how long the cement slurry will remain in a fluid state before it hardens or becomes unpumpable (Akin et al, 2013). In order words, the duration after initial mixing when the cement can no longer be pumped (Salam et al, 2013). Consistency of cement slurry is expressed in Bearden units of consistency (Bc). The Thickening Time (TT) test was performed using a High-Pressure-High-Temperature (HPHT) Consistometer rated at a pressure of up to 206.8 MPa (30 000 psi) and temperatures of up to 204^oC (400^oF). The cement slurry was mixed according to API procedures and then placed in a slurry cup into the consistometer for testing. The testing pressure and temperature were controlled to simulate the conditions the slurry will encounter in the well. The test concluded when the slurry reached a consistency considered unpumpable in the well. The time it takes the cement slurries to reach 40Bc, 70Bc and 100Bc consistency were recorded (Anon,1997 and 2013).

III. Result and Discussion

Table 1: Test Physical Parameter Data

TVD =6500ft; MD =7900ft					
S/No		1	2	3	4
BHST	^oF	164	164	164	164
BHCT	^oF	120	120	120	120
BHP	Psi	3000	3000	3000	3000
Ramp time	Min	11	11	11	11

TVD stands for the True vertical Depth of the well and MD stands for measured depth. In estimating the physical parameter which gives the information about the well conditions such as the well temperature, pressure, ramp time the TVD is used, the reason being that pressure at the same level is the same.

Table 1 Shows the physical parameter which is keyed into the HTHP Consistometer to mimic the well condition in the field. As shown in table 1, the temperature at which the test was conducted was 120^{o}F, the downhole pressure was 3000psi and the ramp time which is the time it takes the consistometer surface temperature to reach the downhole temperature was 11mins.

Table 2: Thickening Time Test Result for synthesized.

Consistency(BC)	Concentration(gal/sk)	Thickening time(hrs:mins)
100BC	0.01	03:06
	0.04	04:06
	0.07	05:28
	0.1	08:18

Table 2 shows that the thickening time of the slurry at 0.01 gal/sk concentration was 3 hours 6mins, the concentration at 0.04gal/sk, 0.07gal/sk, and 0.1gal/sk gave thickening time results as

4 hours 6mins, 5 hours 28mins and 8 hours 18mins respectively

Table 3: Thickening Time Test Result for imported retarder

Consistency(BC)	Concentration (gal/sk)	Thickening time(hrs:mins)
100BC	0.01	04:02
	0.04	05:13
	0.07	06:53
	0.1	09:20

Table 3 shows that the thickening time of the slurry at 0.01 gal/sk concentration was 4hours 2mins, the concentration at 0.04gal/sk, 0.07gal/sk, and 0.1gal/sk gave thickening time results as

5 hours 13mins, 6 hours 53mins and 9hours 20mins respectively

Tables 2 and 3 show that an increase in the concentration of both synthesized cement retarder and imported cement retarder leads to an increase in the thickening time, This may be because of the building of a coating film on the cement particles making it less permeable and the development of the CH nuclei poisoned which would lead to increase in induction period and this means that the slurry will remain in the pumpable state throughout the induction period.

IV. Conclusion

- The test results indicate that the locally synthesized cement retarder has a good thickening time properties when compared with the imported retarder at the various testing conditions meeting the API specification
- There is an increase in the thickening time of both as the increase of the concentration.

REFERENCES

[1] B, Akin S (2013) Utilization of Supplementary Cementitious Materials in Geothermal Well Cementing Proceedings. Thirty-Eighth Workshop on Geothermal Reservoir Engineering Stanford University, California.

[2] (1997) American Petroleum Institute (API) Recommended Practice 10B for Testing Well Cements. American Petroleum Institute, Washington DC, USA.

[3] Recommended Practice 13B-2, Recommended Practice Standard Procedure for Field Testing oil-Based Drilling Fluid, Third Edition February 1998.

[4] Specification 10A.(1995). Specification for Cement and Materials for Well Cementing.22nd Edition. API, Washington, D.C. (January 1995): Addendum 1, October 1999.

[5] D.G. (2006). Preface. In: Nelson, E.B. and Guillot, D. (Ed.), Well Cementing, Schlumberger, Texas, pp. 1-11.

[6] V. Ebadi. T, Rabani. A.R, Ershadi L., Soltanian H. (2011),: The Effect of Nano silica on Cement Matrix Permeability in Oil Well to Decrease the Pollution of Receptive Environment. International Journal of Environmental Science and Development, Vol. 2, No. 2, April 2011.

[7] O. F (2009) The Secondary Effects of Lignosulphonate Cement Retarder on Cement Slurry Properties. Journal of Engineering and Applied Sciences 4: 1-7.

[8] D., He ́braud P ., Le ́colier E ., Van Damme H.(2004) Gelation, shear-thinning and shear-thickening in cement slurries, Oil Gas Sci. Technol.59, 1, 31-40.

[9] P, Azimipour S. S, Motamedi P, Samet M, Taheri S. A. (2009): Priority Assessment of Investment in Development of Nanotechnology in Upstream Petroleum Industry.- Society of Petroleum Engineers, Saudia Arabia Section Technical Symposium, Saudi Arabia.

[10] S., Sonny Irawan S., Bambang Ari W, Jasamai M (2010), Conductivity Dispersion Characteristic of Oilwell Cement Slurry during Early Hydration. International Journal of Engineering & Technology IJET-IJENS Vol:10 No:06

[11] KK, Arinkoola AO, Ajagbe B, Sanni O (2013) Evaluation of Thickening Time of Oil Field Class G Cement Slurry at High Temperature and Pressure using Experimental Design International Journal of Engineering Sciences 2: 361-367.

[12] J. F. and Hansen W. 1987. Volume relationship for C-S-H formation based on hydration stoichiometry Microstructural Development during Hydration of Cement. Mater. Res. Soc. Symp. Proc. (Boston, MA, 1986) Ed L.J. Struble and P.W. Brown (Pittsburgh, PA: Materials Research Society). pp. 313322.

[13] E.B.1990. Well Cementing. Elsener, New York. pp. 9-14.

[14] P., Sun G. K. and Young J. F. 1993. The phase composition of hydrated DSP Cement Pastes. J. Am. Ceram. Soc.