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Original Article

Evaluating a Local Liquid Cement Retarder for Additional Use as a Dispersant for Cement Slurry in the Oil & Gas Industry

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Abstract *- The increasing cost of oil & gas well cementing worldwide prompted this work to investigate the dispersion capability of a Local liquid cement retarder used in the Nigerian oil & gas industry to evaluate it for additional use as a dispersant in cement slurries. This work also aims to establish a procedure for evaluating this additional functionality of a cement retarder, as there is no standard procedure worldwide for such evaluation. Therefore, this work hinges on the effect of the liquid retarder on the rheology of cement slurry. Cement slurries were prepared with different amounts of the liquid retarder and conditioned to the test temperature in an Atmospheric Consistometer in accordance with API Spec 10B. The rheology of each cement slurry was measured using Chan-35 Rheometer. API Free water test was also conducted for each cement slurry in accordance with API Spec 10B. Results showed that the free water content of each cement slurry was less than the API limit of 3.5ml/250ml. Results revealed that the rheological parameters (Plastic viscosity and Yield stress) decreased with increasing amounts of the liquid retarder. This implies that the dispersion effect of the liquid retarder in a cement slurry can be leveraged to save cost by using only the retarder to achieve the required rheology and thickening time for a proposed cement job instead of using a conventional cement dispersant together with the liquid retarder to achieve the same job requirements especially when fluid loss control is adequate or not required.*

Keywords *- Cement additives, Oil & Gas well cementing, Thickening time, Rheology, Viscosity.*

1. Introduction

Liquid retarders are used as cement additives for elongating the thickening time of cement slurries in the oil and gas industry worldwide. Adequate thickening time is very significant for cement slurry placement in the zone of interest in the wellbore. The thickening time must be long enough to allow complete placement of the cement slurry. Consequences of inadequate thickening time include incomplete cement jobs, downtime and remedial cementing operations. Oriji and Zakka (2013) reported that small variations in the amount of retarder could result in large changes in the thickening time of a cement slurry.

The increasing cost of cement additives and cementing operations in the oil & gas industry worldwide prompted this work to investigate if a local liquid retarder used to elongate the thickening time of cement slurry in the Nigerian oil & gas industry can simultaneously serve as a dispersant for cement slurries. This work also aims to establish a procedure for evaluating such dual functionality of cement retarders, as there is presently no established standard worldwide. Nelson and Guillot (1990) stated that a good understanding of the rheology of cement slurry is required to evaluate its mixability, pumpability, displacement rate design and optimum mud removal). Boul et al. (2016) wrote that cement additives influence cement slurry stability, rheology, thickening time and mechanical properties, their interactions with one another and their interaction with the cement. Bannister and Benge (1981) reported that the characterization of the flow properties of a fluid can be determined by relating the shear rate to the shear stress. Rajput (1998) wrote that viscosity is the property of a fluid that determines its resistance to shearing stresses, and it is due to cohesion and interaction between molecules or particles of the fluid. Iyagba (1997) stated that viscosity is a measure of a fluid's internal resistance to flow or its resistance to shearing force and that drilling mud and cement slurry are Bingham Plastic fluids characterized by plastic viscosity and yield stress.

The simultaneous use of a conventional cement dispersants together with a liquid retarder can lead to over-dispersion of the cement slurry if the dispersion effect of the liquid retarder is not considered during the cement slurry design. The consequences of over-dispersion of cement slurry include settling, poor cement job, incomplete cement job, poor cement bond, mud channelling through cement slurry, and remedial cementing. Hence, the consequences of over-dispersion of cement slurries must be avoided. This implies that where the dispersion effect of a particular amount of liquid retarder is sufficient to achieve the required rheology with or without the appropriate amount of fluid floss control additive for a good cement job and the thickening time is not excessive, there would be no need to add a conventional cement dispersant to the cement slurry. This is especially important when fluid loss control is adequate or not critical, as in surface casing cementing, top-up jobs, and plug & abandonment cementing. Ikpeka et al. (2019) wrote that cement slurries are designed for improved rheological properties, proper mud removal and good zonal isolation.

The rheology of cement slurries is key for determining the appropriate displacement rate and flow regime for proper mud removal that will ensure good cement bonding after placement of the cement slurry in the zone of interest in the wellbore. The rheological parameters must be such that the displacement rate is low enough to avoid fracturing the formation and associated lost circulation. Furthermore, when the rheological parameters are too low, there could be over-dispersion of the cement slurry, which can lead to cement slurry settling, cement slurry contamination with mud, incomplete cement fill, poor mud removal, poor cement bonding and poor zonal isolation. Cement slurry settling can be easily detected from excessive free water values in the API free water test. Over-dispersion can also manifest as negative yield stress or settling the cement slurry in the Rheometer cup during the rheology test.

Good zonal isolation can be achieved if the drilling fluid filter cake hardens and permanently bonds to the wellbore walls and the cement to provide a hydraulic seal (Nahm and Wyant 1993). Contamination of cement slurry with drilling mud and its negative consequences on mud removal should be avoided (Isehunwa and Mumuni 2010). For an oil & gas well to maintain its integrity and produce effectively and economically, it is pertinent that a complete zonal isolation is achieved during the life of the well (Teodoriu et al. 2008).

2. Materials and Methods

The materials used include class G cement, water, antifoam additive and the local liquid retarder for cement slurry. Equipment used includes weighing balance, Atmospheric Consistometer and Chan-35 Rheometer. The cement slurries were prepared according to API Spec 10B after measuring the appropriate amount of cement for 16 Lb/Gal cement slurry; a fixed amount of 0.005 Gals/sk of the antifoam additive and varying amounts of the local liquid retarder was used. The cement slurries were conditioned in the Atmospheric Consistometer that has been preheated to the respective test temperature, and the rheology was measured using the Chan-35 Rheometer. Fresh cement slurry was prepared for each test temperature. Varying amounts (0.02 Gal/sk, 0.04 Gal/sk, 0.06 Gal/sk, 0.08 Gal/sk and 0.1 Gal/sk) of the local liquid retarder were used respectively, to prepare the different cement slurries for the rheology at each test temperature to enable comparison. The test temperatures are 80ºF, 90ºF and 100ºF. API Free water test was also conducted for each cement slurry in accordance with API Spec 10B.

3. Results and Discussion

The results revealed that the cement slurries' rheological parameters decreased with the amounts of the local liquid retarder in the cement slurry at each test temperature. The plastic viscosity and yield stress of the cement slurry decreased with an increase in the amount of the local liquid retarder in the cement slurry, as evidenced by Figure 1, Figure 2 and Figure 3.

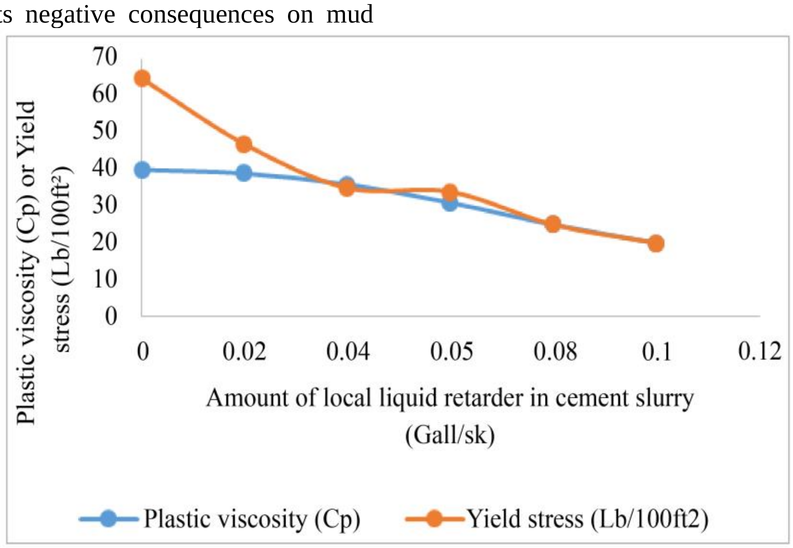

Fig. 1 Plastic viscosity and Yield stress versus the amount of the local liquid retarder in cement slurry at 80ºF

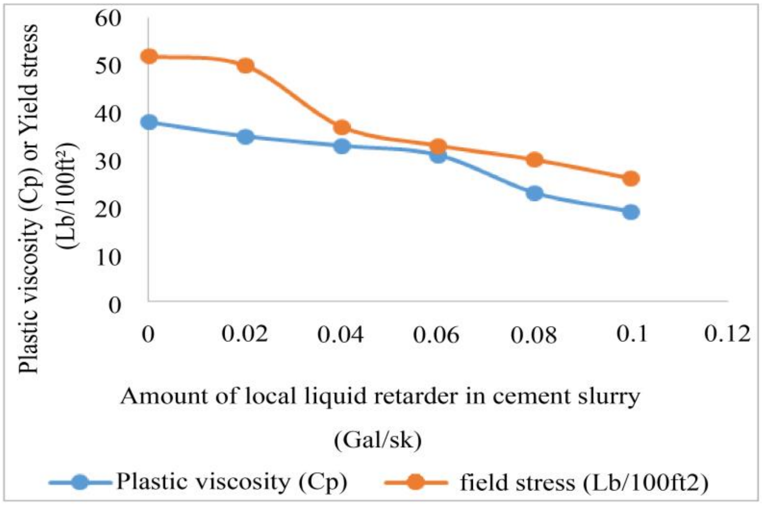

Fig. 2 Plastic viscosity and Yield stress versus the amount of the local liquid retarder in cement slurry at 90ºF

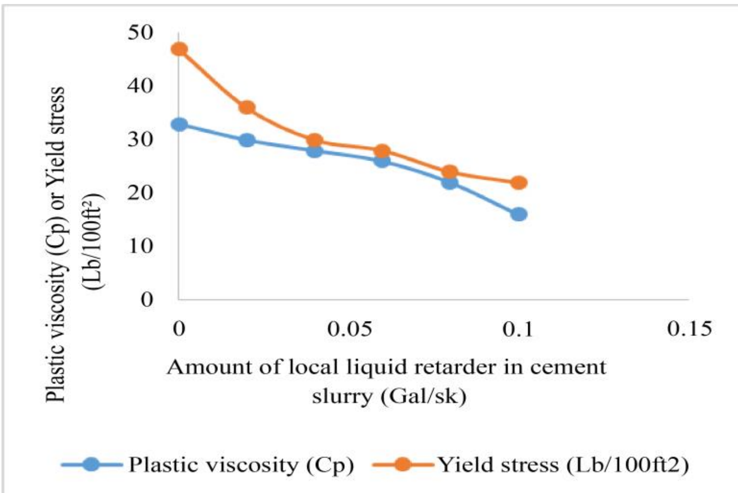

Fig. 3 Plastic viscosity and Yield stress versus the amount of the local liquid retarder in the cement slurry at 100ºF

The results showed that the free water content of each of the cement slurries is less than the API limit of 3.5ml/250ml, as evidenced by Figure 4, Figure 5 and Figure 6. One of the evidences of overdispersion of cement slurries is excessive free water content.

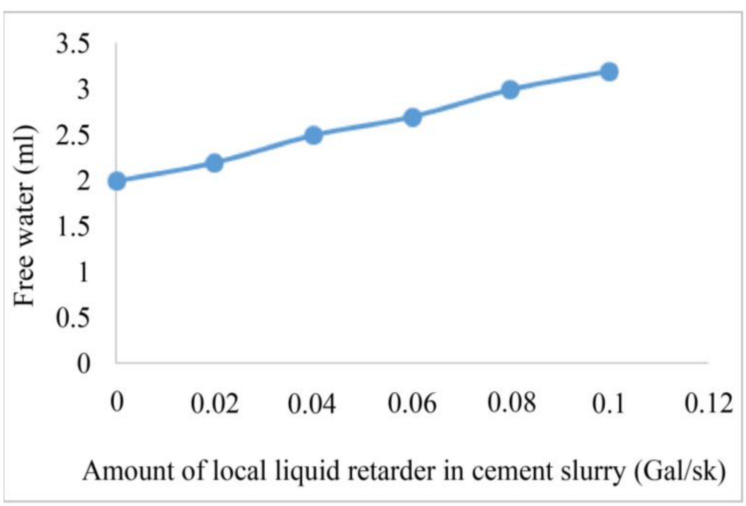

Fig. 4 Free water content versus the amount of the local liquid retarder in the cement slurry at 80ºF

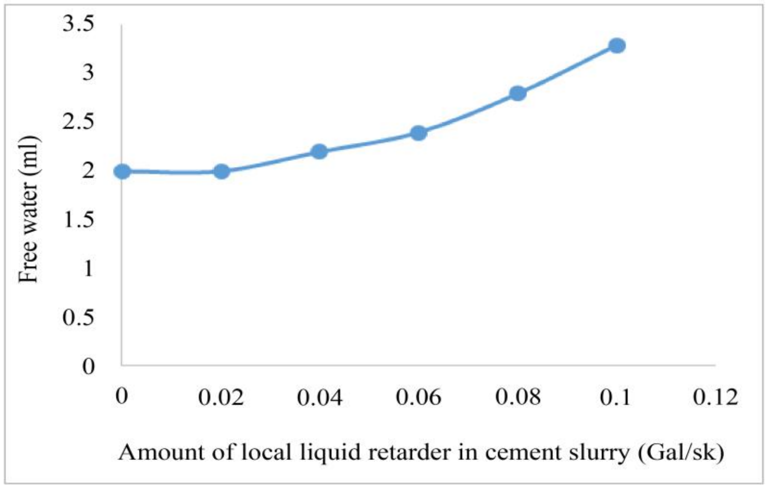

Fig. 5 Free water content versus the amount of the local liquid retarder in the cement slurry at 90ºF

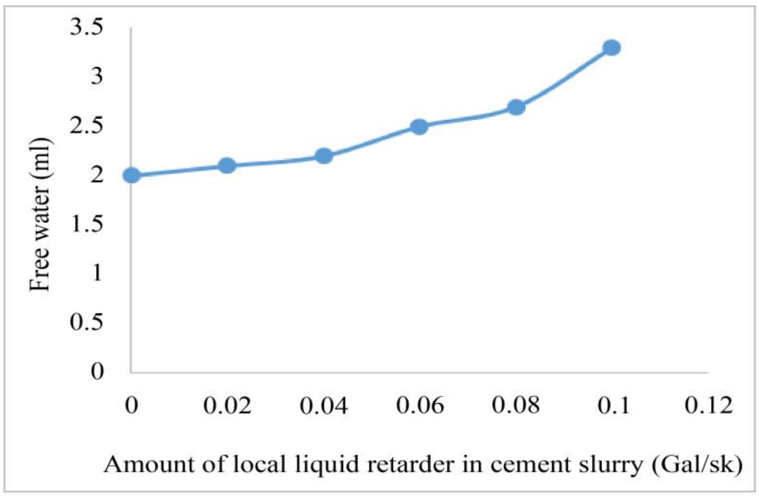

Fig. 6 Free water content versus the amount of the local liquid retarder in the cement slurry at 100ºF

It is evident from the results that the local liquid retarder used to elongate the thickening time of cement slurries in the Nigerian oil and gas industry can also be used as a dispersant for cement slurry, but due attention must be paid to the thickening time requirement for the proposed cement job. Therefore, the dispersion effect of the local liquid retarder must be considered when designing a cement slurry that requires the addition of the local liquid retarder together with a conventional dispersant in order to avoid over-dispersion of the cement slurry.

The aforesaid connotes that in situations where the cost of the amount of the liquid retarder required to achieve the required thickening time and good rheological parameters in a cement slurry is less than the cost of the required amount of a conventional dispersant, the liquid retarder can be used especially when fluid loss control is adequate or when fluid loss control is not critical. The preferred use of the liquid retarder becomes more significant if using only the conventional dispersant will not give the required thickening time for the proposed cement job. Limitations encountered during this study are funding and equipment.

4. Conclusion

It is evident from the foregoing that the local liquid retarder for cement slurry being used in the Nigerian oil & gas industry can also serve as a dispersant for cement slurries. However, testing must be done to avoid excessive thickening time and over-dispersion. The local liquid retarder can serve as a dispersant for cement slurries, especially when the required amount to achieve the required rheology and thickening time is cheaper than using a more expensive amount of a conventional dispersant, especially when fluid loss control is adequate or not critical.

Therefore, as a minimum requirement, evaluation of a cement retarder for use as a dispersant must include a rheology test and the API free water test to avoid undesired rheological properties, over-dispersion of cement slurry and the accompanying consequences.

Using the local liquid retarder or any other liquid retarder to serve the additional purpose of dispersion of cement slurry will be especially suitable for surface casing cementing and remedial jobs such as top-up jobs, plug and abandonment cementing.

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