Application foam agent to foam cement slurry for geothermal well drilling

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Abstract. One type of light weight cement is foam cement which can be used in cementing operations in weak zones with the possibility of small fractures and reducing the amount of light weigh cement suspension levels. The foam cement suspension can be used to solve lost circulation due to natural vertical fractures or cavernous formations. The purpose of this study was to determine the potential of foam cement slurry to solve the lost circulation in geothermal well. Making slurry cement uses class G cement at 200 mesh and 100 mesh size with the composition of cement. The cements put into the waring blender containing water stirrit for 35 second, adding foam agent into cement slurry with variations in foam agent concentration of 0.03%, 0.06%, 0.09%, 0.12% and 0.15%. observations of foam cement above were carried out for 30 minutes to test the stability of bubbles in the mixture. The result this study showed different compressive strength values at variations the concentrations of foam agent. The strength value is strongly influenced by result of sample with 0.03% with Sika-aer concentration have a compressive strength value of 3745 psia, while sample with Sika-aer concentration of 0.15% have compressive strength value of 1701 psia. The value of compressive strength core foam cement can form a linear line according percentage foam agent concentrations. Foam agent between 0.03% - 0.15% with Sika-aer qualified the minimum requirements BHCT compressive strength according API-10B rules to reduce severity lost circulation in the well X-E2 in geothermal drilling well.

1. Introduction
Lost circulation is all that exists or part of the mud during drilling operation which has enter on the weak formations [1]. The cause of lost circulation is the size of a large on gap in the borehole, which allow mud to flow into the formations and the pressure on the hole is the greater than formation pressure. Lost circulation can also occur because there are errors in drilling operations that are related to pressure [2]. This error includes installing an intermediate casing in the wrong place, breaking downhole pressure. The hydrostatic pressure of the cement column must not exceed the formation fracture pressure. Lost circulation problem that need help with cement plug. Foam cement is an application of fluid technology because density can reduce the hydrostatic pressure, off setting the formation pressure [3]. The heavier formation pressure is the differential pressure between the cement column and formation. Foam cements an alternative cementing product in oil and gas industry to overcome lost circulation problems that are lost in conductor and intermediate casing. Filtration los is the event in which the cement suspension enters the porous structures it passes through. The volume of filtration loss filtrate should not to be much as the result the cement suspension will ack water. This event is known as flash set [4].
2. Methodology
The laboratory study will use Sika-aer foam agent. Core foam cement test include foam testing in cement slurry and compressive strength. The composition of the mixtures was developing in the trial mix method, so that the ratio of cement slurry is cement 1: sand 0.25: water 0.5. this study was oriented to ANSI/API recommended practice 10B-4, 2004 [5]. The procedures for collecting data comes from an overview of papers, scientific journal and previous thesis research data. Making cement slurry in the laboratory varied with the addition of Sika-aer foam agent 0.03%, 0.06%, 0.09%, 0.12% and 0.15%. Sika-aer function as an air entraining agent to produce air bubbles in cement slurry, so that cavities form in core foam cement matrix and affect the bulk density core samples later. This is done on the bottom of the pipe that the water in cement mixtures can flow in the plastic hole and there is an air cavity in the core samples as a condition in testing gas permeability [6]. Factor that influence permeability include a water cement ratio, material used, curing process of cement slurry, treatment of material testing, time of cement hardnes [7]. Compressive strength cement testing aims to determine the strength of cement on compressive force in pounds per inch square. In drilling operations compressive strength that the fields are directly related to WOC [8]. Lost circulation problem in geothermal well can be learned which that problem has taken from specific trayek on 17.5” casing with the range of lost circulation as follows on the figure [1].

![Figure 1. Lost circulation problem.](image)

3. Results and discussion
The results of stability foam on cement slurry mixtures can be seen on the below table. Stability observation was carried out for 30 minutes with many samples cement slurry.

| Sample code | Cement | Sand | Water | Sika-aer |
|-------------|--------|------|-------|----------|
| M80-A       | 1.00   | 0.25 | 0.50  | 0.03%    |
| M80-C       | 1.00   | 0.25 | 0.50  | 0.06%    |
| M80-D       | 1.00   | 0.25 | 0.50  | 0.09%    |
| M80-E       | 1.00   | 0.25 | 0.50  | 0.12%    |
| M80-F       | 1.00   | 0.25 | 0.50  | 0.15%    |

Cement slurry samples M80-F accepted the stability bubbles on the cement mixture with observation along 30 minutes where the samples has a uniformity size of bubbles. The result can be seen on the figure below.
The bubbles have been stable during cement slurry to be hardened. The process is making core foam cement ready to do compressive strength testing. Core foam cement sample can be seen on the figure below before that samples are processing in compressive strength test.

The core foam cement samples above are then prepared for a compressive strength test. Testing of compressive strength have did three times test and the results shows increasing of compressive force according with the times. The result can be seen on the figure below.

Figure 4 shows an increase in the value of compressive strength along with the age of core cement samples. The increase in the value of compressive strength on the third day was not significant compared to the increase in the value of compressive strength on the second day. The test results of samples with 0.03% Sika-aer concentration have compressive strength of 3745,533 psia, while samples with Sika-aer
concentration of 0.15% have compressive value of 170,159 psia. The value of core foam cement compressive strength forms a linear line relationship between the variation of foam agent concentration and the age of the sample when testing compressive strength.

Table 2. The result test of core foam cement.

| Sample Code | Foam Ratio (%) | Bulk Density (ppg) | Pore Volume (cc) | φ (%) | k (mD) |
|-------------|----------------|-------------------|-----------------|-------|-------|
| M80-A       | 0.03           | 14.606            | 15.487          | 23.682| 0.239 |
| M80-C       | 0.06           | 14.263            | 15.573          | 29.718| 0.271 |
| M80-D       | 0.09           | 14.035            | 15.773          | 30.025| 0.302 |
| M80-E       | 0.12           | 13.986            | 16.303          | 30.565| 0.331 |
| M80-F       | 0.15           | 13.381            | 17.774          | 33.064| 0.341 |

Table 2 shows that core foam cement M80-F samples meet the requirements and criteria to reduce lost circulation problems that occur in geothermal wells in the X-E2 field at a depth of 646 m - 726 m with loss 3.8 - 4.5 bpm and density cement plug 14 ppg. The M80-F sample has a characteristic of bulk density 13,381 ppg smaller than the cement density used in the circulation in the well. The permeability of the M80-F sample is only 0.341 mD which can be explained that the permeability of the core foam cement is very small. The porosity value of 33,064% and the volume value of 17,774 cc can be explained that although there are many air cavities in the core foam cement matrix, the air cavity is not related to each other [8]. The value of compressive strength core foam cement M80-F samples which reached 1701.459 psia explained that core foam cement has a low density but still has the resistance to be able to withstand formation pressure and minimum casing pressure recommended by the API which is equal to 1000 psia [9].

Based on the results of the test results, it turns out that the value of permeability and compressive strength of foam cement is influenced by the bubble characteristic test in cement slurry as evidenced with composition of foam agent ratio between 0.03% - 0.15%, having a permeability value of 0-1 mD and compressive value minimum strength> 1000 psia.

The smaller the permeability value affects the increasing value of compressive strength foam cement where samples core foam cement with a concentration of 0.03% foam agent have the highest compressive strength value and sample core foam cement with 0.15% foam agent concentration having the lowest compressive strength value.

The composition of cement slurry and the right concentration of foam agent were obtained using the trial mix method to produce foam cement formulations. At a mixture ratio of 1: 0.25: 05 it produces foam cement cores with lower permeability and density values. The cost of polymer based cement slurry is much lower than the conventional cement slurry and suitable for geothermal well cementing [10].

4. Conclusion

M80-F sample has qualified to reduce severity lost circulation in the well X-E2 at the depth 646 m - 726 m proven by minimum compressive strength 1078 psia. Addition foam agent between 0.03% - 0.15% BWOC generate stability bubbles during 30 minutes’ observation, bubbles doesn’t much shrinkage until cement slurry mixture start to harden. Obtain the minimum compressive strength 1078 psia, where it’s qualified the minimum requirements BHCT compressive strength according API-10B rules. Compressive strength stability reached by core foam cement after the third lab testing which is indicated by differential value doesn’t significant with the second lab testing.

Acknowledgments
This research was facilitated by the Laboratory at Petroleum Engineering, Faculty of Earth Technology and Energy, Trisakti University. We also thank to AASEC 2019 who publishes this article, which in turn will benefit the society.
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