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Research on a New Latex Anti-Gas Channeling Cement Slurry System

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Abstract

It is one of the technical problems existing in the current cementing technology that gas channeling frequently occurs after the well cementation process. The new latex anti-gas channeling cement slurry system is put forward to solve this problem effectively and also filled up the domestic blank in this field. The study found that the new cement slurry system has the good ability of water loss control, liquidity and the thickening time can be adjusted. The static gel strength analysis and gas channeling simulation analysis shows that under the condition of high temperature, the anti-gas channeling has good effect. In addition, the sensitive factor experiment research shows that the cement slurry system has less affected by the site factors, so it has good application prospects.

Key words: Cementing technology; Gas channeling; Latex anti-gas channeling cement slurry system

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INTRODUCTION

Annular gas channeling refers to that at the end of the cement, in the process of the cement slurry turns liquid into solid, the cement slurry is difficult to keep the gas pressure or due to the causes such as cement channeling which causes the poor cementing quality[1-2]. The gas intrude into cement matrix, or enter the annular gap may result in interlayer channeling or even into the wellhead. The dangers of annular space gas channeling are mainly composed by the following respects: Affecting the cementing strength of the cement directly; it also leads to the interlayer cross flow so that affecting the evaluation of hydrocarbon reservoir directly; the reservoir will be polluted and it will reduce the oil and gas recovery[3-4]. It will adversely affect the follow-up operations such as water flooding, acid fracturing and slice mining. The accidents such as oil and gas upward flow or even blowout will occur after cementing, the remedial process is also very difficult even using the cement squeeze.

Anti-gas channeling cement slurry system was studied at home and abroad for many years, has already formed the expansive cement, impermeable cement and thixotropic cement slurry system series, but the relatively mature cementing technique in solving channeling is a delegate with Schlumberger company anti-gas channeling D600G agent latex anti channeling cement slurry system[5-6]. The system is mainly used in deep wells, ultra-deep wells and high pressure well cementing, with particles channeling prevention and film-forming channeling prevention double functions. It can adapt to the temperature of 200 ℃ and improve the quality of deep Wells and ultra-deep wells in cementing effectively[7]. It is recognized at home and abroad of high performance the cement slurry system in anti-gas channeling. There is a new anti-gas channeling latex cement slurry system which fills the domestic market because of its advantages.

1. THE BASIC FORMULA

Anti-gas channeling latex cement slurry composed of DC200 Styrene butadiene latex and other related cement additives, the latex added amount generally account for 8~15% of cement. The DC200 is styrene butadiene copolymer emulsion with high temperature resistance, anti-gas channeling and filtration reducing. In addition to auxiliary mix the non-permeable gas channeling filtration-reducing agent FSAM to constitute the slurry system.

The basic formula is as follows:

JHG+30%SiO_2+3%MS+10%DC200+7%SD-1+2%SD-2+1.2%DZS+0.57%DZH+42%Water.

2. EXPERIMENT RESEARCH

2.1 Experimental Analysis of the New System Conventional Performance

The experiment carried out in accordance with API SPEC10B and GB/T19139-2003, Table 1 shows its comprehensive performance: The slurry density in 1.86~1.90 g/cm^3, applicable temperature 40~120 ℃. Under the synergistic effects of latex and fluid loss additives, API filtration of slurry is less than 100 ml. The fluidity of cement slurry is good, easy to realize the turbulent state. Liquidity index ≥ 0.75, fluidity > 24 cm; The slurry system is stable, free liquid < 0.5 mL; Thickening time of cement slurry is adjustable.

2.2 Performance Test of Gas Channeling Prevention

2.2.1 Analysis of Static Gel Strength

Model 5265 ultrasonic static gel strength analyzer is used to test the development of the gel strength of latex cement slurry to judge its capability (as shown in Figure 1).

Table 1
Slurry Conventional Performance

Temperature (℃)	Pressure (MPa)	Density (g/cm^3)	Thickening time (min)	API filtration loss (ml)	Fluidity (cm)	Freeness (ml)	24h compressive strength (MPa)	Flow index	Consistency
100	60	1.86	210	60	28	0.21	21	0.76	0.43
105	60	1.86	350	64	28	0.21	22	0.79	0.38
110	70	1.87	298	75	28	0.22	20	0.81	0.33

In Figure 1, the change rate of new slurry system cement static gel strength curve is very small, nearly right angle curve. Due to the slurry has a long time in the liquid state, transmitting the fluid column pressure of slurry which is contribute to the pressure balance. When the slurry once get strength, slurry rapidly transform from liquid state to low permeable solid state which will effectively prevent the occurrence of oil, gas and water channeling in long cementing section and improve the cementing quality of wells efficiently.

2.2.2 Gas Channeling Simulation Test

Model CHANDLER7150 gas channeling simulation analyzer is used to do the laboratory test. Through 5,270 data acquisition and processing system to deal with the experimental data which directly provides experimental curves of cement slurry internal pore pressure variation, slurry volume change curve, gas channeling speed and gas channeling volume curve and so forth. Pouring the well maintained slurry into the gas channeling simulation kettle, the cement slurry begins to hydrate. With the hydration, the cement slurry begins to thick and the liquid column pressure gradually decreases. When the liquid column pressure of cement slurry is less than the formation pressure, gas channeling is most likely to occur. When the cement slurry column pressure equals the formation pressure, if there is no amount of gas channeling at this time, it means that the cement slurry has a good anti-gas channeling effect[8-9].

Figure 2 refers the gas channeling prevention performance testing under the condition of 110 ℃ and 130 ℃. The curves show that when the cement slurry column pressure equals to the formation pressure, gas channeling volume is shown as zero which means that the slurry system has good anti-air channeling capability.

2.3 New Anti-Gas Channeling Latex Cement Engineering Sensitivity Factors Evaluation

The performance of slurry is mainly affected by the influence of additives and water-cement ratio, but in the construction site in the process of external factors, such as changes in water quality, temperature, shear rate and condition of cement slurry performance have varying degrees of impact. Through the test research we can determine the influence rules of these factors on the performance of the cement slurry which will provide guidance to the construction site.

2.3.1 The Influence of Temperature Change on Thickening Experiments

By changing the temperature condition of the experiment, the results of API water loss and thickening time of the slurry system show in Table 2. It shows that the system API water loss can be completely controlled within 50 ml, and the slurry forms a polymer film and tense filtrate cake at the same time to achieve the performance of anti-high temperature and anti-gas channeling. Under the same amount of retarder conditions, temperature fluctuations at 10 ℃ thickening time reduced by about 100 min, the temperature fluctuations at 5 ℃ the thickening time reduced by about 60 min are both in a reasonable range.

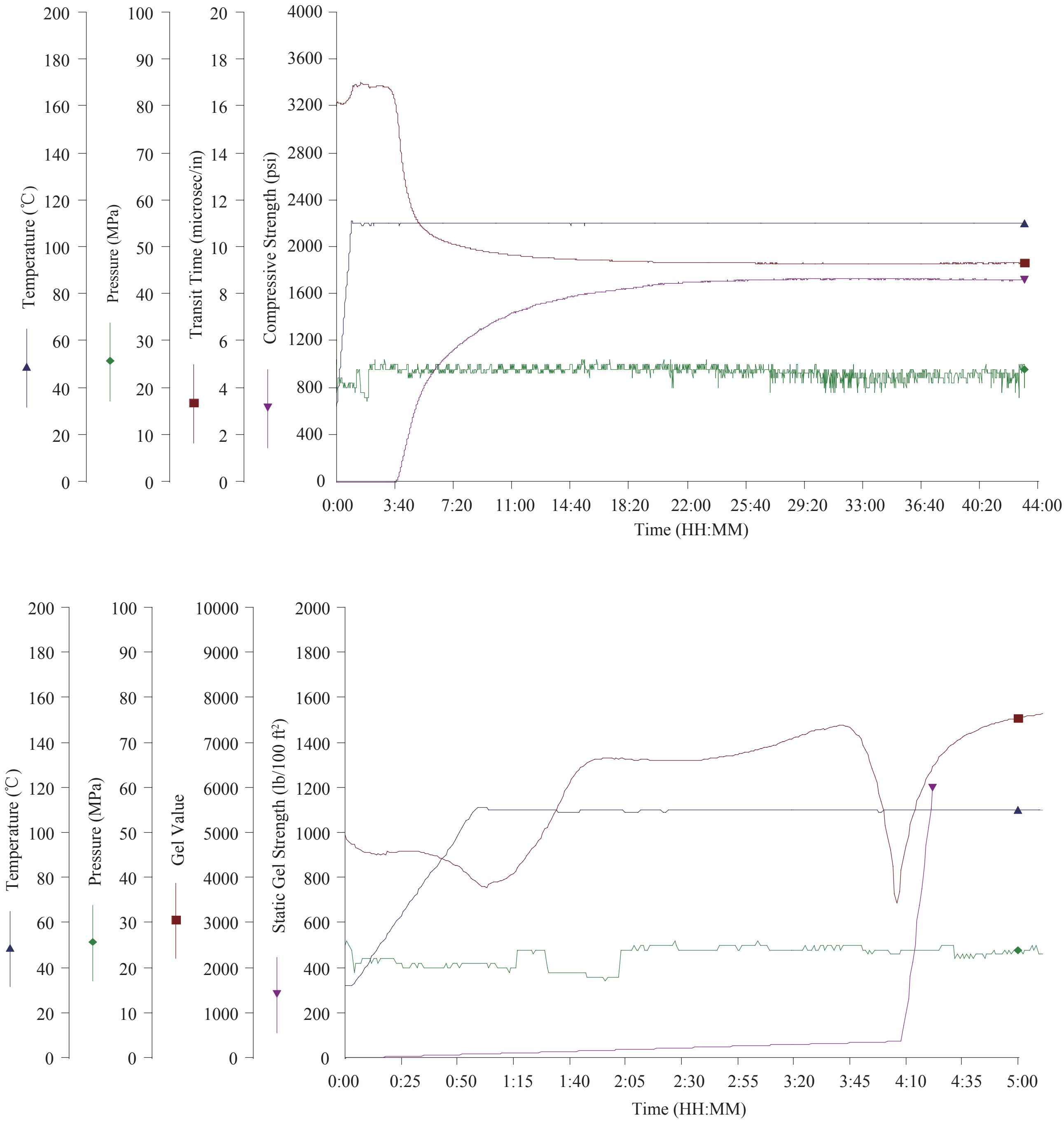


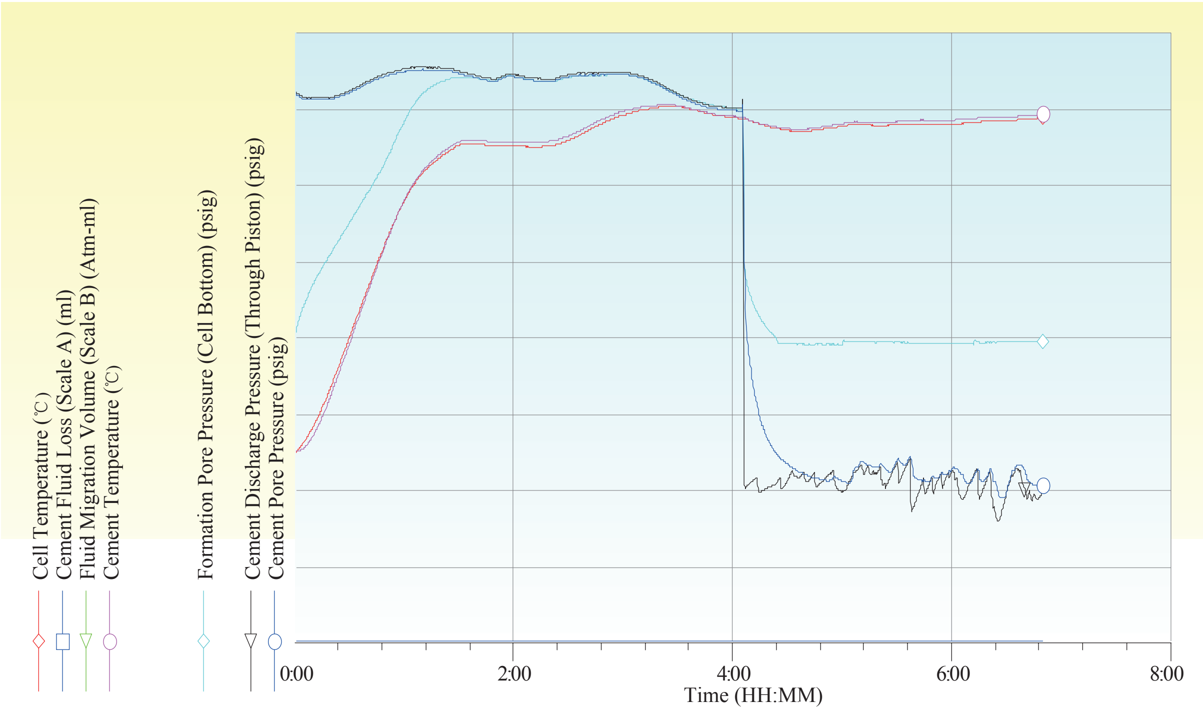
Figure 1
Latex Anti-gas Channeling Cement Slurry System Static Gel Strength Test Curve at 110 ℃

Table 2
Influence of Temperature Fluctuation on Cement Slurry Performance

Temperature	**30 ℃—50 ℃ 30 ℃—110 ℃**	**110 ℃—80 ℃**	**110 ℃**	**115 ℃**	**120 ℃**	**110 ℃ (halt 20 min)**
API water loss	--	--	11 ml	12 ml	17ml	--
Thickening time	235 min	341 min	208 min	141 min	107 min	228 min

Basic formula: JHG+30%SiO_2+3%MS+10%DC200 +7%SD-1+2%SD-2+1.2%DZS+0.55%DZH+42%Water.

Experiment condition: API water loss: 110 ℃×6.9MPa; Thickening experiment: 110℃×55min×75MPa.



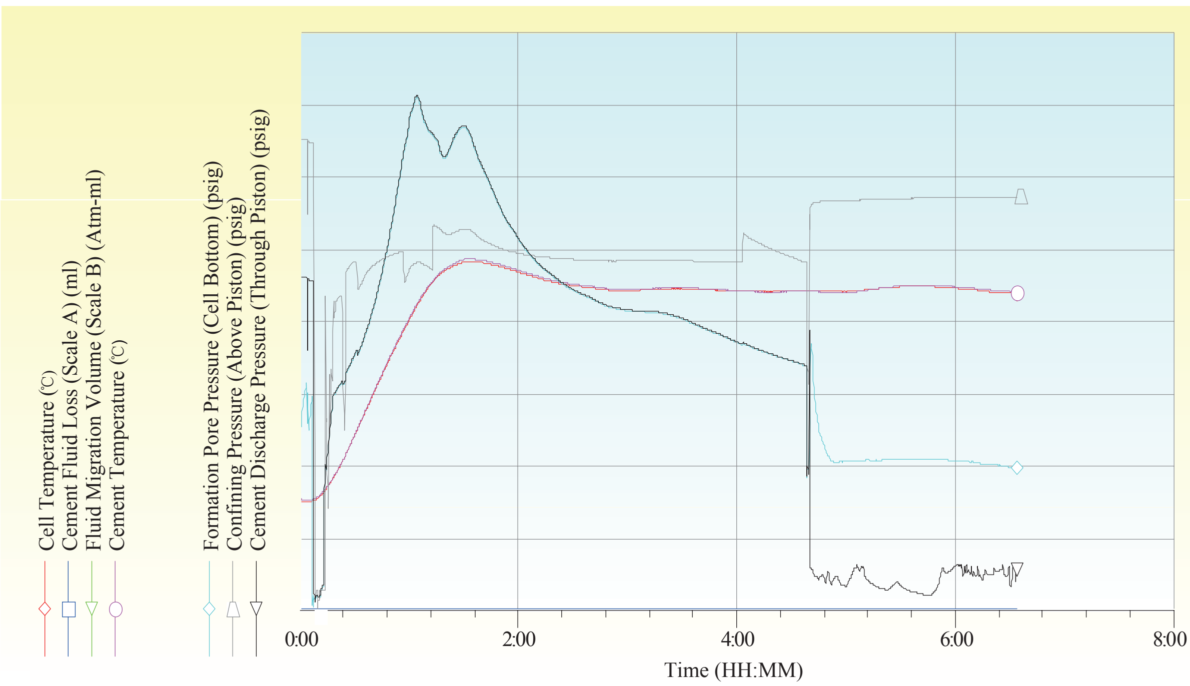


Figure 2
Anti-Gas Channeling Latex Cement Slurry System Performance Testing Curves

2.3.2 The Change of the Shear Rate Effect on Thickening Time

Shear thickening fluid, also known as expanded fluid, the shear viscosity increases with increasing shear rate. The vast majority dispersions such as suspensions, latex, polymer filler system have the behavior of shear thickening. Anti-gas channeling latex slurry belongs to the typical shear thickening fluid. Therefore, researching the relationship between thickening time and shear rate has a certain guiding role in the field configuration.

By changing the mixing machine speed to determine the influence of shear rate on the thickening time of anti-gas channeling the latex cement slurry system, the result is shown in Figure 3. It can be seen that with the increase of shear rate, the thickening time gradually decreases, but not obvious. It shows that the stability of latex cement slurry system is pretty good.

The basic formula: JHG+30%SiO_2+3%MS+10%DC200+7%SD-1+2%SD-2+1.2%DZS+0.55%DZH+42%Water.

Experiment condition: 110 ℃×55 min×75 MPa.

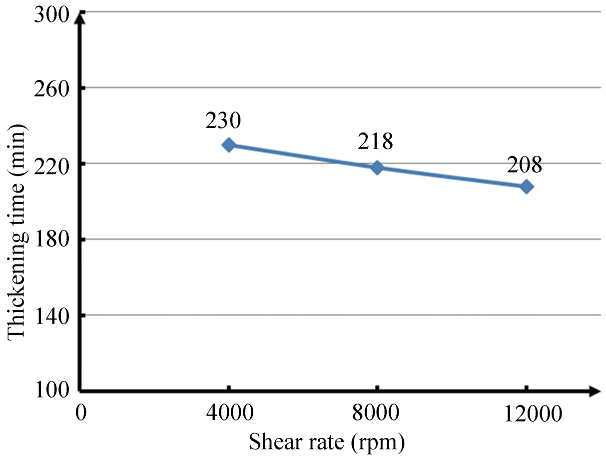


Figure 3
Relationship Between Shear Rate and Slurry Thickening Time

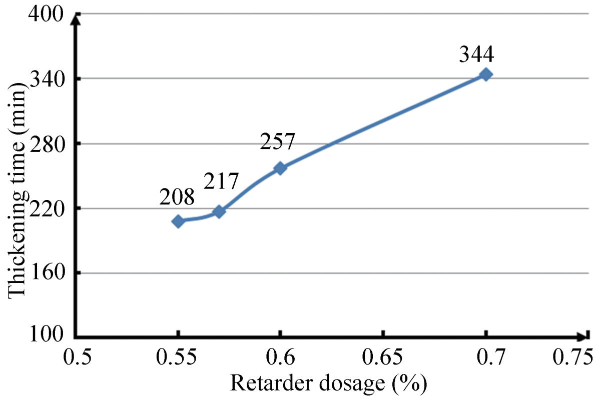


Figure 4
Relationship Between Theadded Amount of Retarder and Slurry Thickening Time

2.3.3 The Influences Between Different Adding Amount of Retarder and Thickening Time

Retarder is an additive that delays the reaction rate between cement and water which enables the cement paste hydration induction period extended, slow down the setting time. To meet the technical requirements of construction, a reasonable amount of retarder has become an important design work to the cement slurry formulation.

The thickening time is determined by changing the retarder addition in the system, the results are shown in Figure 4. The results show that the thickening time increases with the increase of retarder, and represent a good linear relationship. So that we can adjust the thickening time according to the field experiment conditions completely.

2.3.4 Effects of Changes in Water Quality on Thickening Time

Cement slurry test must be conducted before cementing operation in order to determine the curing time of cementing operation in design. The thickening time is tested by adopting the field water of different blocks, to evaluate the applicability of this system. The results are shown in Figure 5.

Basic formula: JHG+30%SiO_2+3%MS+10%DC200+7%SD-1+2%SD-2+1.2%DZS+0.55%DZH+42%Water.

Experiment condition: 110 ℃×55 min×75 MPa.

The result shows that the change of water quality does not have a significant effect on the thickening time and it also shows that the system has good compatibility with the matching admixture.

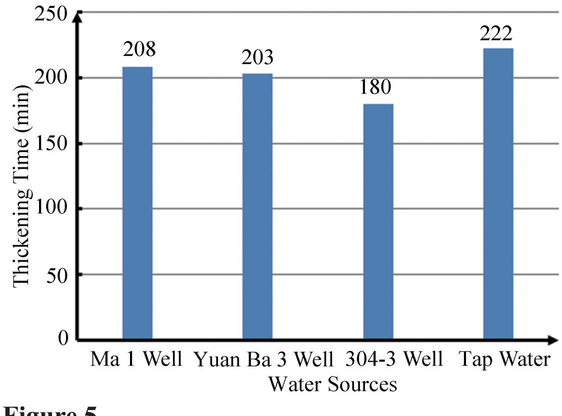


Figure 5
Relationship Between the Change of Water Quality and Cement Slurry Thickening Time

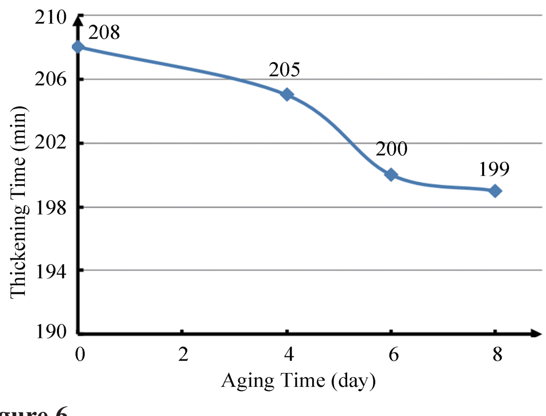


Figure 6
Influence of Aging Time on Thickening Time of the System

2.3.5 The Mixing Water Aging Experiment

Considered the situation that it would suspend sometime in the field application, so put the mixing water for 4 days of aging and then measure the thickening time of the slurry, the results are shown in Figure 6. It can be seen in the figure that there is no significant change after 8 days aging. It can be concluded that the cement slurry system is stable.

CONCLUSION

(a) Under the synergistic effect of latex and fluid loss additives, the new cement slurry has good ability of water lose control and good fluidity, the cement slurry system is stable and the thickening time can be adjusted.

(b) Through the static gel strength analysis and gas channeling simulation tests show that under the condition of high temperature model, the new latex cement slurry system has good effect of preventing gas channeling.

(c) The results show that shear rate, the change of water quality and aging time of mixing water have little effect to the thickening time. There is a linear relationship between the amount of retarder and thickening time. The more retarder cost, the less thickening time taken. The influence of temperature change on the thickening time of cement slurry system and API loss water is in a reasonable range. Through proper adjustment, the wanted curing time can be achieved.

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