Application of Nano-Particles in Cementing Applications

Associated With: B.tech Project (V Semester)

Department: Petroleum Engineering & Geo-Engineering

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Session : 2022-23

ACKNOWLEDGEMENT

We wish to express our deep gratitude to the Rajiv Gandhi Institute of Petroleum Technology, Amethi, Uttar Pradesh India for providing an opportunity to perform the project on cementing operation. We sincerely thank Petroleum Engineering & Geoscience Engineering Department, for their great support. We are also thankful to Dr. Shivanjali Sharma for providing a deep understanding of such an interesting topic. This work can't be possible without her support and valuable guidance. Finally, We have not any words to express our gratitude to our parents who have shown us this world and for each and every support they have given us.

This project has added a lot of knowledge and has provided the best exposure to knowing the cementing operation and their application in oil and gas field.

Sincerely

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1. Introduction :

Oil well cement is special cement , which is made of Portland cement clinker with calcium silicate hydrate as the main component, adding a proper amount of additives. Portland cement systems are designed for temperatures ranges from below freezing in permafrost zones to 662°F (350°C) in thermal recovery and geothermal wells. According to American Petroleum Institute Recommended Practice, additives are materials added to cement slurry to modify or enhance desired property.

1.1. Objective :

The main objective of the study and experimentation part of this study to increase the compressive strength of oil well cement and reduce the filter loss.

Other objective is to study is working of cementing equipments that are :

1. **Autoclave**
2. **HPHT Filter Press**
3. **Cement Slurry Mixer**

Our secondary aim for this study is understand the effect of different additives (nan0-particles) on cement slurry. For our project , we have used :

1. **Anhy. $CaCl_2$**
2. **PAC-R**
3. **Zinc Oxide**
4. **Cuttle Fish Bone**

2. Cement Additives :

We have used anhy. $CaCl_2$ as an accelerator. Others are cuttle fish bone and commercial ZnO with Pac-R for strengthen the cement.

2.1 Calcium chloride:

Calcium Chloride is undoubtedly the most efficient and economical accelerator . It is available in regular grade (77% calcium chloride) and anhydrous grade (96% Calcium Chloride). The anhydrous calcium chloride is in more general use because it absorbs moisture less readily.

2.2 Cuttle Fish Bone :

Cuttle fish bone is the normal source of Calcium. It is referred as Bi-calcium (higher amount of Calcium Carbonate is present). It is used for early strengthen the oil well cement.

2.3 Commercial Zinc Oxide :

Zinc oxide/eugenol cement are mixtures of zinc oxide (powder) and eugenol (liquid). They are mainly used as a **lining or base under amalgam restorations and as temporary luting cement or filling materials.**

2.4 PAC-R :
(Polyanionic Cellulose)

PAC-R filtration control agent is used to reduce the filter loss, can provide secondary viscosity and is effective even at low concentrations.

3. Slurry Preparation :

Cement slurries were prepared according to API 10A [45] specifications with water to binder ratio of 0.44. The amount of cement, water and additives were weighted in the dry beaker using a clean spatula. The water was put in the mixing container and started mixing for 83 seconds at the speed of 4000 rpm. The mixing was initiated slowly and then the cement and other additives were added. The manual mixing was undertaken for 30 s with the rubber spatula to facilitate recovery of the material sticking to the wall of the mixing container. If the process of putting additives and cement were not done in 83 seconds, then we would again start mixing for 83 Seconds. Then we will run the mixer on 12000 rpm for 35 seconds. In this way, we prepared cement slurry.

To prepare cement slurry , I require Cement Slurry Mixer and stabilizer.

Precaution :

- Prepare the cement slurry by adding all the additives in a time duration of 118 seconds (remember to stir the slurry at 12000 rpm for 35 seconds).
- Make sure that cement slurry do not spill out of the cement mixer.
- Always wash the cement mixer equipment after making a cement slurry.
- Always use a stabilizer for a steady power supply to prevent damage to equipment.

Stabilizer

Mixer

4. Autoclave :

It is one of the important equipment that is used to check the soundness of cement and make cement blocks. We can use these cement blocks for further testing purpose in UTS.

4.1.Construction :

The construction of autoclave can be considered within these points :

- **Temperature probe-** for measuring the temperature.
- **Handle bar pressure equipment**- used to apply pressure.
- **Jar**- a cylindrical jar of steel in which cubes filled with cement slurry are kept.

Autoclave

4.2.Working :

To check the soundness, we put our slurry sample in a 2*2*2 in^3 cubic block and put the block in a cylinder filled with hydraulic oil and then put that cylinder in an autoclave with applied temperature and pressure condition and retrieve the cement block after a day.

5. HPHT Filter Press :

Filter Press is the one of most important equipment for cementing operation. It is used to know the filter loss(spurt loss) in cement slurry at applied pressure and temperature condition.

5.1.Construction :

The filter press consists of a heating jacket, Safe Cell, Type J thermocouple probe, pressurizing assemblies, and two power cables. The test cell can be heated to a maximum temperature of 500°F (260°C) with a 100ml sample or 350 ° F (177°C) with a 130ml sample in thirty minutes. Maximum working pressure is 1800 psig (12,410 kPa).

HPHT Filter Press

5.2.Working :

- Assemble the cell properly.
- Pour cement slurry in the cell.
- Then close cell tightly with screws.
- Set the temperature of HPHT setup at 80 degree celsius.
- Connect pressure line to the cell at 500 psi.
- Start taking the reading till API time of 30 minutes.

6. Result & Interpretation :

6.1.Using Cuttle Fish Bone :

6.1.1.Slurry Composition :

Substance	Amount	unit
Cement	600	gm
Anhy. $CaCl_2$	3 (0.5%BWOC)	gm
Water	264(44%BWOC)	gm
Cuttle Fish Bone	0 to 1% BWOC	gm

6.1.2.Autoclave Result :

Cuttle fish bone is not able to disperse due to its higher amount. So when we increase the conc. Of cuttle fish bone , the block formation got affected and its shape got distorted.

6.1.3.HPHT Result :

S. No.	Conc. Of Cuttle fish Bone	Spurt Loss	unit
1	0% BWOC (base mud)	47	mL
2	3gm (0.5% BWOC)	43	mL
3	6gm (1%BWOC)	42	mL

- HPHT results confirms that the filter loss is in quite higher amount. This is clear case of channeling.

- Only cuttle fish bone is not sufficient for our main objective. We have to add some more additive to reduce the filter loss.

6.2 Using Zinc Oxide along with PAC-R :

6.2.1. Slurry Composition :

Substance	Amount	unit
Cement	600	gm
Anhy. $CaCl_2$	1.2 (0.2%BWOC)	gm
Water	264(44%BWOC)	gm
PAC-R	3 (0.5% BWOC)	gm
ZnO	0 to 0.3% BWOC	gm

6.2.2 Autoclave Result :

Autoclave results are quite good with this combination. We got the cement blocks of perfect shape.

6.2.3 HPHT Results :

S. No.	Conc. Of ZnO	Spurt Loss	unit
1	0% BWOC (base mud)	25	mL
2	0.9gm (0.15% BWOC)	23	mL
3	1.8gm (0.3%BWOC)	23	mL

- Still filter loss is quite high. So changing the additive doesn't work for us that much.
- The higher amount of spurt loss is clear indication of channeling.
- We have to change the additive one more time to achieve our main objective.
- The purpose of using PAC-R is not fulfilled.

7. Future Plans :

Now we will think about new additives that can help us to achieve our aim. Our next combination is cement slurry with TP(Tetra Polymer).
We haven't perform any test to check the consistency and strength of cement. So we will try to perform these experiments as well.

We will learn about the working of these equipments to know the consistency and compressive strength :

1. UTS Equipment
2. UCA (Ultrasonic Cement Analyzer)
3. Atmospheric Consistometer

UTS

UCA

Atmospheric Consistometer

8. Conclusion :

We are still working on the perfect combination of additives to strengthen the cement with lesser amount of filter loss. With this project , we got familiar to working of cementing equipment and the effect by changing of conc. of additives.

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