Improving Zonal Isolation With Foam Cementing

Rizki Akbar, Rini Setiati, Abdul Hamid

Abstract— Cementing is the most important part of well construction and requires effective compatibility with nitrogen (N2) additives. Some of the challenges associated with this process are high temperatures, brine corrosion, and CO2 gas. The cementing process in geothermal wells is similar to oil and gas with high displacement efficiency to ensure adequate processing during low velocity. This study, therefore, aims to determine the function of foam cement using nitrogen to improve zonal isolation. The low use of variable density and relatively high strength of the foamed cement help operators to achieve long-term hydraulic bonds and zonal isolation by preventing hydrostatic pressure damage. In Indonesia, geothermal wells are developed with the fracture and low temperature gradients using lightweight foamed cement. This ensures job success, proper engineering, and control.. The results foam cementing are to establish good bonds and zonal isolation, the engineering process allows operators to adjust slurry density during cementing as needed. It is first mixed then pumped into a hole, and stabilized to create foam. This study concludes foam pumping has the ability to improve zonal isolation in oil and gas drilling wells.

Index Terms— cement, slurry, nitrogen, zonal isolation, foam, engineering.

INTRODUCTION

Cementing process is the way of placing cement into annulus between casing and wellbore. For achieve this purpose, hydraulic sealing have to obtain casing and cement, also casing and cement, in the mean time preventing the chanelling. For this main requirement for cementing oil and gas wells are [1] to tying and supporting the casing, limiting the movement of fluid between formation and sealing the lost circulation zone. Nevertheless, there are several factors causing failure cementing process, such as cause of mechanical shock of pipes and extension of the casing. Pressure causes conventional cement to break down quickly, thereby, creating a new flow in the annulus. Furthermore, continuous casing pressure (SCP) is generated when the pressure returns to the annulus after thermal expanded of the fluid and closure of the valve. The compressible and flexible nature of cement tends to flex and absorb pressure, which damages conventional cement. Its flexibility without foaming tends to increase cementing lifespan by maintaining the integrity of the hydraulic bond, preventing the formation of microannules, and eliminating pressure cracks.

2. METHOD OF THE RESEARCH

Foam cement is a mixture of slurry, foaming agents, and nitrogen gases. When mixed with the correct composition, it forms a stable and lightweight slurry. In development of foam cementing must suitable with base-water. Stable base-water slurry cement have a same mechanism that will produce free fluid depend on properties of set foamed cement. [1]. The cement slurry is first mixed and pumped into the well, which is followed by the injection of a proportional amount of high pressure N2. The layout of producing a sample foam is presented in Figure 1. Nitrogen is put into the cement slurry with adequate energy to produce descriditated gas cells, thereby producing a stabilized and unconnected product in the form of bubbles. These bubbles are not fused (Figure 2), thereby producing a cement matrix with low-density permeability and high strength. For example, slurries are bubbled up to densities as low as 4 lb /gal and are easily placed in weak formations, thereby preventing problems associated with lost circulation and fallback. Foam cement tends to support the functions of primary cementing and repairing for offshore and onshore usage, as shown in the following list [1]:

1. With some additives of cement, foaming creates a synergistic effect that enhances its properties. This effect is proven by some additives which lose fluid, material circulation, and latex.

2. The density of foam cement varies. Its ductility allows expansion and maintenance of pressure during hydration, thereby assisting in the production of long-term zone isolation. When cement expands, it fills the swept hole, and the circulation zone disappears very broadly without damaging the formation.

3. Increased sludge removal capacity from foam cement also helps to improve zonal isolation. Furthermore, its tenacity provides sheath support for wells.

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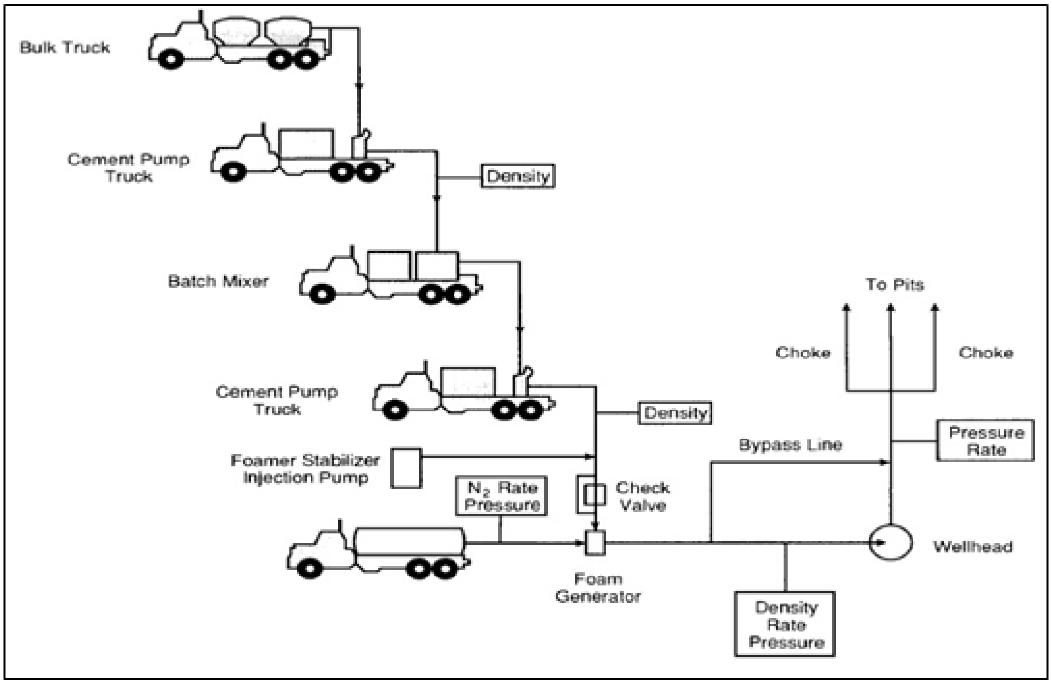

Fig. 1 Layout of foam cement [1]

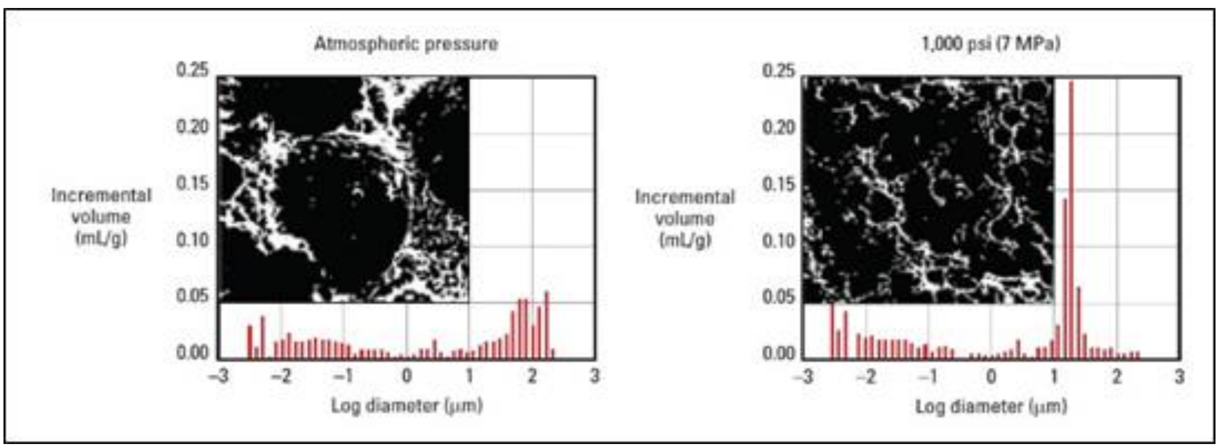

Fig. 2: Structure and size distribution of foam cement [2]

When the foam cementing operated by the operator, the foam will produced on the surface, then injected into the slurry base and pumped down into casing and upward to annulus and formed between casing and borehole. Becasuse of the liquid can not be compressed, the density of slurries relatively constant and does not changed by the presure. On the other hand, the foam liquid, consist of liquids, which has fixed volume and gas, Nitrogen, which is can be develop and/or compressed depend on variations of pressures and temperatures. If the volume was occupied by nitrogen inside foam slurry will reduced due to compression (could be decrease in temperature, incresed in pressure. Then, the density of slurry base of foam cement will increase.

3 TECHNICAL ENGINEERING AND OPERATION CONTROL

The process of technical isolation and control produces high-quality, controlled, and stable foam cement. Cement operators are always at the mixing site for proper management, and with the right technical and control processes. Other factors include design parameters, stabilization, and composition of the cement slurry. This engineering work maximizes benefits and prevent problems associated with high and low-pressure zones. To ensure the foam cementing has good quality, the technical isolation process and operation control provides the factors that influence quality control, as follows:

1. The cementing work simulation software produces an overview of the possibilities of the cement program and analysis in real-time.
2. Laboratory testing: identify potential problems, such as incompatibility of fluid or additives.
3. Cement mixture is made to meet cementing specifications.
4. Data acquisition provides valuable downhole information during crucial decisions.
5. Certified personnel is a team of trained specialists with cementing experience and skills.
6. Full automation this consists offactors such as density control, N2 rate, and auto-foamer injection. All equipment is connected to provide an electrically integrated communication loop. Therefore, it has the

ability to operate with the rate of cement slurry production.

7. Cementing best practices enables the team to adapt the procedures of experts to achieve optimal results.

For the foamed cement have three phases system such as gas liquid an solid, within many happen on the interfaces [3]. The system will be constant because of the gas bubble can reorganize that may grew, shrink or merge because of reaction happen in slurry base. The foam is difficult to characterize because they are depend on shear-fluids, and the texture were very depend on proceudre in mixing. Foam cement has been made in bigscale in the filed, with high shear rate, high pressure, and found be maore stable than foam cement in laboratory [3]. In labarotory scale foam cement showed more stable [2] that can generate at pressure value conditon all set-up and has narrow bubble distribution size than slurry did in atmospheric condition. The most method commonlly for foam cement prepare at he filed is to mix slurry base with additives, except surfactants, then pumping down surfactants and gas as slurry into wellbore. Besides, the pressure in foam cement is worked, the foam will affected equipment for the stability of bubble distribution particel of foam cement. The solids play a significant role in foam stabilization [3]. Since solid particle combined with bubbles it can be inhibits bubbles. Foam stability has relation to the particle of size and wettability. The behaviour in which particle solid are can can maintain on liquid and/or gas interface. On both of cases, worked is required to transfer material from the surface to the bulk. This is called thermodynamic phenomenon of foam stability [5]. Then, the size of particle is very important affected the sedimentation. Properties themodynamic could affected foam stability [2]. The selection of suitable foam cement and stabilizers must be consider the criteria, such as, firts is safety and handling for the consideraton. Second, the compatibility. Third, the effected of the cement strength and permeability. Fourth, the stability. Fifth, Efficiency and cost [1]. The selection of density slurry base affected to the requirement of set foam cemented properties. A normal density will guide gas with large volume to reach a foam density given, hence, it will made an affect to he higher permeability.

Table 2

Thermodynamic Parameters [1]

Stabilizing	**Phenomena Destabilizing Phenomena**
Laplace diffusion	Gravity drainage
Plateau border suction	Surfactant concentration gradient
Marangoni effect	Gibbs elasticity
Surface viscosity	

4 RESULTS AND DICUSSIONS

The following 2 cases influences the operator's decision to use foam cement.

Case History 1:

The formation consists of water sand with several high permeability lines and the well is stable with a small flow. The operators need to cement the 13-3/8" sheath in the well to prevent problems with the hydraulic bond. The cement slurry is energized to reduce return flow with a flexible density. Technical engineering isolation processes and operation controls enable operators to change the weight of the cement slurry to prevent hydrostatic pressure in order that it does not from damaging the previous casing shoe. This is because the well has a fracture and low-temperature gradient, and requires light cement slurry. Its service has the capability of using 16 ppg premium lead cement as a base material, which is foisted to 11 ppg with N2 520 scf/bbl. The tail liquid contains the same basic slurry with a foam of 13 ppg at 232 scf/bbl N2. Furthermore, at low displacement rates, characteristics of foam cement ensure good radial coverage in wellbores with large angle inclination.

Case History 2:

This formation contains a lot of gas sand, and mud is cut during drilling. The company needs to cement a 7-5/8 "size production liner to ensure long-term hydraulic bond and production zone isolation. Due to the fracture and low-temperature gradient of the well, high strength lightweight slurry is needed. The operator selects the liner attached by companies with conventional cement. This ensures effective coverage despite low displacement rates and large inclination holes (77°), which enables companies to successfully place cement across dangerous zones. Furthermore, rig costs and squeeze are blocked by using a technical engineering isolation process and operation control allowing operators to benefit from foam cement efficiency and variable density. The isolated long-term zone is expected to be the right hydraulic bond.

5 CONCLUSION

Foam cement is generally used for lightweight and relatively high strength displacement and it is also used because of its displacement efficiency and variable density. The technical engineering isolation process and operation control used to provide premium foam cement reaches long-term isolation zones and are appropriate for hydraulic bond on oil and gas drilling wells.

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