Journal of Engineering and Applied Sciences 14 (11): 3583-3587, 2019
ISSN: 1816-949X

The Properties of Oil Well Cement Slurry with Variable W/C Ratio and their Impact on the Environment in Cement Job

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Abstract: The water cement ratio W/C plays an important role in influencing on the physical properties of the slurry which is used in the process of cementation of the oil and gas well which consists mainly of cement and water the properties of this mixture are to develop directly on the surrounding environment in terms of how to dispose of the mixture residues. This process is one of the most important processes in the drilling of oil wells and the cement slurry plays the main role also is important in order to ensure the safety of the well oil and gas and oil leakage, failure in the process of cementation or weakness in the characteristics of the mixture leads to major disasters, economic losses and environmental disasters. Factors affectin the characteristics of the physical mixture as density, viscosity, the thickening time and compressive strength, etc. In this study, we want to clarify the effect. The water cement ratio to these characteristics and know the best proportion of the mixture for the safety of the oil well.

Key words: Water cement ratio, cementing, thickening time, apparent viscosity, free water , environmental

INTRODUCTION

Virtually any well whether it be oil, gas, water, disposal, injection need to be cemented (PI, 2009). Cementing is the common term for the process of placing slurry, usually formed by combining cementation material with a liquid into the annulus between the outside of the casing in the hole and the wall of the hole. Cementing is carried out to accomplish the following objectives: bond and support casing, restricts the fluid movement between formation Craft *et al.* (1935) showed that a neat cement slurry having more than 50% BWOC water on standing formed cylinders of neat cement separated by horizontal bricks of clear water while a slurry having a W/C of <0.5 formed a solid cement plug they also concluded that pressure has little effect on the separation behavior.

Indicated that slurries mixed at high W/C ratio showed much higher permeability at the tops of plug than at bottoms while those mixed at an optimum W/C ration showed little variation in permeability of top and bottom plug (Al-Yooda and Kolosova, 2017; API., 2002; Bourgoyne *et al.*, 1991; Coleman and Corbign, 1987; Hartog *et al.*, 1983; Schlumburger, 1984). Reported compilation result of an experimental study for the pump, reported compilation result of an experimental study for the pump displacement pressure obtained.

From slurries of neat and low water loss tests (Smith, 1984). They found that the pressure reminded constant for over 180 min with slurries of the latter cement but increased gradually for about 90 min and then abruptly with the slurries of neat cement (Smith, 1976; Saleh, 1990). Emphasized that excess water content of cement slurries always produce a wackier cement with lower resistance to corrosion (Shahriar, 2011). Reported that for stable cement slurry little free water should separate from the slurry during standing and that a 200 cc in 30 min for API high pressure fluid losses test is adequate to prevent cement dehydration (Brearden and Lane, 1961).

Observed that cement slurries were still stable even with W/C ration of 0.65 and at this ratio, neat class G cement can attain a 24 h compressive strength of about 3400 psi cured under 200 F (Yuanguang *et al.*, 2001). Observed that mixing neat class G cement with 0.525% water BWOC will result in a free water separation of 1.5% while the maximum allowable fluid loss will be exceeded with a W/C ratio of observed that the increase of the W/C ratio causes a retardation to a cement slurry and that the degree of retardation is grater at 100 F than that at 125 F he also observed that the increment of W/C ratio causes a compressive strength decrement and free water content increment (Merritt, 2005). Cement properties including cement slurry properties as: pumping (ticking time), compressive strength, slurry density, free water content, etc. Pumping (thickening time or sitting time) the thickening time of a cement slurry is the time during which

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the cement slurry can be pumped and displaced into the annulus (i.e., the slurry is pump able during this time).

All the thickening time test were run in according schedule 5 of API sep.10 (Coleman and Corbign, 1987). Two basic influences on the down hole performance of cement slurries are temperature and pressure (Shahriar, 2011) they effect how long the slurry will be pumped and the development of the strength necessary to support pipe. Practical time varies from (1h to 50%) in excess of total working time (Coleman and Corbign, 1987).

The density of the slurry should be great enough to maintain well control (Shahriar, 2011). Its range of neat cement slurries is limited by minimum and maximum water/cement ratio (Coleman and Corbign, 1987). Free water content or F.W. The percentage is one of the most important properties of the cement slurry that will affect the stability of cement slurry. As free water increase, a weaker cement with lower resistance to corrosion produced (Brearden and Lane, 1961) water cement ratio and cement particles size effect directly on free water content.

Compressive strength when water added to the cement gelatinous hydrates of silicates and aluminates are formed which gradually develop strength. Compressive strength is one of the important factors in the engineering design of cement job it was considered good practice to use a cement of strength at least equal to that of the producing horizon (Bearden, 1995). API procedures (Coleman and Corbign, 1987) explain procedure of testing mortar cubes either atmospheric pressure in water bath 60°C the strength of set cement is effected by the cement composition, water cement ratio, temperature, pressure, age and any additives materials (Coleman and Corbign, 1987). In general, the accepted minimum strength for drilling according API out is 500 psi (API., 2002).

MATERIALS AND METHODS

Cement: Cement used in this study using class G (API Class G) oil well cement with a specific gravity of 3.14. The chemical and physical properties of this cement are summarized in Table 1 accordind API. Indicated that cement used was tallying API requirements. In Table 1 test were done to check storage efficiency, small cans closed were used in the laboratory in order to avoid moisture.

Water: Use clear water not have organic materials the percentage of water on water cement ration (Yuanguang *et al*., 2001). In general, the mixture is prepared. The mixing method and the mixing time greatly affect the results of the laboratory.

In the beginning, the cement is added to the water according to the quantity of the experiment.

Table 1: Test result physical properties for cement type G

Physical properties for cement G	Test results
Free water content with 0.4 W/C	1.2
Compressive strength at 8 h @ 38°C and atmospheric pressure (psi)	1600 psi
Thickening time (min)	105 min

The continuous stirring by plastic shovel and removing all the feeders around the walls (Coleman and Corbign, 1987). Determined proportions manual mixing lasts for 5 min the temperature of the room is up to 20°C the speed of the drum machine 200 cycles/min the time in all experiments is constant to avoid external variables. After easily assembled on location, calibration mud balance, measured the slurry density under sufficient balance temperature about 20°C room temperature.

Free water content: After preparing sample, mixed for 35 sec in waring blender and then used to fill a 250 cc graduated glass cylinder, free water was measured by means of a 10 cc graduated glass cylinder (Shahriar, 2011). After creating slurry we poured it into a 250 cc cylinder, let it settle down for 2 h the measured free water by means of 10 cc graduated cylinder.

Thickening time: To determine the setting time for slurry used device (atmospheric consist Meter Model 60) OFITE. The sample container is placed on turntable in the pressure chamber and rotate at 120 rpm the device calibrate in according with ASTM E 220. All according test result run in accordance with schedule 5 of the API spec 10. The test were run under 125°F and 5200 psi.

Compressive strength: A part from the prepared slurry poured into molds cubic shape with 2 inches longitudinal rib according with the ASTM. After 24 h or more we opened this molds and take the sample and put it in 20 L water with 20°C for curing, after curing find the compressive strength for cub by hydraulic press (compression test machine).

Rheological properties determination (apparent viscosity) to determine the viscosity for each slurry Ø6, Ø 100, Ø 200, Ø 300 were reported for purpose of calculation choose Ø300. (Measured at 80°F temperature test).

RESULTS AND DISCUSSION

Figure 1 show the research results of the influence water cement ratio on the density of slurry, the density is very important for pump slurry it was established all parameter are acts on this result for all trials tests for example, weight of cement, time mix, calibration balance and mud test in first test, we start with 0.3 W/C the density was 2.05 after increase W/C the density had been decries but the relation was not linear alltest was according API (Craft *et al*., 1935) (Table 2).

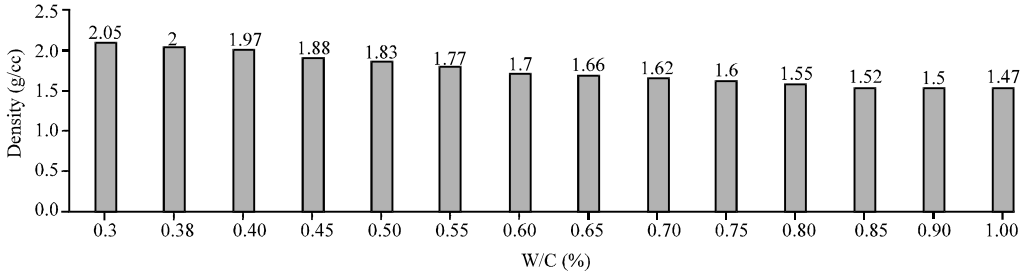

Fig. 1: The effect W/C (%) on slurry density (g/cc)

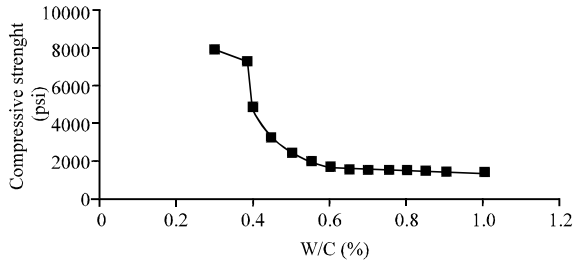

Fig. 2: The effect W/C % on C.S (psi)

Table 2: Water cement ration percentage used in experimental

Experimental No.	W/C
1	0.30
2	0.38
3	0.40
4	0.45
5	0.50
6	0.55
7	0.60
8	0.65
9	0.70
10	0.75
11	0.80
12	0.85
13	0.90
14	1.00

Figure 2 show the research results of the influence water cement ratio on the compressive strength, it was established all parameter are acts on this result for all trials tests for example weight of cement, time mix, calibration balance and hydraulic compressive pressure, compression strength is one of the important physical properties of the slurry which is used in the cementation oil well predict the performance of the role of the slurry after (Bearden, 1995). The hardening and resistance to different stresses and thus, prevent the leakage of gas and oil and good insulation of the pipes, the relation was not linear to find this result depending on ASTM (Craft *et al*., 1935) and used equation:

$$\sigma = p/A \; \sigma = psi, p = Ib \; A = in^2$$

Figure 3 show the research results of the influence water cement ratio on the apparent viscosity, viscosity is

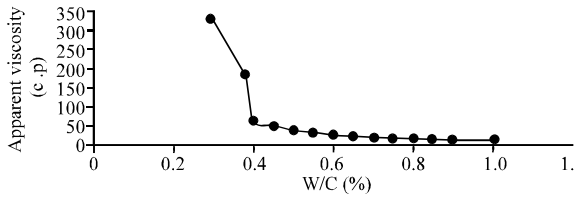

Fig. 3: The effect W/C (%) on apparent viscosity (cp)

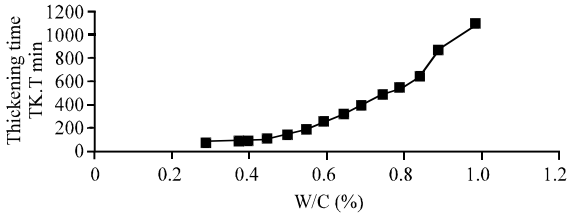

Fig. 4: The effect W/C (%) on thickening time (min)

very important for pump slurry and adhesion between pipes and slurry if the viscosity is high this is bad indicate about easily pump [ ], it was established all parameter are acts on this result for all trials tests, for example, weight of cement, time mix, calibration balance and (8-speed viscometer Model 800) OFITE. For each slurry Ø 6, Ø 100, Ø 200, Ø 300. Were reported for for purpose of calculation choose Ø300. (Measured at 80°F temperature TEST) when used 0.3 the apparent viscosity was very high this value not suitable for pump its not easy while the W/C was 1% from the weight of cement the apparent viscosity was 5 cp and this value give us indicate about the slurry was not homogenous, all tests was according API (Shahriar, 2011; Brearden and Lane, 1961).

Figure 4 show the research results of the influence water cement ratio on the thickening time, it was established all parameter are acts on this result for all trials tests, for example, weight of cement, time mix, calibration balance and the device (Atmospheric Consist Meter model 60) OFITE, the TK.T or setting time gives us an impression of the time required to pump and not to calcify the slurry inside the pipes pump (Yetunde and Ogbonna, 2011).

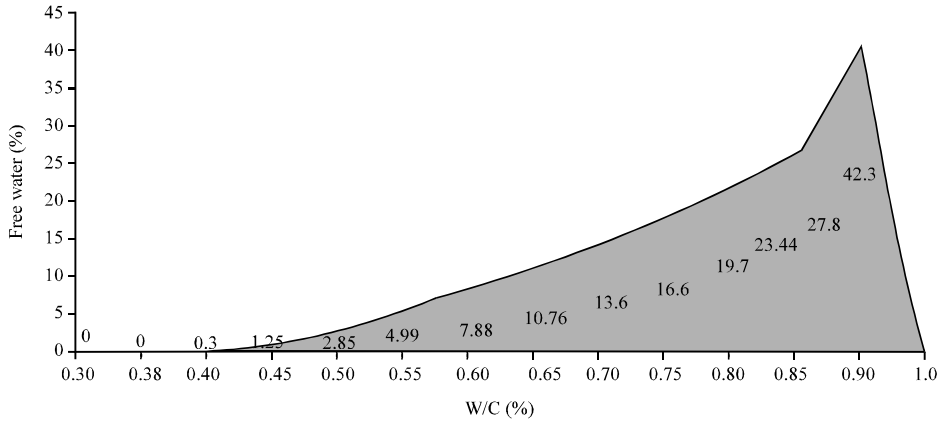

Fig. 5: The effect W/C (%) on free water content percentage

The water ratio has a very strong effect on this property when used 0.38 the setting time was little but according to the experience it's enough time for primary cementation (Evans, 2011) but when we used high W/C the setting time was too much.

Figure 5 show the research results of the influence water cement ratio on free water content it was established all parameter are acts on this result for all trials tests, for example, weight of cement, time mix, calibration balance, this property give us an impression aboutdeposition the particle of cement and additive, if we used, the W/C ratio effect on this property and the relation is nonlinear, all tests meet with API (Al-Yooda and Kolosova, 2017; API., 2002).

CONCLUSION

The result of this investigation is to prove the effect of water cement ratio on some important physical properties of the cement slurry which is used in the process of cementation there properties as free water content, compressive strength, setting time (Thickening time) and apparent viscosity. The effect of water cement ratio on these properties have been discussed and their effect was found to be different for each property. The water cement ratio optimal ratios was from 0.4-0.5 to the pure cement mixture without additives which is suitable for pumping and safety well. There are many experiments that must be done in order to have a complete picture on this subject exactly when we added additive to slurry.

ACKNOWLEDGEMENT

NATALIA KALASOVA Peter the great Saint Petersburg polytechnic university.

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