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Study on Axial Stress Variation of Casing in Cementing Process

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Abstract

Cement slurry solidification process is an important part of cementing engineering, cement slurry solidification directly affects the quality of cementing, and then affects the whole drilling engineering and cost problems. In the process of cement slurry solidification, the decrease of slurry column pressure will increase the pull of upper casing, which is also the main reason for oil, gas, water channeling and early casing damage. In the process of cement slurry gelling, hydration will cause it to heat up, and then lose weight, and the combination of temperature and pressure will cause great deformation of the casing string. With the solidification of cement, this deformation will also be consolidated in the cement-sealed section. With the change of temperature and pressure under the injection-production condition, the casing in the sealed section may be under serious stress and strain, and may become an important factor affecting the service life of the casing. However, previous research on casing damage only focused on the completion of cementing. After cementing, due to the influence of formation high temperature and high pressure, construction and other factors in the later stage of oilfield production, people's attention mainly focused on the mechanical and chemical effects, and rarely considered the change of casing state during the cement slurry gaging process. Therefore, it is necessary to study the stress and deformation rule of casing string during the weight loss of cement cement gel. This paper simulates the casing force and change under different working conditions under the influence of factors such as cement slurry density, cement ring length, admixtures and formation environment. It is found that the axial tension of casing increases step by step with the cement slurry setting time and tends to decline at last. The research of casing damage in the later period provides a reference.

Keywords: Cementing; Cement paste; Weightlessness; Casing; Force analysis

1. INTRODUCTION

Cementing is one of the most important steps in the drilling of oil and gas Wells. Its main purpose is to seal the oil, gas and water layer in the hole, protect the casing of oil and gas well, increase the life of oil and gas well and increase the oil and gas production. Some problems are often encountered in cementing operations: wellhead oil and gas pumping after cementing; During production, high pressure oil and gas reservoir flows into low pressure oil and gas reservoir or non-production high permeability reservoir [1-3]. The upper gas layer intrudes into the oil layer or the lower bottom water intrudes into and inundate the oil layer. At first, it was believed that this phenomenon was caused by the micro-gap formed at the interface of cement slurry channeling and solidification. After the 1970s, it was gradually realized that the decrease of slurry column pressure during cement slurry solidification was the main cause of oil, gas and water channeling.

In foreign countries, Cooke CE and Chenier ME et al. conducted a lot of research on the change law of temperature and pressure in the process of cement slurry gelling, and realized the dynamic prediction of the change of pressure in cement slurry column. The change rule of pressure drop at each point of cement slurry sealing section in the natural gelling process can be expressed by the following formula [4-7]:

$$\Delta p = \frac{d_{\mathrm{p_m}} t}{a_{\mathrm{t}} + t} \tag{1}$$

where Δp——Pressure decrease at a certain moment, kPa; $d_{\mathrm{p_m}}$——the final pressure reduction value, kPa; a_{t}——heat half-life of cement hydration, s; t——time, s.

According to the cement slurry density required by the stratum, the ratio of water to cement and the dosage of admixtures and admixtures are determined. The formula for calculating the cement slurry density is as follows:

$$\rho_{\mathrm{cs}} = \left(M_{\mathrm{c}} + M_1 + M_2 + M_{\mathrm{w}}\right) / \left(V_{\mathrm{c}} + V_1 + V_2 + V_{\mathrm{w}}\right) \tag{2}$$

After transformation, the cement slurry density can be written in the following form.

$$\rho_{\mathrm{cs}} = \frac{(1 + m_1 + m_2 + m)\rho_1 \rho_2 \rho_{\mathrm{c}}}{\rho_{\mathrm{c}}(m_1 \rho_2 + m_2 \rho_1) + \rho_1 \rho_2 (1 + m\rho_{\mathrm{c}})} \tag{3}$$

where ρ_{cs}——cement slurry density, kg/m^3; M_{c}——dry cement quality, kg; M_1——admixture quality, kg; M_2——quality of the admixture, kg; M_{w}——quality of slurry water, kg; V_{c}——dry cement volume, m^3; V_1——admixture volume, m^3; V_2——volume of external admixture, m^3; V_{w}——volume of slurry water, m^3; m_1——ratio of additive mass to ash mass; m_2——the ratio of the quality of external admixtures to the quality of ash; m——water-cement ratio; ρ_1——additive density, kg/m^3; ρ_2——density of external additives, kg/m^3; ρ_{c}——dry cement density, kg/m^3.

When m_1 and m_2 2 and 3 are determined, the required cement density can be calculated by adjusting the water-cement ratio. If the admixture is not used, that is $m_2 = 0$, the additive amount is generally small, and $\rho_1 = \rho_{\mathrm{c}}$, then formula (3) will become the following formula

$$\rho_{\mathrm{cs}} = \frac{(1 + m)\rho_{\mathrm{c}}}{1 + m\rho_{\mathrm{c}}} \tag{4}$$

If P_0 is expressed as the upper slurry column pressure or other form of pressure, then the effective bottom hole pressure during the cement slurry setting process:

$$P_e = P_0 + \rho_c g L - \Delta P \tag{5}$$

where P_0——the pressure on the upper column of cement slurry, kP$_a$; P_e——effective slurry column pressure of cement paste, kP$_a$; ρ_c——cement slurry density, g/cm^3; g——acceleration of gravity, m/s^2.

2. MATERIALS AND METHODS

2.1 Introduction of weight loss mechanism of cement slurry

2.1.1 Weight loss mechanism of cement slurry in high permeability layer

At present, the method commonly used at home and abroad to calculate the weight loss of cement slurry during the setting process adopts the model proposed by Sabins et al:

$$\Delta P = \frac{4\pi L}{D_H - D_P} \tag{6}$$

where ΔP——loss of cement slurry, P_a; $\tau_{(t,\ T,\ P)}$——gelling strength, P_a; L——slurry column strength, m; $(D_H - D_P)$——annular clearance, m.

According to this mechanism, the flow and pressure transfer ability of cement slurry becomes worse after a large amount of water is lost in the highly permeable layer, which forms a bridge plug, resulting in the upper slurry column pressure cannot be transferred downward, resulting in weight loss of cement slurry [8-9]. However, practice has shown that under the condition of the existence of pre-mud cake on the well wall, the cement slurry water loss can be reduced to a fraction or even a tenth of the API standard water loss [10-12]. Moreover, due to the extensive use of water loss reduction agents, the current cement slurry has a good filtration control ability, and the API water loss is generally less than 200ml. There is little possibility of mass loss of cement slurry due to mass loss of water and bridge blockage.

2.1.2 Weight loss mechanism of cement slurry settling

According to this mechanism, the weight loss of cement slurry is caused by the poor stability of cement slurry system and the large amount of cement particles settling. This mechanism can reasonably explain the weight loss of cement slurry caused by poor stability of cement slurry system, upper and lower stratification or free water channel. The mechanism is based on the extreme case, that is, the cement slurry system is seriously unstable and the cement particles settle in large quantities [13-15]. However, under normal circumstances, due to the large amount of use of fluid loss reducer, most cement slurry systems are stable or relatively stable, and there is no problem of serious instability of the system and large settlement of cement particles. Therefore, this mechanism is not universal and representative, and cannot explain the weight loss phenomenon in most cement grout during the setting process.

2.1.3 Weight loss mechanism of cement slurry gelling suspension

According to this mechanism, after the cement slurry is displaced in place, a kind of space network structure with certain strength will be formed quickly, which is bonded with the formation and casing surface. At the same time, due to the water loss and hydration volume shrinkage of cement slurry, the cement slurry column will have a downward trend under the combined action of its own weight and the pressure of the upper slurry column. Under the combined action of the two, the weight loss of the whole cement slurry is formed, so that part of the weight of the cement slurry column is suspended on the formation and casing surface. As a result, the effective slurry column pressure decreases and the cement slurry loses weight [16-18]. The greater the cement cement strength, the stronger the suspension capacity of the grid structure, the greater the weight of the suspended cement cement column, the lower the effective slurry column pressure. Therefore, the effective slurry column pressure of cement slurry decreases continuously with the progress of cement slurry setting process and the increase of cement slurry gelling strength. At present, this mechanism has been widely accepted by the cementing community at home and abroad.

2.2 Damage mechanism of oil casing

1) Influence of rock pressure around borehole on casing damage. Before drilling, each rock layer is in the equilibrium state of the original formation stress field. After drilling, the stress in the borehole is released, and the distribution of stress in the borehole wall and surrounding strata is affected by the borehole. The stress concentration is generated near the borehole, so that the stress on the hole wall is much larger than that in the far distance. When the stress at the stress concentration reaches the yield limit of the surrounding rock, the plastic deformation occurs. This deformation is limited by the casing and the cement shell outside the casing, and the casing is also deformed and damaged by the reaction of the surrounding rock.

2) Mudstone expansion and creep Rock has creep and stress relaxation characteristics, Under the action of non-uniform ground stress, the creep formation produces a non-uniform extruding load on the casing, and its

magnitude increases with the increase of time. After a long time, the non-uniform load tends to be stable and no longer increases. At this time, the non-uniform load stable on the outer wall of the casing presents a non-uniform elliptical distribution, and the stress distribution law is approximately expressed by the cosine function.

$$\sigma = \mathrm{P}_1 + \mathrm{P}_2\cos 2\theta \tag{7}$$

where σ——casing subjected to radial creep extruding load, MP_a; P_1, P_2——stress boundary model, MP_a; θ——the Angle between the maximum horizontal ground stress and the connection between the upper point of the casing wall and the center of the hole.

The fourth strength theory believes that the specific energy of shape change is the main factor causing the damage of tea therapy. It is believed that no matter what stress state, as long as the shape change ratio can reach a certain limit value related to the properties of the material, the material will be damaged. The specific energy value is:

$$u_f = \frac{1+\mu}{6E}[(\sigma_1 - \sigma_2)^2 - (\sigma_2 - \sigma_{32})^2 - (\sigma_{31} - \sigma_{21})^2] \tag{8}$$

Under unidirectional tensile, the corresponding specific shape change energy of the maximum equivalent stress subjected to the material can be obtained from the above equation:

$$u_f = \frac{1+\mu}{6E}(2\sigma_s^2) \tag{9}$$

This is the limit of the specific energy of shape change that causes the material to break. Under any stress state, as long as the shape change ratio can reach the above limit, the material damage will occur. The expression of the theory obtained from the above two formulas is:

$$\sqrt{\frac{1}{2}}[(\sigma_1 - \sigma_2)^2 - (\sigma_2 - \sigma_{32})^2 - (\sigma_{31} - \sigma_{21})^2] \leq [\sigma] \tag{10}$$

where $[\sigma]$——allowable stress of a material.

3) Sand production and compaction During the production of oil Wells, cavities and tunnels will be formed in the lower liner interval, and the rock matrix will lose part of its bearing capacity. When the oil reservoir is compacted and formation pressure drops, the stress state of the surrounding rocks will change, causing the rock to collapse and form the acting load on the casing, resulting in casing damage.

4) Other geological factors caused by the casing damage rock creep, crustal movement, earthquake and other geological movements, will produce the horizontal tectonic stress of the formation, the tectonic stress to the casing exert an external extrusion force. Under the action of extruding force, the casing can also be damaged.

2.3 Influence of cement slurry weight loss on casing

In the process of cement slurry gelling, due to the action of hydration heat, the phenomenon of rising temperature in the process of cement slurry gelling, and then weight loss. The combination of temperature and pressure will cause the casing string to deform greatly. With the solidification of cement, this deformation will also be consolidated in the cement-sealed section. With the change of temperature and pressure under the injection-production condition, the casing in the sealed section may be under serious stress and strain, and may become an important factor affecting the casing life. In addition, due to the influence of various factors in the process of cement slurry waiting to set, the axial force of casing has a great influence on casing head.

3. RESULTS AND ANALYSIS

3.1 Experimental scheme

3.1.1 Experimental design

Experimental design is the design of experimental scheme, which is a commonly used optimization method in industrial production and scientific experiment field. Its main functions are: ① improve the quality and optimize the performance; ② Shorten the experiment cycle of new products; ③ Increase production and reduce costs; ④ Extend product life; Some unknown statistical laws can be obtained to promote the development of the discipline. There is much to learn about how to plan and conduct experiments. If the experimental scheme is well designed, it will get twice the result with half the effort. Otherwise, it will be half the effort, or even fruitless, which shows the importance of arranging the experimental design before the experiment. Therefore, this paper first does a good job of experimental design before the experiment.

3.1.2 Experimental principles

After cementing, hydration reaction between cement and slurry water, temperature and slurry column pressure began to change, and the casing began to be stressed. The force on the casing can be transferred to the test rod, and the stress change on the top of the casing can be recorded by the strain gauge.

3.1.3 Experimental materials

Cement: G grade oil well cement, Zhangdian, Zibo, Shandong, dry cement density 3200 kg/m3.

Additive: Quartz sand (to increase the density of cement paste).

Additives: Calcium chloride (coagulant), sodium chloride (retarder), water loss agent.

Mixing water: laboratory tap water.

3.1.4 Experimental device

The experimental equipment is shown in Figure 1, which mainly includes several parts used as simulation casing (seamless steel pipe with a diameter of 50mm×1700mm), simulation formation (PVC pipe), experimental bench, data measurement and acquisition system, etc.

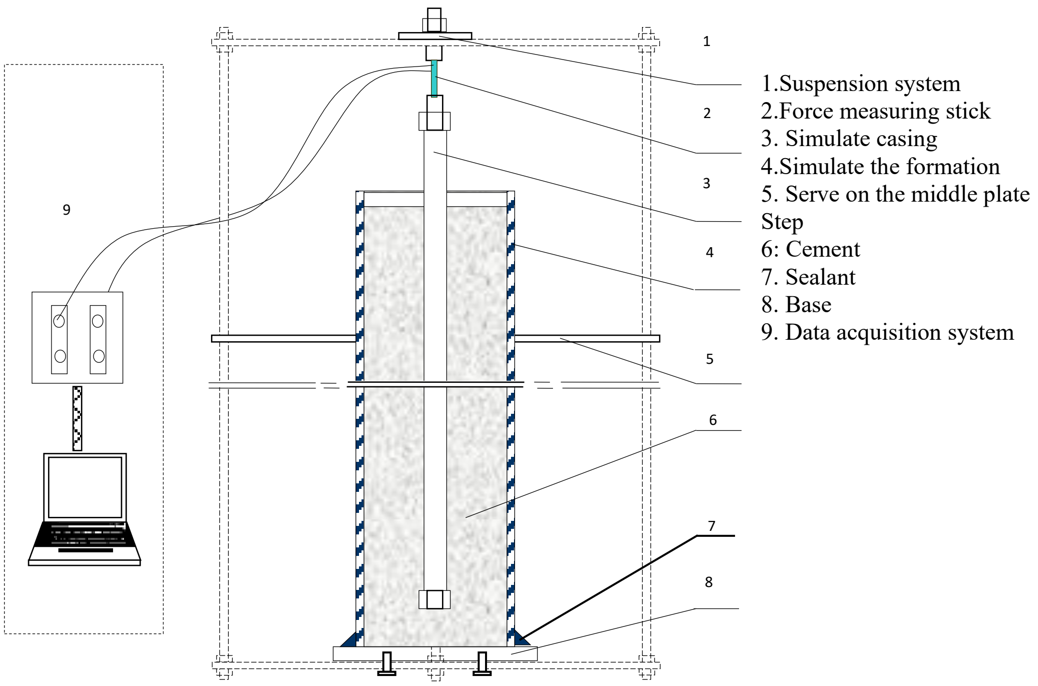

Fig.1 Experimental setup

3.1.5 Experimental procedure

This experiment considers the influence of six factors, and the influence experiment of each factor must be done several times to ensure the accuracy of the experimental results, but the steps of each experiment are similar. The details are as follows:

(1) Before each experiment, experiment preparation should be carried out, including: cutting PVC pipes of different lengths of simulated strata according to the requirements of each experiment; Attach the strain gauge to

the test rod and connect it with the resistance strain gauge for testing; Lift the casing, install the PVC pipe on the experimental device and seal it with glass glue.

(2) After the glass glue of the sealed PVC pipe and the base of the experimental device is completely solidified and effective, the cementing experiment is carried out. The first is the configuration of cement paste, cement, additives, mixing water in proportion, and then mixing with a constant speed mixer, so that the cement can be fully mixed with various additives, but also slow down the thickening time of the cement slurry, enhance the fluidity of the cement slurry, in order to fill the cement.

(3) Measure the cement slurry density. After mixing the cement paste evenly, the density of the cement paste should be measured with a density meter, and the density of the cement paste can be adjusted with quartz sand, water, and cement to meet the requirements of the experimental program.

(4) Inject cement slurry and start recording data at the same time.

(5) After the experiment is completed, save the data, remove the casing, knock off the solidified cement, clean the casing, and prepare for the next experiment.

3.2 Experimental results and analysis

In order to study the axial force on the top of casing under different working conditions, the following six factors were considered in this paper: different cement slurry density, different cement ring length, different admixtures, different PVC pipe wall thickness (simulating different rigid formations), different wall smoothness (simulating hole wall with filter cake) and temperature. In the following figure, the axial stress at the top of the casing was set to zero at the beginning of waiting for setting, and the change law of the axial stress at the top of the casing with the waiting time was studied.

3.2.1 Influence of cement slurry density on top stress of casing

In order to study the effect of cement slurry density on the stress of casing top, two kinds of cement slurry densities of 1880kg/m3 and 1950kg/m3 were designed. In addition to the different cement slurry density, other conditions such as cement ring height, additives, temperature, etc., are the same.
In the first experiment, the water-cement ratio is 0.45 and the cement slurry density is 1950kg/m^3. In the second experiment, the water-cement ratio is 0.55 and the cement slurry density is 1880kg/m^3. Figure 2 and Figure 3 show the change trend line (495) of the axial stress of the casing with time at the initial stage of the two experiments.

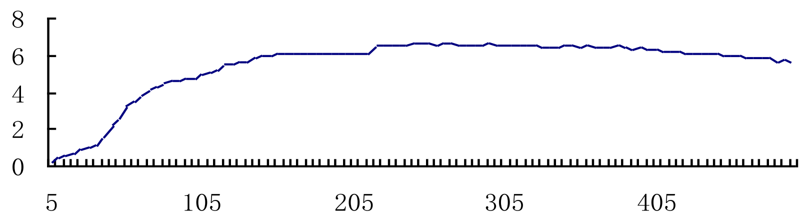

Fig. 2 Casing hanging stress of slurry with density 1950kg/m^3

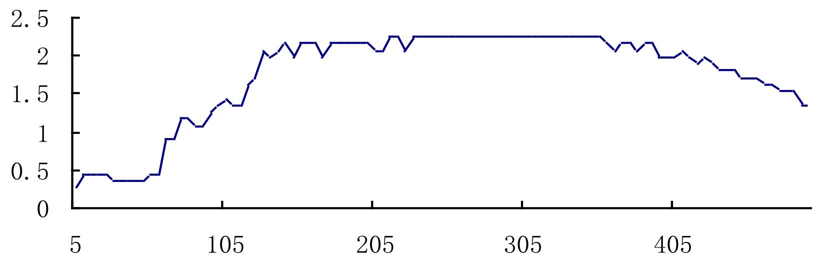

Fig. 3 Casing hanging stress of slurry with density 1880kg/m^3

From Fig. 2 to Fig. 3, it can be seen that due to the constraint of cement slurry on the pipe wall, the axial strain on the top of the casing generally increases step by step with the increase of time, and this effect gradually tends to be stable with the extension of time, but the main axial tension on the top of the casing is completed in a relatively short time. The time and size of the strength formation during the solidification process of cement slurry in the two experiments are basically similar, the only difference is that the axial force on the top of the casing is larger in the cement slurry with high density, while the axial force on the top of the casing is smaller in the cement slurry with low density. It can be seen that the higher the cement slurry density, the greater the axial force on the top of the casing, and the greater the axial displacement of the top of the casing. The reason for this result is obviously due to the high density and the high weight of the cement slurry.

3.2.2 Effect of the length of cement ring on the stress at the top of casing

In order to test the change of the force on the top of the casing under different cement ring lengths, the cement ring lengths were set as 0.6m, 0.7m and 1m respectively in this experiment. Other conditions of the experiment are the same. The ratio of cement to water is 0.45 and the density is 1870kg/m^3.

As can be seen from Figure 4, the stress law of the top of the casing is basically the same in the three experiments, and the condensation time is also very close, but the stress size of the top of the casing is different. It can be seen that the length of the cement ring is related to the force on the top of the casing. Other conditions are the same, the longer the cement ring, the greater the axial force on the top of the casing, but the force on the top of the casing is not proportional to the length of the cement ring.

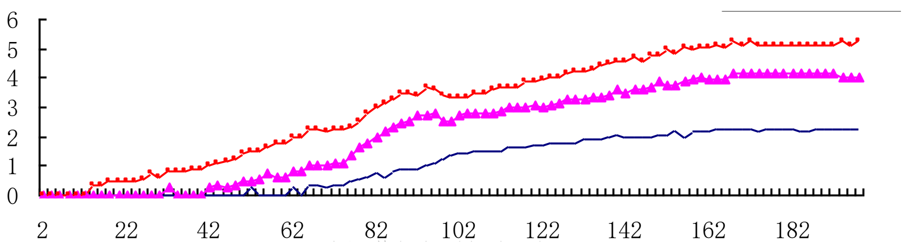

Fig. 4 Casing hanging stress VS time of different cement slurry length

3.2.3 Influence of different admixtures on the stress at the top of casing

In order to test the effect of cement slurry with different admixtures on the stress of casing, retarder, coagulant and water loss reducer were added to the cement slurry of three experiments respectively.

Calcium chloride is the most commonly used coagulant in oil fields, and sodium chloride is the most commonly used retarder. Calcium chloride is the most effective and economical coagulant. The normal addition is 2-4 (mass fraction). When the mass fraction of sodium chloride to cement is less than 10, it is a coagulant. The content of sodium chloride in the range of 10-18 neither promotes nor retards coagulation; However, sodium chloride showed retarding effect when the mass fraction of cement increased to more than 18. Under the action of a certain pressure difference, the ultrafine particles of the water-loss reducer dispersed in the cement slurry enter the micro-pores of the filter cake, and pile up between the cement particles to form a cement cake that can reduce the permeability, control the speed of liquid leakage from the cement slurry to the permeable formation, and achieve the purpose of reducing the water loss of the cement slurry. The water-loss reducer has obvious retarding effect.

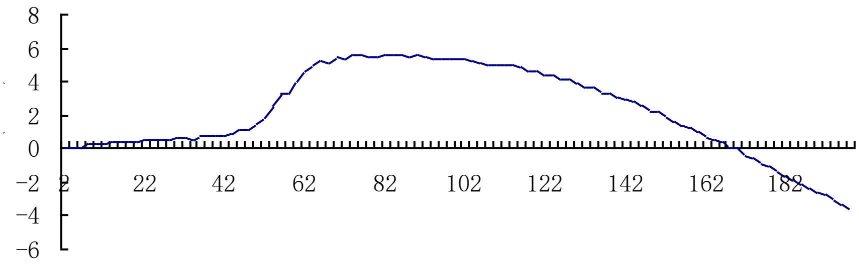

Fig. 5 Casing hanging stress VS time after adding accelerant

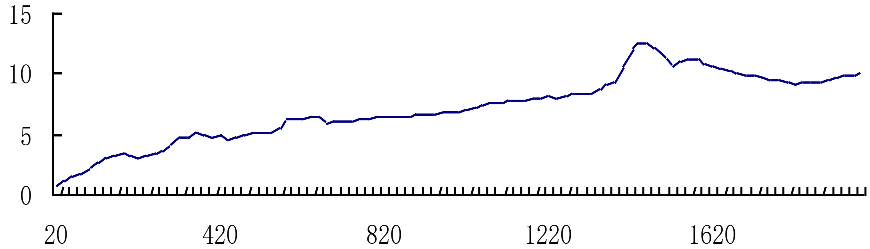

Fig. 6 Casing hanging stress VS time after adding extender

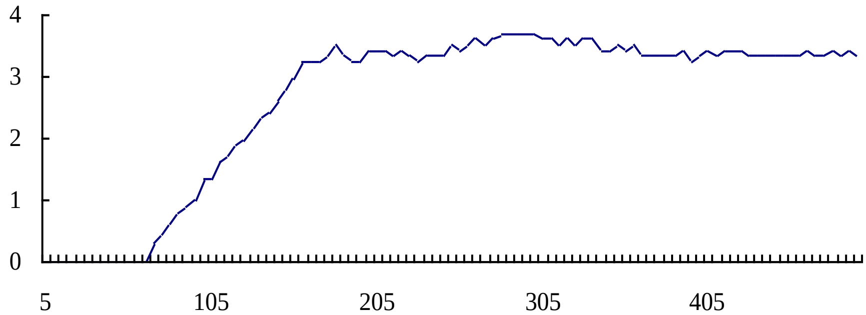

Fig. 7 Casing hanging stress VS time after adding filtrate reducer

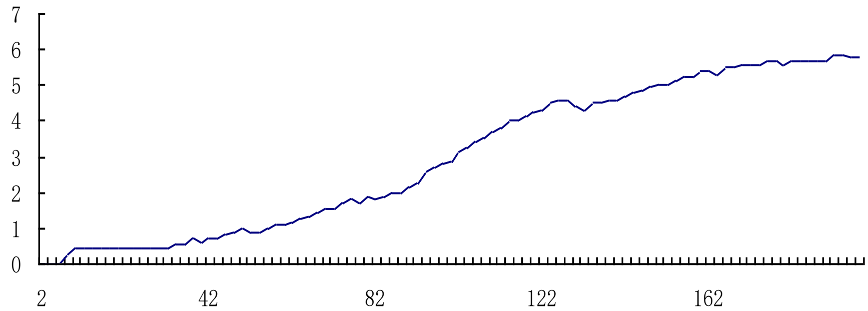

Fig. 8 Casing hanging stress VS time with original slurry

In these experiments, the slurry density was 1870kg/m^3, the water-cement ratio was 0.55, and the cement ring height was the same. From Fig. 5 to Fig. 8, it can be seen that the axial stretching of casing is completed in a long time in the cement slurry with retarder, while in a short time in the cement slurry with coagulant. In addition, it can be seen from the figure adding coagulant that the stress on the top of the casing appears negative in the late period, indicating that the casing is under upward pressure. The cement slurry with water-loss reducing agent has obvious retarding effect, and the peak axial force of casing is obviously smaller than that without water-loss reducing agent. This is because the cement slurry with water-loss reducing agent does not set into cement stone effectively within the experimental time range, so the axial force of casing is small. The solidifying time of cement slurry with retarder is obviously longer than that with coagulant. Moreover, the axial force of casing in retarded cement slurry is larger than that in accelerated cement slurry, even nearly twice as large. It can be concluded that the axial force on the casing is large in the cement slurry with retarder. Reason analysis: Such a result is caused by the effect of cement ring on sealing casing displacement, the cement slurry added with coagulant sets rapidly, and the casing has not been sealed before there is a large stretch. On the contrary, the cement slurry added with retarder sets slowly, so the casing has a great stretch, and the axial force will be great. The pressure drop at the top of casing is related to the rise of slurry temperature. The faster the hydration, the faster the heat release and the more significant the stress reduction.

3.2.4 Influence of different rigid strata on top stress of casing

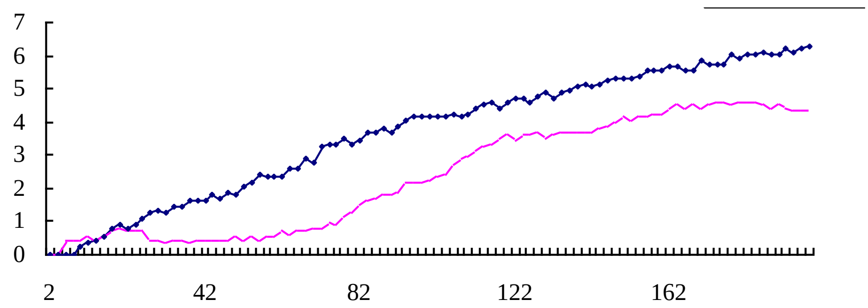

Fig. 9 Casing string hanging stress of different PVC tube thickness

In this experiment, PVC pipe with different wall thickness was used to simulate the influence of wall rigidity on the top stress of casing. The wall thickness of thick-wall PVC pipe was 0.003m and the pipe length was 1.2m. Thin-wall PVC pipe wall thickness 0.002m, pipe length 1.2m, simulate non-rigid shaft wall; The cement slurry density is 1870kg/m^3, and the water-cement ratio is 0.55. It can be seen from Fig. 9 that the stress at the top of casing is greater than that at the non-rigid well wall under the simulated rigid well wall.

3.2.5 Influence of drilling fluid cake on casing top stress

In the process of cement slurry displacement, incomplete displacement will form a filter cake in the well wall, which will affect the degree of cement bonding with the well wall. The following is an experimental method to verify the force of the casing in cement slurry solidification when the cake is formed. This experiment is divided into two parts, namely, the top stress of casing when the wall is smooth and the top stress of casing when the wall is rough. In order to make the wall smooth, the method of applying butter on the inner wall of PVC pipe in the simulated wall is used. In order to achieve the simulated rough effect of the wall, the inner wall is polished with sandpaper. For the convenience of comparison, the cement slurry density is 1870kg/m^3, the water-cement ratio is 0.55, and the cement ring length is 1m.

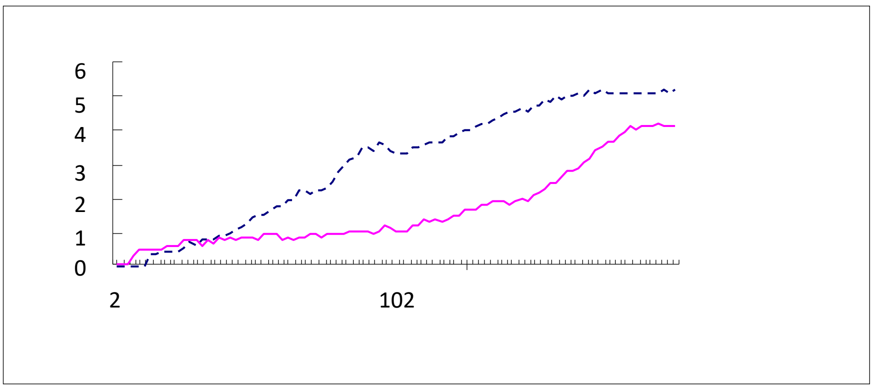

Fig. 10 Casing string hanging stress of different PVC tube roughness

As can be seen from Fig. 10, when drilling fluid filter cake is present on the well wall or casing wall, the cementing quality of the double junction will be reduced, resulting in the deterioration of cementing quality, which is easy to induce channel drilling and formation fluid intrusion. The oil, gas and water channeling caused by the reduction of slurry column pressure is also the main reason for the early casing damage.

3.2.6 Temperature experiment of cement slurry hydration process

As can be seen from the above five groups of experimental data, the axial tension of the casing does not tend to be stable in the later period, but tends to decline when the axial tension reaches the peak value. Especially after the addition of coagulant, the axial pull of the casing reaches a peak in a short time and then decreases rapidly, and finally the pull value becomes negative (forming an upward thrust). In order to explain the reason of this phenomenon, the author has done a series of additional experiments, and finally found that the heat release in the process of cement slurry hydration can not be ignored, and it will definitely affect the force of casing.

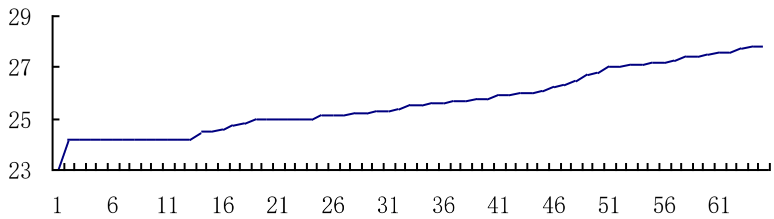

Fig.11 Temperature of solidifying of original slurry VS time

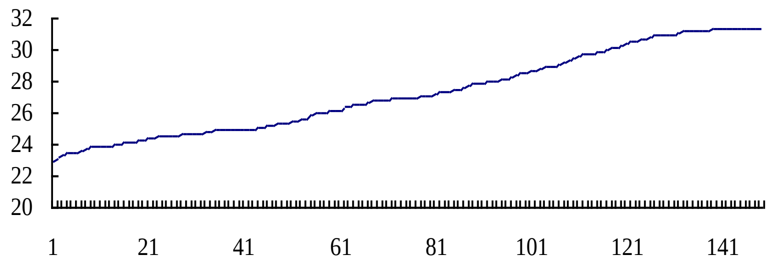

Fig. 12 Temperature of solidifying of cement slurry with accelerant VS time

The above two experiments had the same conditions except for the presence or absence of the addition of coagulant. It can be seen from the results of the two experiments that the hydration temperature of the cement slurry increases gradually and tends to be stable when it reaches a certain value. The peak hydration temperature of the slurry with coagulant added is higher than that without coagulant added, and it is about 4℃ higher.

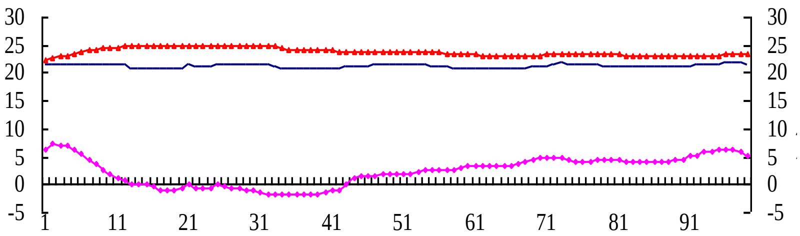

Fig. 13 The relationship between the temperature of original cement slurry and casing hanging stress

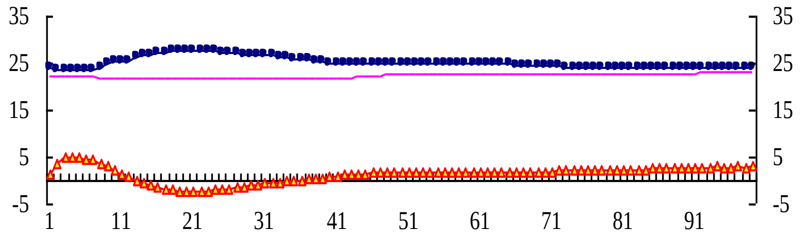

Fig.14 The relationship between the temperature of cement slurry with accelerant and casing hanging stress

It can be seen from Fig. 13 and Fig. 14 that there is a certain regularity between the axial force of casing and the temperature change of cement slurry when the room temperature change is basically constant. Therefore, the drop in tension in the middle and late stages of the above experiments can be explained as follows: in the early stage, the tension of the casing was mainly caused by the weight loss of cement slurry gelling, and the hydration temperature of cement slurry during this process had little effect; In the later stage, when the axial tension on the casing tends to be stable, the hydration temperature of the cement slurry still rises. In this process, due to the principle of "thermal expansion and cold contraction", the cement stone expands in the process of temperature rise, thus giving the casing an upward thrust.

4. CONCLUSIONS

In this paper, the axial force law of casing during cement slurry solidification is studied by experimental method. The factors affecting the casing stress law are studied from six aspects: different cement slurry density, different cement ring length, different admixtures, different PVC pipe wall thickness (simulating different rigid strata), different wall smoothness (simulating hole wall with filter cake) and temperature. The following conclusions are drawn:

(1) Experimental and theoretical studies have shown that although the weight loss of cement slurry gelling suspension is generally accepted now, the influence of the weight loss of cement slurry settlement cannot be ignored. Since the weight loss of cement slurry suspension requires a stable cement slurry system as the premise, and the stability of cement slurry is often not guaranteed at the cementing site, so the problem of solid phase precipitation and water out loss is prominent, resulting in poor cementing quality. The irregular consolidation of cement stone leaves hidden danger to the safety of casing.

(2) The influence rules of cement slurry density, gelling time, different additives, sealing section length and drilling mud cake on casing stress were found out by experimental analysis. The increase of cement slurry density, the prolongation of gelling time, the increase of cementing length and the presence of drilling fluid filter cake in the well wall will change the weight loss of cement slurry and increase the stress on the top of casing.

(3) Through the temperature change experiment of cement slurry curing process, it can be known that the hydration temperature of cement slurry can not be ignored when studying the stress condition of casing during cement slurry curing process. The temperature changes greatly when cementing cement is waiting for setting. Due to irregular borehole or the presence of mixed slurry section during cementing, the heat release during the cement slurry waiting for setting is not uniform in the sealing and cementing section, and the temperature change causes the casing to expand and shrink, resulting in casing deformation and rupture. The casing is prone to fatigue fracture under the alternating action of compression and tension. Under the dual action of thermal stress and large formation extruding force, the casing often suffers local buckling or whole buckling.

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