FILTRATION LOSSES IN OILWELL CEMENT CONTAMINATED BY PSEUDO OIL BASE MUDS

Sunday Isehunwa, Ph.D.* and Thomas O. Mumuni, M. Sc.

Department of Petroleum Engineering, University of Ibadan, Nigeria
*E-mail: isehunwa@yahoo.com

ABSTRACT

Contamination of oilfield cement slurries by drilling fluids is one of the causes of cement job failures and it results in expensive remedial actions. While the general adverse effects of Pseudo Oil Base Mud (POBM) contamination of cement slurries are known, little has been published on the actual effects of POBM on specific slurry properties. The effect of POBM on the filtration losses in oil well cement slurries was investigated. POBM contaminated slurries at varying contamination volumes up to 40% at intervals of 5% were prepared. The filtration losses were determined using standard American Petroleum Institute (API) procedures. The results show that while API fluid losses increased with time, it decreased with increasing POBM contamination in cement slurries.

Keywords: Cement Slurries, Pseudo Oil base mud, filtration losses, cement contamination

INTRODUCTION

Cementing is one of the key processes in the making of an oil well. In its simplest form, it is the process of preparing an aqueous slurry of cement, pumping and placing it between the casing and wellbore annulus and allowing it to set and exhibit bonding and sealing properties. Cementing could be primary or remedial. To accomplish a good cement bond, complete removal of all fluids including drilling mud and spacers is necessary. Unfortunately, during displacement, inside the casing, density differences may cause mixing and contamination of the cement slurry by drilling muds. Efforts are therefore usually made to enhance the displacement efficiency of the cement by maintaining a positive density hierarchy of successive displacing fluids to improve mud removal and minimize channeling.

Mud contamination is a common problem during primary cementing. It prevents hardening of cement, extends setting time and distorts slurry properties from predetermined values. Efficient cement slurry placement relies on effective displacement of drilling fluids from the casing-borehole annulus and on avoiding of mixing and contamination of slurry during placement.

Cement contamination by POBM remains a major challenge during cementing jobs. Most drilling jobs use water base muds at shallow depths and oil base muds or POBM in the deeper sections because of obvious advantages. However, mixtures of oil and cement may form a viscous slurry leading to pumping difficulties and could result in cement channeling, lost circulation, oil wetting of casing and borehole and consequently, poor cement bonding. Poor fluid loss characteristics in cement also lead to excessive pressure and less efficient mud displacement as well as accelerated setting. The cement filtrate will cause permeability damage and consequent loss of productivity in hydrocarbon bearing sands.

It has been noted by Gandelman, et al. (2004) that the productivity of an oilwell is affected by the cement quality and this is directly related to the slurry rheological properties. Vuk, et al. (1998) had earlier noted that premature viscosification or gel strength build-up in cement slurries can lead to difficulty in pumping of slurry and poor cementing. The need to achieve successful cementing through proper understanding of displacement mechanics was highlighted by Lindsay, et al. (1996). Frigaard and Pelipenko (2003) have discussed strategies for effective mud removal and cement slurry designs. In 2004, they modeled the shape of cement displacement front and how the shape changes with key physical parameters of the cementing process.

This study investigated the specific effects of POBM contamination on the API fluid losses of different cement slurries. This has practical implications on achieving successful cement jobs.

MATERIALS AND METHODS

Experiments were carried out to determine the API fluid loss characteristics of uncontaminated and POBM-contaminated Lead, Plug and Tail cement slurries. The slurries were contaminated with 5% to 40% POBM volume (BWOC slurry).

A low pressure/low temperature filter press at ambient temperature was used. The filter press consists of a frame and 6-cylinder assembly. Each cylinder has an internal diameter of 3+/-0.07 inches and a minimum height of 2.5 in. The filter assembly consists of a 325 mesh (45 micrometer) filter paper supported on a 60 mesh screen as the filter medium. The bottom of the cylinder is closed by a cap having a drain tube and necessary gaskets to provide an effective seal. The filtration area is 7.1 in^2 as in the standard filter press.

The different slurries were prepared using the appropriate standard volume of additive with respect to the cement volume. The desired POBM volume was then added. The recipes of the cement slurries are presented in Tables 1- 3. Slurries were stirred for about ten minutes using a Waring blender and samples were placed in the press as quickly as handling would allow.

The graduated cylinders were positioned under the filter tubes and a gas pressure of 100 +/- 5psi was applied within five seconds after closing the relief valve. Filtrate readings were taken at 1, 2, 5, 10, 15, 20, 25, and 30 minutes. The amount of filtrate in the graduated cylinders was read to the nearest 0.1cm^3.

Experiments were conducted with test criteria as indicated in Table 4. For each cement recipe, replications of experiments were undertaken to improve accuracy.

RESULTS AND DISCUSSION

The API fluid losses for different cement slurry recipes are presented in Figures 1-3. A clear relationship was established between the API fluid loss, time and percentage POBM-contamination for all the cement slurries. With an average shrinkage test of about 20%, the correlation equations were established as follows:

Tail Slurry:

$$FL = 94.6875 - 0.2016\,X + 1.4358\,T \qquad (1)$$

Where,
FL = Filtration loss (mls)
X = % Mud contamination (BWOC slurry)
T = Time (minutes)

Plug Slurry:

$$FL = 4.6824 - 0.1767\,X + 0.2307\,T \qquad (2)$$

Lead Slurry:

$$FL = 1.9389 - 0.0871X + 0.0888\,T \qquad (3)$$

These results were further statistically evaluated. Table 5 shows that that the coefficient of multiple determination, R^2, were 0.78, 0.82 and 0.84 for the lead, plug and tail slurries respectively. The highest R^2 of 0.84 obtained for the tail slurry can be attributed to the absence of fluid loss additive. The decrease in R^2 to 0.81 in the plug cement slurry is attributed to the presence of a fluid loss additive, while the drop to 0.78 in the lead slurry is attributed to its high water-to-cement ratio of 50.75% in addition to the fluid loss additive. These observations confirm that fluid loss additives in cement slurries could mitigate the effects of mud contamination.

Equations (1) – (3) show that mud contamination actually leads to reduction in fluid losses, with the lowest contribution obtained in lead cement slurries and the highest in Tail slurries. The results also confirm the well-known fact that time plays a very significant role in filtration losses. However, the effect of time is more pronounced in tail than in plug and lead cement slurries. It should be noted however that while POBM contamination leads to reduction in filtration losses, it could lead to some other problems during primary cementing.

Table 1: Recipe for Typical Lead Cement Slurry

Material	Quantity (g)	Remarks
Fresh Water	379.12	
Cement	367.79	
Additives Sodium Silicate 2-propenamide-N-(hydroxymethyl) polymer with 1,3 butadiene and ethylbenzene monoethanolamine Calcium Chloride Sulphonated organic polymer BJ 2001 Mixture FP-30L Silicon emulsion Lignosulphonate	 13.71 49.46 1.84 15.28 22.53 1.32 12.24	 Extender Bonding agent Accelerator Dispersant Cement additive Antifoamer Retarder

Table 2: Tail Cement Recipe

Material	Quantity (g)	Remarks
Fresh Water	345.11	
Cement	786.99	
Additives FP-21L Silicon emulsion Lignosulphonate	 1.17 3.06	 Defoamer Retarder

Table 3: Plug Cement Recipe

Material	Quantity (g)	Remarks
Fresh Water	320.38	
Cement	781.52	
Additives Sulphonated organic polymer BJ 2001 (mixture) FP-21L (silicon emulsion) Lignosulphonate	 16.23 14.36 2.33 1.47	 Dispersant Cement additive Defoamer Retarder

Table 4: Cement Slurries Testing Criteria

Property	Lead Slurry	Tail Slurry	Plug Slurry
Bottom hole circulating Temperature (^oF)	132	126	172
Initial Pressure (Psi)	500	500	500
Final Pressure (Psi)	4600	4400	6600
Heating time/ramp rate (minutes)	30	38	25
Expected density (ppg)	12	15.8	15.8
Expected Thickening time (± 30 mins)	5hrs 36 mins	4hrs 34 mins	4hrs 45 mins

Table 5: Coefficient of Multiple Determination

Slurry recipe	Variables	N	R^2
Lead	Fluid loss (mls) Time (mins) % mud contamination	72	0.78450
Plug	Fluid loss (mls) Time (mins) % mud contamination	72	0.81597
Tail	Fluid loss (mls) Time (mins) % mud contamination	72	0.83991

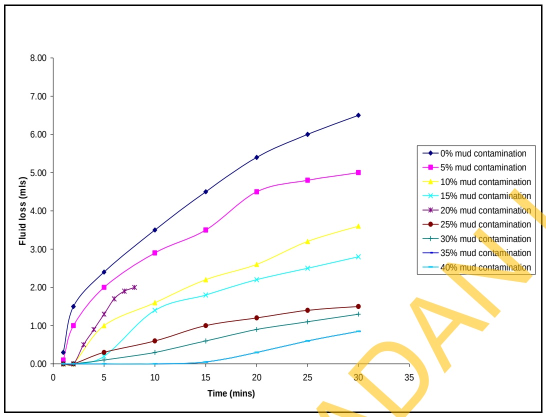

Figure 1: Effect of POBM contamination on Lead slurry fluid loss

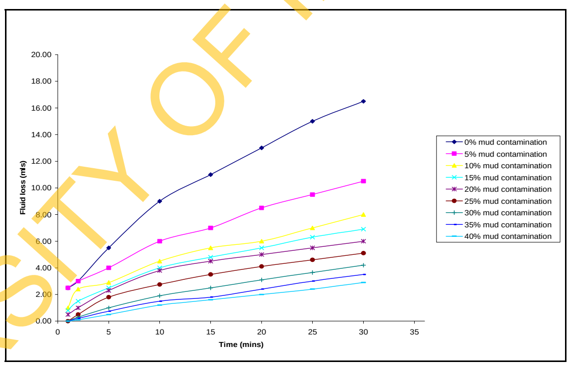

Figure 2: Effect of POBM contamination on Plug slurry fluid loss

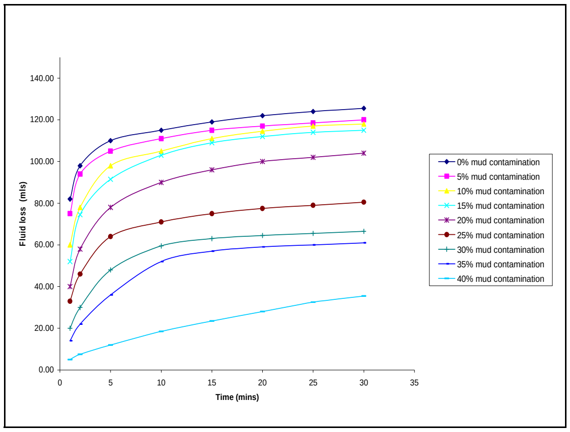

Figure 3: Effect of POBM contamination on Tail slurry fluid loss

CONCLUSION

POBM contamination and time affect filtration in oilwell cement slurries. Fluid losses tend to decrease with POBM contamination in cement slurries, but increase with time. The use of additives tends to reduce the effect of contamination on fluid losses.

ACKNOWLEDGEMENT

The use of facilities at the Production Chemistry laboratory of SPDC Port Harcourt is gratefully acknowledged. This work was supported by Shell Petroleum Development Company (SPDC), Nigeria through research grants to the Shell Chair at the University of Ibadan.

REFERENCES

[1] David, S., Tom Jr. G.J., Dale, D, 2003. “Cement Pulsation Reduces Remedial Cementing Costs”, Gas TIPS. pp 22.
[2] Frigaard, I.A. and Pelipenko, S. 2003. “Effective and Ineffective Strategies for Mud Removal and Cement Slurry Design”, SPE Latin America and Caribbean Petroleum Engineering Conference, April 27-30.
[3] Frigaard, I.A., Allouche M. and Gabard-Cuoq, C. 2001. “Setting Rheological Targets for Chemical Solutions in Mud Removal and Cement Slurry Design” SPE 64998, presented at The International Symposium on Oil field Chemistry, Houston, Texas, Feb. 13-16.
[4] Gandelman, R., Miranda, C., Teixeira, K., Martins A.L., and Waldmann, A. 2004. “On the Rheological Parameters Governing Oilwell Cement Slurry Stability”, Annual Trans. Of the Nordic Rheology Society, Vol. 12.
[5] Lindsay F., Tom G., Mourhat J., Greg S., Mike S., and Peter V., 1996. “Seamless Fluids Programs: A Key to better Well Construction”, Oilfield Review 8, No 2, pp.42-56.
[6] Lockyear, C.F., Ryan, D.F., Gunningham, M.M., 1990. “Cement Channeling: How to Predict and Prevent”, SPE Drilling Engineering, pp.201- 208.
[7] Pelipenko S. and Frigaard, I.A., 2004. “Mud Removal and Cement Placement during Primary Cementing of an Oil Well: Part 2- Steady State Displacements”, journal of Engineering Mathematics, 48: 1-26.
[8] Rogers, T., Dillenbeck, R.L. and Eid, R.N., 2004. “Transition Time of Cement Slurries, definitions and Misconceptions Related to Annular Fluid Migration”, SPE 90829, presented at the Annual Technical Conference and Exhibition, Houston, Sept. 26-29.
[9] Vuk, T., Mlakar, T.L., Gabrovek, R, and Kau, V., 1998. “Gelation of Oilwell Cement”, KZLTET, 32 (1-2), 125.