Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 55(6) (2023) 261-264
DOI: 10.22060/ceej.2023.21171.7640

The effect of cementing additives on the rheological properties, thickening time, and compressive strength in drilling operation

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ABSTRACT: Plastic viscosity (PV), yield point (YP), fluid loss volume, thickening time, and compressive strength of cement are the main parameters that are necessary for a successful operation. In this study, 25 tests were done to design different slurries and find the effect of various additives, including extenders (bentonite and sodium silicate), accelerators (calcium chloride and sodium chloride), retarders (calcium lignosulfonate and CMHEC), and fluid loss controller (FLC). Calcium chloride provides acceptable results up to 6% of the weight of cement. For more than 6%, it provides unpredictable results. The amount of sodium chloride in high concentrations (30%) also acts as a retarder. Calcium lignosulfonate slows down thickening timeless than CMHEC, while CMHEC can retard the slurry more and increase the closing time. The slurry setting time trend increases in calcium lignosulfonate almost linearly while CMHEC increases nonlinearly. addition of FLC to cement water causes water to be retained in the slurry system and this causes the increase of this additive in the slurry to increase the setting time of cement and reduce its short-term strength (24 hours).

Review History:

Received: Mar. 01, 2022
Revised: Apr. 03, 2023
Accepted: Apr. 17, 2023
Available Online: May, 29, 2023

Keywords:

Oil Well cementing
HPHT cement design
Thickening time
Compressive strength

1- Introduction

In 1995, a study found that 15 percent of primary cement work in the United States failed, about one-third of which was due to the penetration of gas and fluids into the cement. Slurry design and optimization are one of the most important tools in the process of gas migration blockage. Several parameters of the slurry must be modified by optimizing the formulation to the desired level. In this field, we can mention characteristics such as density, filtration, free water, particle settling status, rheological properties, development of gel strength, permeability, and water loss. Each of these should be considered during slurry evaluation to achieve acceptable standards.[1]

Four components called tricalcium silicate (C3S), dicalcium silicate (C2S), tricalcium aluminate (C3A), and tetracalcium aluminophosphate (C4AF) are the main components of the cement formulation. [2] By placing these materials along with cement and water additives, the desired characteristics of the operations engineers themselves in cement are formed. [3]

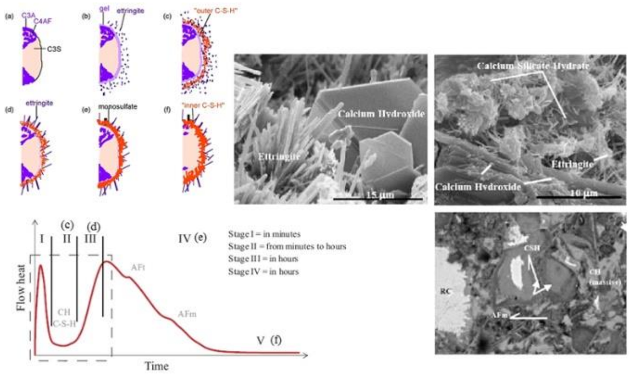

Fig. 1. shows the stages of cement hardening at the same time as the growth load of its internal structures. The amount of heat released during the thickening time of the slurry. It also shows a view of the crystalline and amorphous structures of the cement structure.

2- Materials and Methods

To measure the rheology of the slurry including PV, YP, 10-second gel, and 10-minute gel at the rotational temperature of the bottom of the well, the slurry is placed in an atmospheric consistometer to rotate for 20 minutes at the bottom of the well at 150 RPM. Then the rheology is read again according to the instructions.

In this research, various additives have been used to design the slurry. To prevent and control filtration, two types of filtration

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controller additives with the brands loloss109LT and FLC-502 have been used. Only one type of dispersant (turbo-6) is used. Bentonite and sodium silicate has been used as an extender in the design of the slurries. Calcium lignosulfonate and CMHEC are used as retarders. Accelerators used are calcium chloride (CaCl2) and NaCl. The antifoam was used under the brand name defoam-802. With changing the additives, several tests have been performed on their effects on the setting time of cement.

3- Results & discussion

Increasing the amount of bentonite from 0% to 6%, the PV and YP increased. Increasing the amount of sodium silicate, the 24-hour the compressive strength of cement has decreased. The compressive strength of cement made with bentonite has decreased more than cement made with sodium silicate.

As the CaCl2 content increases from 0% BWOC to 6% BWOC, the values of PV, YP, gel for 10 seconds, and gel for 10 minutes increase, while the slurry gels with 30% calcium chloride at BHCT temperature and their properties cannot be determined by the viscometer was measured. Increasing the concentration of calcium chloride from 0% to 3%, the setting time of cement increases from 414 minutes to 321 minutes, which reduces 93 minutes. By increasing from 3% to 6%, the thickening time will decrease by 119 minutes. With an increase of more than 6%, the slurry behavior is not predictable.

As the concentration of sodium chloride increases, the filtrate volume increases from 46 cc/30min to 64. Despite the sharp increase of salt to 30%, the filtrate change increases slightly. By increasing the salt concentration, the performance of filtration control agents decreases. As a result the filtration volume increases, the thickening time is shortened and the cement reaches strength sooner, and finally, the rate of compressive strength growth declines at high percentages. Increasing the amount of sodium chloride from 0% to 6%, the amount of PV, YP, ten seconds, and ten minutes gel raised but when the amount of salt reaches 30%, the amount of YP decreases.

Increasing the percentage of salt to 6% by the weight of water, the salt acts as an accelerator, reducing the thickening time from 414 minutes to 250 minutes. Increasing the amount of salt to 30%, the salt acts as a retarder and increases the setting time to 598 minutes. Calcium chloride has a greater effect on the cement slurry than sodium chloride. It reduces the effect of filtration control additives and increases the amount of filtrate in calcium chloride slurries. The slurry containing calcium chloride produces more gel than sodium chloride. This property causes the cement cake to not form well and have larger pores, in which cases more water is removed from the cement due to pressure.

Increasing calcium chloride and sodium chloride by up to 6% increases the 24-hour compaction strength of cement. crystallization phenomenon in the concentration of 30% causes the slurry to be retarded and the 24-hour compressive strength declines.

As the percentage of calcium lignosulfonate increases from 0 to 1 wt% of cement, the setting time increases with an almost constant slope. This indicates that calcium lignosulfonate increases the slurry setting time by a constant ratio. This property can be used in the better design of cement and the appropriate amount of this retarder.

As the amount of retarder increases, the setting time of the cement increases nonlinearly, so that as the amount of retarder increases, the setting time of the cement increases sharply. As the amount of retarder increases, the 24-hour compressive strength of cement decreases. So that with a 1% increase in retarder, the amount of compressive strength of cement has decreased to 1120 psi. (1280 psi)

Increasing the percentage of retarders in the slurry system, the CMHEC retarder further affects the thickening time. This increase was almost linear for the calcium lignosulfonate retarder, while the CMHEC retarder increased nonlinearly with a steep slope and was stronger than calcium lignosulfonate at percentages higher than 0.1%.

4- Conclusion

Increasing bentonite and sodium silicate in cement slurry increase the YP of cement and absorbing the slurry water cause the amount of fluid loss to be controlled so that by increasing the amount of bentonite up to 6% by weight of cement, the amount of fluid loss decreases from 380 cc/30min to 89 While sodium silicate has dropped to 180.

Bentonite and sodium silicate both reduce the setting time of cement and also act as an accelerator in the cement system. The accelerating side effect of cement in bentonite is greater than that of sodium silicate.

Bentonite, compared to sodium silicate, shortens the setting time, and reduces the final strength of cement from 900 ppm to 400 ppm, while sodium silicate has less effect on reducing strength.

At high percentages (30%) calcium chloride causes the cement to not provide suitable rheology and is practically useless for cement operations and provides unpredictable results.

Calcium lignosulfonate has less effect on Thickening time than CMHEC.

CMHEC has a greater effect on strength and has led to a further decrease so that with a 1% increase in CMHEC to cement, the compressive strength of cement has decreased from 2400 psi to 1730 psi, while for calcium lignosulfonate decreased from 2400 psi. to 1120 feet.

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HOW TO CITE THIS ARTICLE
M. Dehvedar, S. M. M. Hosseini, The effect of cementing additives on the rheological properties, thickening time, and compressive strength in drilling operation, Amirkabir J. Civil Eng., 55(6) (2023) 261-264.

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