Study of microfine cement use on squeeze cementing operations in plug and abandonment work

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Abstract. The purpose of this study is to develop guideline and decision tree for selecting proper material of squeeze cementing operation as part of permanent well abandonment project in PT XYZ. The existing guideline in oil and gas industry does not cover the detail of cement type selection prior to do squeeze cementing job and this may cause failure in the operation and give the high cost impact due to remedial job. It is expected that the result of decision tree and guideline in this study can be used as a reference for plug and abandonment project in. The method used in this research is by calculating the value of the injectivity factor obtained from field study as a key factor in determining the type of cement for squeeze cementing operation. If the injector factor value is less than 2000 (<2000), it is concluded that G type cement (G class cement) is preferred to be used to isolate the reservoir formation zone. While for the injectivity factor value more than 2000 (> 2000), the reservoir is considered as tight formation and difficult to penetrate, so the use of microfine cement is expected to isolate the reservoir formation zone.

1 Introduction

Upon cessation of oil and gas activities, permanent well abandonment should be done by isolating the well reservoir and other supporting facilities safely in order to avoid any future hazards in the future. All Production Sharing Contract Companies are obliged to perform the proper abandonment along with site restoration [1]. From the total of 86 Production Sharing Companies in Indonesia in the year of 2013, none of them have performed properly permanent well abandonment referring to government and international regulations. The ideal plug and abandonment project is to get the result of cement plug barrier as shown on the figure 1 below. According to international and local regulations, the cement barriers consists of cement plug 1 which is the plug material to isolate the formation and also cement plug across it. The second barrier is cement with bridge plug which is set above first barrier. The third barrier is also cement with bridge plug where the location is set on the shallower depth closed to the mud line. All these three barriers are created with well intervention technique considering the safety operation and economical calculation in order to achieve high level of standard for plug and abandonment operation.

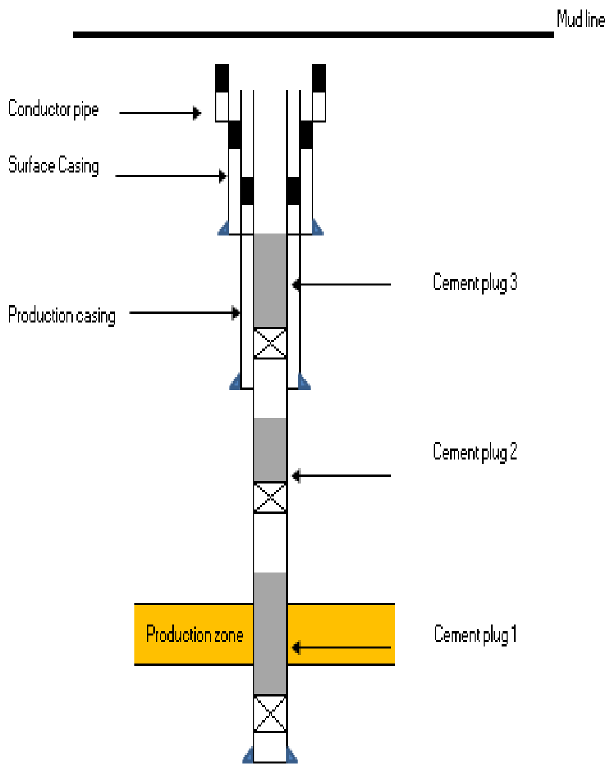

Figure 1. General schematic of plug and abandonment design

Reservoir isolation is one of the critical point during plug and abandonment operation. It is done by squeezing the amount of cement volume and place it to

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the reservoir zone. Squeeze cementing method is categorized into two different ways depending on the formation tightness which are continuous squeeze and hesitation squeeze [2]. This method can be determined by doing injectivity test. The determination of cement type becomes very important in squeeze cementing operation as the successful of the next cement plug placement depend on the successful of this stage.

Microfine cement is a type of cement that has a very fine particle size of 6 µm-15 µm compared to type G cement (API class cement) which has a larger size about 42 µm - 105 µm [3] as described on the figure 2 and 3 [4]. With this fine particle size, microfine cement can be easily penetrated into tight formation and useful in squeeze cementing operations [5].

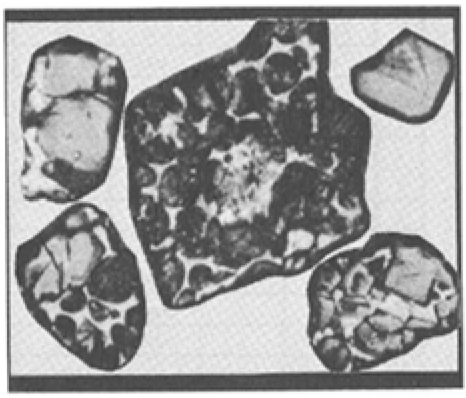

Figure 2. Normal API cement particle size

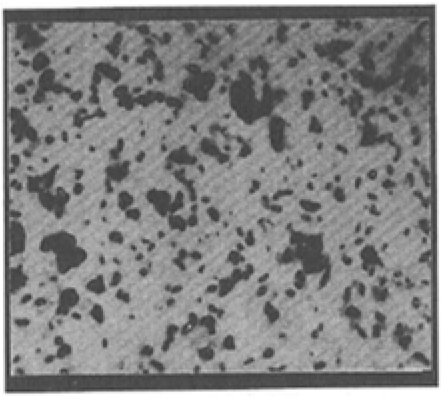

Figure 3. Microfine cement particle size

2 Methods

The research methodology undertaken in this study is to identify problems followed by literature studies and the collection of technical data related to the subject of the study. The expected result of this research is to have a decision tree that will assist in determining the type of cement used of microfine cement utilization in the plug and abandonment project. To obtain the decision tree, the injectivity test needs to be done in order to capture the character of the reservoir formation and to obtain the value of injectivity factor. Prior to the squeeze operation, common practice is to inject fluid into the interval to be squeezed to make sure cement can be injected into it. During the test, the injection rate and injection pressure applied are recorded. The result of injectivity test giving the parameter to calculate injectivity factor value to define cement type for squeeze cementing operation. With this decision tree, it is expected that the company can make an accurate decision regarding what type of cement to be utilized and avoid the remedial job caused by failure of squeeze cementing operations.

3 Results and discussion

3.1 Injectivity factor value

The relationship between injection pressure and injection rate is important information for designing successful squeeze operation. This can be defined by the quotient of the injection pressure divided by the injection rate. The formula of injectivity factor calculation below was obtained from the actual field study and trial that has been done and recorded in the various of wells [6]. From the record of the field study, it was concluded that the value of injectivity factors indicating the ability of the materials/cement to penetrate reservoir formation of the wells. If the value of injectivity factor less than 2000 (< 2000) we may utilize normal G class type of cement for doing squeeze cementing job. While if the value of injectivity factor more than 2000 (>2000) then we need to utilize microfine cement for the squeeze operation.

$$Injectivity\ Factor = \frac{\text{Injection pressure}}{\text{Injection rate}} \quad \text{.......... (1)}$$

Where:
Injectivity Factor = psi-minute/barrel
Injectivity pressure = surface pressure gauge reading, psi
Injectivity rate = fluid injection rate, bbl/min

Table 1. Initial Injectivity Factor Result

Well Name	Injection Pressure (a)	Injection Rate (b)	Injectivity Factor (a/b)
A	100	2	50
B	150	2.5	60
C	700	0.3	2333
D	300	2.5	120
E	250	2	125
F	750	0.25	3000
G	300	3	100
H	250	2.5	100
I	200	2.5	80
J	150	2	75

From the injectivity test result, the value of injectivity factor can be simply calculated by dividing the injection pressure and injection rate. Based on the result in table 1 above, there were 2 wells (well C, well F) which have injectivity factor value > 2000 while the other wells have the injectivity factor < 2000. This results indicating that the formation characteristic in well C and well F is tight and less permeable. The initial squeeze cementing had been done on these wells by using type G cement (API class cement) and the result was unsuccessful to penetrate the formation on well C and well F.

3.2 Microfine cement utilization

The Laboratory test and analysis are required prior to execute the utilization of microfine cement. This lab test or compatibility test need to be done in order to get proper recipe of cement and its properties for the compatibility with the formation and the ability to penetrate the formation during squeeze cementing job. The results of the lab test had been done for those two wells (well C and F) and the design of program for those wells are also mentioned below

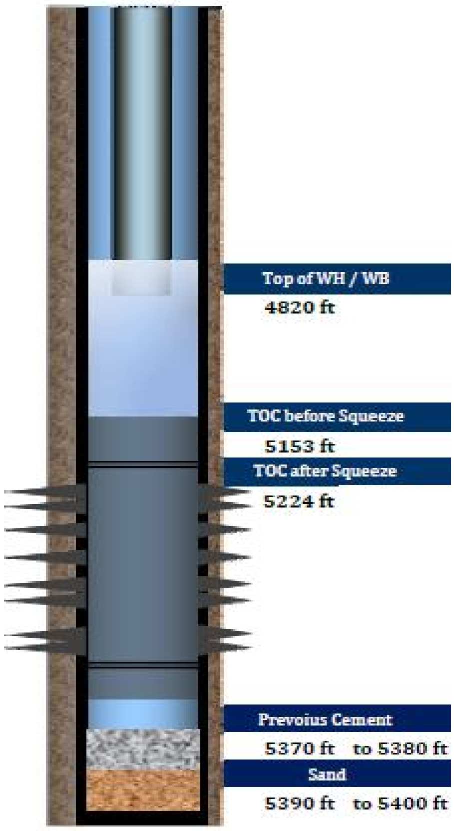

Figure 4. Program design of well C with microfine cement

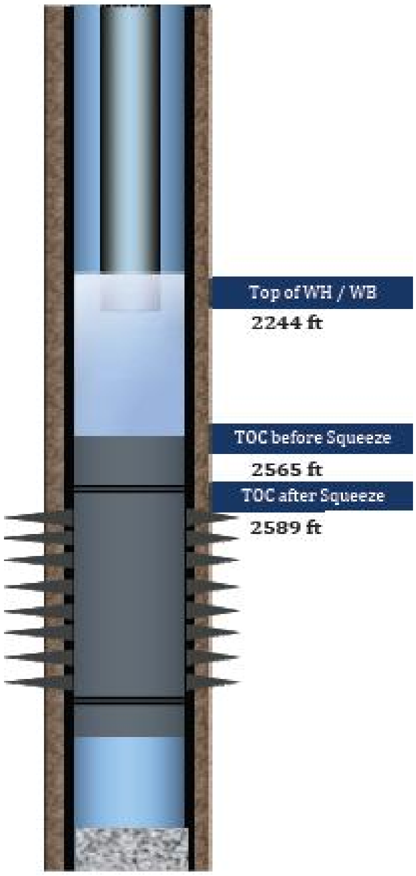

Figure 5. Program design of well F with microfine cement

Main slurry: Well C

Ultrafine Cement + 35.00 % (db-BWOC) S-8, Silica Flour

+ 0.050 GPS FP-9LS, Foam Preventer
+ 0.400 GPS CD-37LS, Dispersant
+ 3.500 GPS FL-47LS, Fluid Loss Additive
+ 2.500 GPS BA-58L, Bonding Agent
+ 0.100 GPS R-21LS, Retarder

Slurry Density : 12.50 ppg or 1.50 sg
Slurry Yield : 2.871 Cuft/sack
Mixing water : 9.250 gal/sack (Fresh Water)
Total Fluid : 15.800 gal/sack

Main slurry: Well F

Ultrafine Cement + 35.00 % (db-BWOC) S-8, Silica Flour

+ 0.050 GPS FP-9LS, Foam Preventer
+ 0.420 GPS CD-37LS, Dispersant
+ 3.100 GPS FL-47LS, Fluid Loss Additive
+ 2.830 GPS BA-58L, Bonding Agent
+ 0.150 GPS R-21LS, Retarder

Slurry Density : 12.50 ppg or 1.50 sg
Slurry Yield : 2.871 Cuft/sack
Mixing water : 9.250 gal/sack (Fresh Water)
Total Fluid : 15.800 gal/sack

The difference recipe between G class cement compare to microfine type cement is the utilization of Silica Flour and more additives volumes to be mixed prior pumping the cement into formation. Today's well cements have to withstand an enormous range of well depths and conditions. The Silica Flour in microfine cement act as a material to improve the strength of cements, decrease capillary and the voids in concrete. The volume of dispersant was also added for microfine cement in order to lower the frictional pressure of cement slurries while they are being pumped into the well and providing slurries with high solids to water ratio. The significant volume of fluid loss additive need to be added in the recipe to prevent solids segregation during cement placement and to control the rate of fluid leak off. The additional of bonding agent will enhance the joining of individual members of cement structure and finally the retarder volume assisting to slow down the chemical reaction that takes place when the concrete starts the setting process.

3.3 Microfine cement pumping result

Having discussed and analysed the lab test result, the conclusion is to prepare rig-less field execution [7] based on the lab test result for well C and F. The injectivity factor during microfine cement pumping is shown in the graph on Figure 6 and 7. The method used during cement pumping is direct squeeze method by combining 3 different rates of pumping. In the well C, pumping the microfine cement with rate of 1 BPM result in 920 psi of pumping pressure, rate 1.5 BPM result in 733 psi of pumping pressure and rate 2 BPM result in 600 psi of pumping pressure. While in the well F, pumping the microfine cement with rate of 1 BPM result in 1000 psi of pumping pressure, rate 1.5 BPM result in 800 psi of pumping pressure and rate 2 BPM result in 690 psi of pumping pressure. All the injectivity factor value during microfine cement pumping are less than 2000. This value is also in line with the successful parameter used on the reference of field study for squeeze cementing operation [8]. The cement finally can be placed into formation and act as a barrier to isolate the formation.

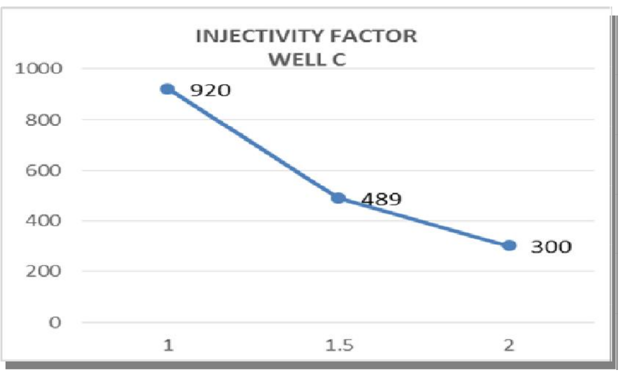

Figure 6. Injectivity factor result of well C with microfine cement

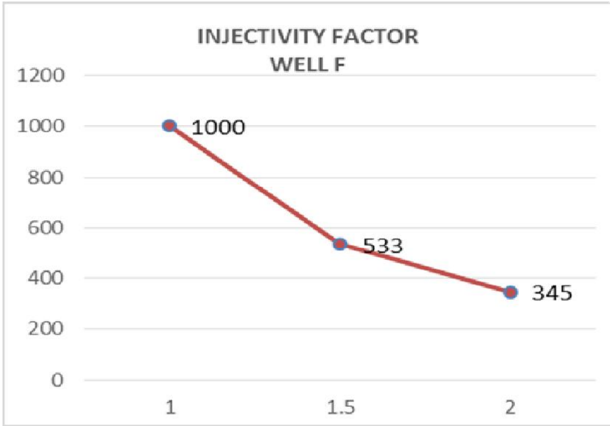

Figure 7. Injectivity factor result of well F with microfine cement

3.4 Proposed decision tree

The result of field execution for squeeze cement operation with microfine cement is considered successful method to solve the well problem in plug and abandonment of PT XYZ. The result also give justification to the company to establish decision tree for selecting proper cement material prior to do squeeze cementing operations as shown on figure 8. The proposed decision tree explaining steps in selecting cement for the project where the first step to do is performing injectivity test in order to have recorded pressure and rate data. The result of data can be used for calculating value of injectivity factor for each well and divide them into two groups: wells with injectivity factor value less than 2000 (<2000) and wells with injectivity factor value more than 2000 (>2000). From this value, then the company can select type of cement to be used for squeeze cementing operation. The idea of decision tree is to assist the company in optimizing the operation and avoid any remedial job that cause in high operation cost due to improper cement material. It is expected that all the related parties in the company, especially engineer and manager to comply with this decision tree and program before the execution of cementing operation. Further study can also be performed in order to get more advanced microfine material such as Smart Dynamic Concrete (SDC). SDC is low-fine, self-compacting concrete, that combines the benefits of normal concrete (stability) and self-compacting concrete (fresh properties) [9].

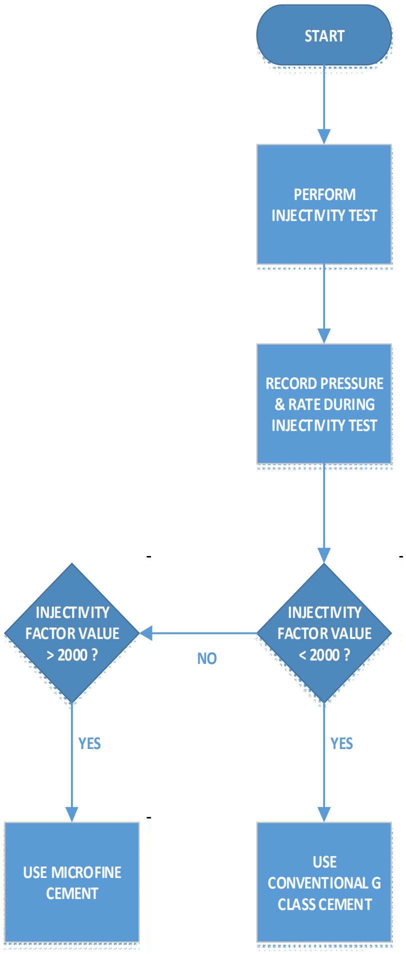

Figure 8. Proposed decision tree

4 CONCLUSION

The decision tree which has been developed in this study can give a clear guideline for the decision maker in the company to select proper cement material to be used in squeeze cementing operation. Budget consumption can be optimized because of the reduction of remedial job during cementing operations.

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