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The Performance of Foam Cement in Iran Oil Wells and Comparison of Bentonite Light Cement with Foam Cement and Presentation of Foam Cement Advantages in Iran Oil Wells

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Abstract: Depth of Iran oil wells is increasingso needing cement with different formulationisfelt more than ever.Now in Iran bentonite light cements are used as lightweight cements whichthis type of slurry for reasons thathas been mentioned in this paper is not effectivein high depth and have many problems.Considering this fact,the foam cements especially silicafoam cement that has low weight and also high strength, will be discussedin detail.As we will see further,the foam cements, reduce time of cement work operation andin this senseare economically affordable.The foam cement because of itsformulation and the nature ofits ingredientshas extremely low permeability, which thiscauses higher resistance ofthis type of cement in against the sulfate watersthat is mentioned further.Also foam cement significantly reduces the problem of formation failure which is because of thehigh pressure gradient of modern light cement that here has been discussed.

Key words: Cement - Well - Failure - Foam - Heavy.

INTRODUCTION

Lightweight slurry of cement is said to slurries that their weight is 90 - 111 PCF.The lightest pure slurry that can be created is the slurry of cement of C Class.That if its WCR sets to the desired number of 0.56, slurry with111PCF weight is achieved.If other classes of slurry are made with the WCR that has been recommended by API, theywill be heavier than thisamount.Many of formation do not bear the hydrostatic pressure caused by these heavy slurriesand for this reason they cannot be cemented with this kind of slurries.For cementing sections of anoil well which consist of weak and fragile zones,lighter slurry must be used.The easiest way to lighten slurryisadding the water to cement but the easiest way always is not the best way.Adding water to the cement slurry increases its WCR and this leads to a reduction in slurry viscosity and subsequently deposition of suspended solids in the slurry.Aside from this disadvantage,waterpostponesthickening time of the slurry and dramatically reduces rock compressionstrength.As once again was said,reduces concentration of chemical additives such as cement, and accelerators, retarders and FL controllersand decreases their impact on the slurry.Therefore cement slurry diluting in order to lightening ofthem is not permitted at all.Nowadays to lighten slurry cement two methods are commonly used: The first method is using the extenders and the second method is the use of light additives in cement or slurry.Extenders (or water-absorbing additives) are said to substances thatfor drenching of them significant amounts of waterarerequired.When these materials add to cement, raisewater requirement,this means that to produce this cement slurry, more water is needed.Obviously, more water usage reduces the slurryweightbut it should be noticed thatthis additional water does not causes problems that were mentionedbecause all of themis spent to extenders drenching and also increase yield (or efficiency) of cement thus the cost of cement per volume unit (or unit-volume cost) is reduced.The most famous extender of oil wellcement is bentonitewhich is main constituent of the drilling muds.

Other extendersof oil wells cement are:

- Pozzolans
- Diatomaceous earth
- Perlite

Some of extenders are used in oil wells cement for different reasons that arenot mentioned above.For example, some of pozzolans because oftheirless water requirement than the cementare used as materials for "strength reduction" minimizing.There are special conditions and cases that extenders should not be used, among them: inhigher temperature of 230 ^{o}Fthat strength of cement rock that contains diatomaceous earth and bentonite rapidlydegrades.For example, cement rock that has been formed from bentonitecement slurry with weight of 90 FCFthat had been cured at a temperature of 290 ^{o}F for28 days, was broken with hand pressure.In the second method by using the light additives in the cement slurry weight is reduced. The most effective chemical thathas been madeso far in this regard is Gilsonite.Gilsonitein terms of mineralogy is a solid hydrocarbon that belongs to the asphaltenes family and is found in nature in free mode.Its melting point is high

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but softens at temperature of 300±29°F.One kind of it that is used as additive ofoil well cement is a tiny black seeds that is rough and very light (SO = 1.07).Unlike the extenders, does not absorb water and does not swell. Gilsonite besides to lighten cement slurry and bridging interioralso is effective in preventing and controlling cement slurry loss in formations. In many cases, the mixture of glisonite and anextenderacts very effective and commodious than each one of them.

In addition to the above methods for reducing the weight of the cement slurry, there are other methods that are relatively successful.For example, use of liquid hydrocarbon such as gas oil or fuel oil with less than oneSO and emulsify it in the water that must be mixed with cement to make the slurry and causes to createslurries that are lighter than those has been made with bentonite,but since production and transmission of theseoil-based slurry require special facilities,they are not used widely.Recently nitrogen gas for blowing in drilling mud and lightening it has also been experienced.Principleis that in the part of the drilling mud that moves ahead of cement slurry, this gas is blown to lighten mudand to reducehydrostatic pressure resulting from iton the formation. This hydrostatic pressure reduction is compensatedby the cement slurry column behind it.In this method, nitrogen gas directly does not lighten the cement slurry but lightening mud into the well allows cement slurry that enters to well with higher weight.But using materials that has been mentioned hasdisadvantages that are:

1- Reduces the compression strength of cement rock.
2- Increases Cement rock permeability and thus its resistance against sulfate water damage is reduced (except pozzolans).

The main reasons for using light slurry can be summarized in the following cases:

1- Reduction of hydrostatic pressure of cement column to prevent failure of floors and lost circulation and consequently probable well breakthrough.
2- Reduction of Cement rock column weight behind the casing due to hanging of casing string.
3- Prevention of channeling and gas migration in case that length of the casing string is long.
4- Prevention of high exerting pressure by pumps and Prevention of piping rupture or it'sbending.

The objectives of usinglightening slurry materials can be summarized as follows:

1- weight reduction of slurry and ultimately weight reduction of cement rock
2- Increasing of the primary strength of cement rock
3- Preventing of slurry lost
4- Enhancing of cement rock durability over time withreducing of rock permeability and heat resistance
5- Reducing effect of separation of water from the slurry
6- Increasing of slurry volume with the lowest costs
7- Increasing or decreasing of slurry thickening time as side-effect of additives

In Iran light cementsare produced mainly by bentoniteand this type of light cement in low depth are not so problematicbut if the reservoir and the target zone are located in higher depth certainlycement column pressure will be more than the failure pressure and this will lead to formation failure.

Into better interpretation,in high depth cement should be designed in the way that is lightweight and has also high strength. But one of the main problems is thatbentonite light cement because of bentonite swellingin the cement leadtopermeability increase of this cement which this leads to penetration of sulfate water andconsequently strength reduction of the cementbehind the casing (Figure 1) and on the other handif amount of bentonite is low, cement will beheavier and thus lead to formation failure (Figure 2).

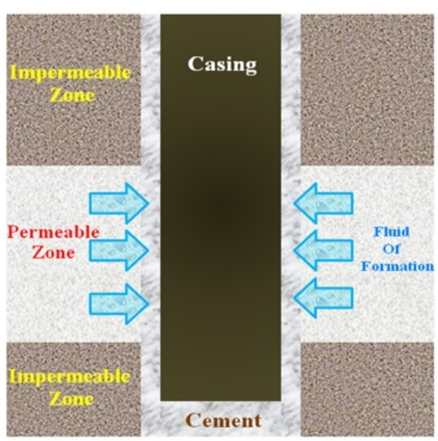

Fig. 1: Penetration of formation fluid into the bentonite light cement because of high permeability.

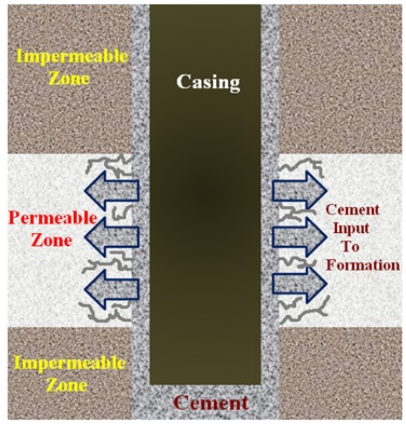

Fig. 2: Formation failure by the cement because of high pressure gradient of cement.

The point is here thatboth types of the cement is exposing to the formation fluidand the compression strength of cement decreases with timeespecially if formation fluidcontains sulfate ions, butbentonite light cement is affected much faster by sulfate water and the strength reduction will be faster.

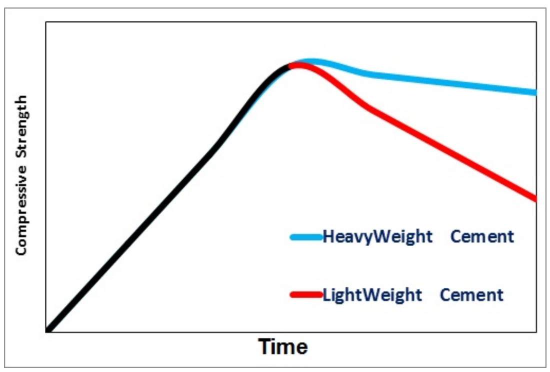

Fig. 3: Compression strength of light andheavy cementsversus of time in situation that are exposed to sulfatewater.

So with any situation this type of cement will not undertaker and causes problems that have been mentioned above. Nowadays cements are produced that are known as foam cement whichhas low weight and also high strength. Because in Iran the depth of oil wells gradually increases, need to high-strength lightweight cement is felt more which foam cements are examples of these cements.

2.Foam Cement:

As with all slurry formulations there is a compromise in final slurry properties to meet specific objectives. With lightweight slurries there is often less cement in the mixture and higher water: cement ratios. Hence the set cement can have a lower compressive strength. A high water ratio can lead to slurry instability and excess free water. High-water cement slurries typically take longer to develop strength and can be susceptible to gas/fluid channeling. Permeabilities of the resulting set cement column are typically higher than those of conventional slurries.

The use of microspheres and foam is increasing in the petroleum industry to provide slurries that better provide the properties required to meet these tough challenges. Most of the common microspheres used in our industry are pressure-sensitive. By pressure-sensitive, we mean that an increasing portion of these microspheres crush as the pressure increases during slurry placement. This leaves fewer microspheres to effect the reduction in slurry density, which in turns means that more products must be used to attain the desired result. As with the water-extended example mentioned above, there exists a varying minimum slurry density for each bead type at any given pressure, below which the amount of cement in the slurry will be insufficient to create stable slurry. As bottomhole pressures increase, stronger microspheres are often used. Using stronger microspheres leads to less crushing, but because these microspheres typically start out heavier, they also have a limit on minimum achievable downhole density.

Foamed cement formulations have been developed which show promise for application:

- As a cheap, economical and effective light-weight cement for application in formations with a low fracture gradient. Use of normal cement in these areas would cause the breakdown pressure in these weak formations to be exceeded, resulting in incomplete cement columns and inadequately supported casings. The density of the foamed cement may be easily adjusted in order to minimize cement losses while foamed-cement strength is being maximized.

- As a means for curing lost circulation in areas where cavernous vugs cannot be plugged by conventional lost-circulation materials. Lost circulation in cavernous vugs is a drilling problem frequently encountered in the Middle East. Foamed cement can be formulated with an adjustable density. It also has thixotropic properties. It is thus an ideal material for cementing depleted, low-pressure or vugular lost-circulation zones. As to the latter, it would be possible to obtain 'ideal' placement by matching the cement/density to that of the formation water in place. (Denser cements tend to slump, under the influence of gravity to the bottom of the cavity before they have had time to set up – see fig. 2).

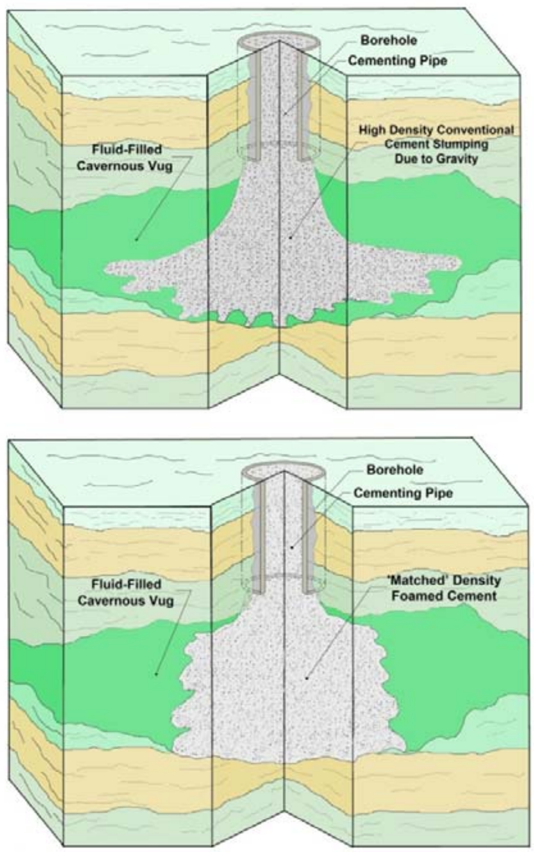

Fig. 4: Use of 'Matched' – density foam cement for curing lost circulation in cavernous vugs .

- As expansive cement which will ensure good zonal isolation in zones where gas channeling behind the casing and pressurized casing annuli are frequently encountered.

The properties of the final in-place foamed cement are only partially dependent on the final in-place foam density. More realistically, they are based on (1) the properties of the base fluid and (2) the volume-percent gas (foam quality). When the foam quality is only a few percent, the foamed cement will have set properties very similar to that of the base fluid. As the foam quality increases, the compressive strength of the set cement decreases while the permeability, elasticity, and compressibility increase. While the changes in strength and permeability are not helpful and therefore should be controlled, the increase in both elasticity and compressibility are beneficial. This increase in elasticity has been shown to be a very beneficial property in helping maintain a long-term seal. The increase in compressibility will help counter loss in hydrostatic pressure, creating slurries more capable of controlling fluid-migration problems. In general, as long as the quality stays below 35%, the permeability of the set cement will be lower than that of the formation, which is required to provide an effective seal.

3. The Benefits of Foam Cement in Oil Wells of South of Iran:

As was mentioned,bentonite lightweight cements in Iran,because of high permeability and low strength are not effectivein large depths such as more than Asmari reservoirs in south.Foam cements because of theirnature can be utilized in such circumstances.One of these types of foam cementsis the cement that has been made of silica. Indeep and very deep water drilling that surface temperature of the earth is low,this types of cement hassuitable properties such as primary viscosity and good thickening time.Considering that the cement thickening time is reduced,wait on Cement is reduced and drillingcontinues with more speed.When tiny particles are added to the cement, materials affect to deposition or accumulation.When they are contact with water this phenomenon will affectonthe rheological behavior ofslurry and ultimate hardness.Because of high cost in deep drilling, always goal of cement work is to done more quickly.The foam cement has lower setting time than other cementswhich this reduces operating time of the cement work.

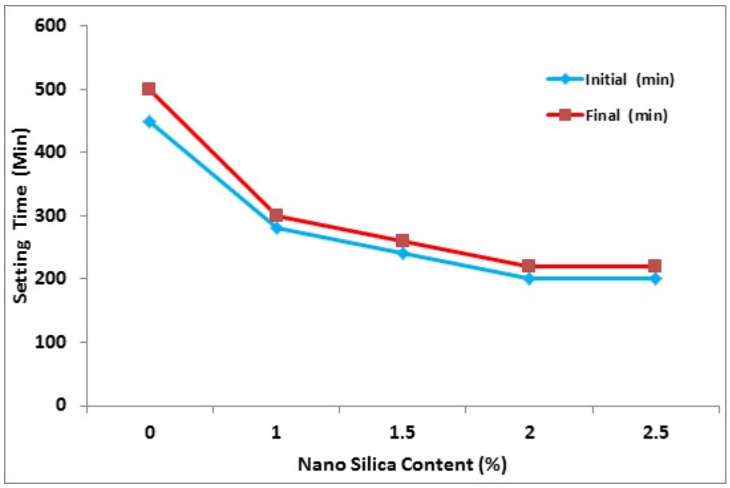

Fig. 5: Variation of setting time (initial and final) on the mortar with the Nano Silica content.

As it is obvious from Figure 5, setting time decreases with increasing of nano-silica but after 2 percent will has no effect and 2 percentby weight is optimal amount. Foam cement in terms of permeability and porosity has significant advantages than other cement.This amount of porosity for silica foam cement compared to the pure cement is shown in Figure 6.Basic cement type is class A.from the point of Pressure gradient of foam cement, Figure 7 well indicates this that generated pressure gradient is located in the region that will create minimum problemand is less than failure gradient offormation and in this aspect it will has noproblem.

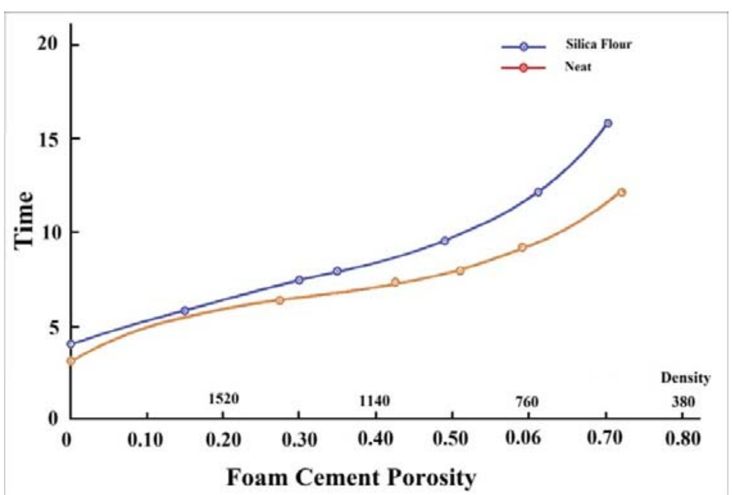

Fig. 6: Comparison of porosity with passing time in pure cement with silica A class of foam cement.

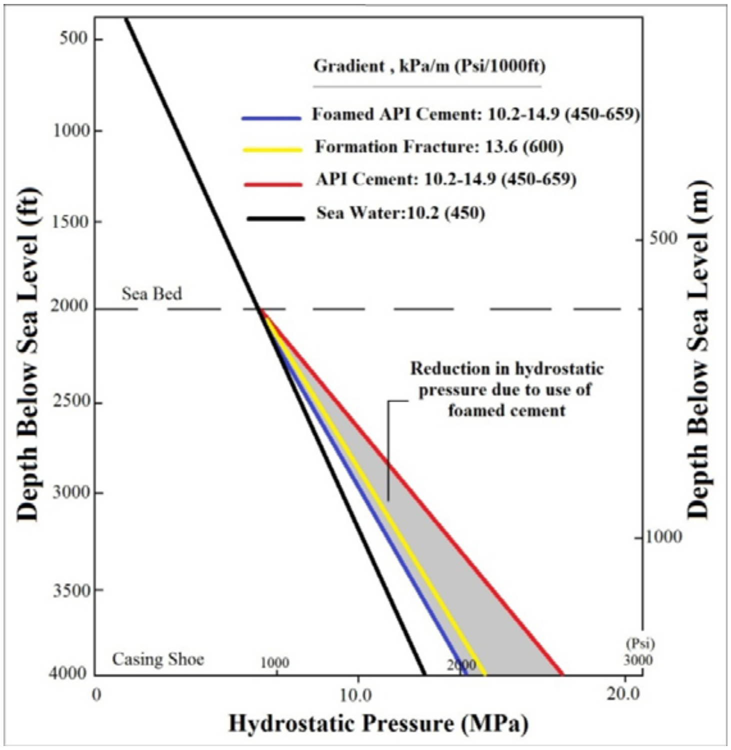

Fig. 7: Schematic of hydraulic pressure of silicafoam cementand A classpure cement.

4. Conclusion:

With regard to that,depthof oil wells in Iran is increasingby passing time consequently, needing a new formulation of cement with high strength and low weight is feltwhich the foam cement is provided for this that are:

- The light foam cement compared with bentonite cement which is now used in Iran has lower permeability and porosity, consequentlywill havehigher resistance against thesulfate water.
- The silica foam cement with 2 wt% of nano-silica has less setting timewhich causes operation of cement work isperformed in less timeand will be more economical.
- The foam slurry formulation is in a manner that is almost consistent with all of conditions and additives.While bentonite light cement in the presence of salt and salinity of water will lose its effectiveness strongly.
- According to large depth of oil wells in Iran,Using bentonite light cements in terms of formation failure because of aggression of formation failure pressureis associated with numerous problemsbut as we saw,the foam cement minimizes this problem.
- One of the disadvantages of foam cement is high cost that with new production methods can be reduced. One of the technologieswhich arenow working on itis production of gas in the cement slurry by adding aluminum powder in the slurry.
- Silica foam cement because of silicanature and also foam greatly reduces permeability and increases strength.
- One of the most important features of foam cements is their density and this unique parameter of foam cement can be largely reduced. This unique property, especially in Iranreservoirs that have numerous fractures, has high performance. Unlike the bentonite light cements that have displacement limitations, foam cement can be circulated at any point even fractures and tiny cracks.
- The foam cement has high elegance in design andshould be completely managed and implemented fromproduction stage to run.

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