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Calcite Inhibition System: Lihir Experience

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ABSTRACT

Calcite Inhibition has been an integral part of maintaining geothermal power generation at the Lihir Geothermal Field, Lihir Island, Papua New Guinea. Due to the unique composition of the field's brine chemistry, conventional simulation software is not compatible for easy evaluation of a geothermal well's scaling potential. Thus, a strategy of using antiscalant systems on all the wells with considerable brine contribution was adopted.

Since 2003, only one chemical, a polyacrylate based inhibitor, was proven to be effective for the Lihir chemistry. With the increasing cost associated with the inhibitor, it was deemed necessary to find an alternative product that is more economical.

In 2010, laboratory and field trials of new, antiscalant chemicals were conducted to determine their inhibition efficiencies and relative effectivity to Lihir geothermal fluids. Based on the results of these tests, one of the new anti-scalant chemicals was chosen to replace the current inhibitor and its optimum dosing rates was determined. The utilization of this new chemical equates to a 73% reduction in the antiscalant system's operational costs.

1. INTRODUCTION

The Lihir geothermal field is situated on the main island, Aniolam of the Lihir group of Islands in New Ireland Province, Papua New Guinea. The exploitation of the geothermal resource is secondary to the gold mining activities. Initially, geothermal well discharges were limited to the purpose of reducing ground pressures to be able to continue with open pit mining.

In 2002 a 6 MW pilot plant was installed to prove that geothermal power generation can be achieved. One of the issues that were needed to be addressed before geothermal power expansion was pursued by management was the well bore blockages caused by carbonate scales, which caused a rapid decline in output within a few weeks. In 2003, Sinclair Knight Merz (SKM) conducted calcite antiscalant trials and proved that wellbore deposition can be controlled.

By 2005 a 30 MW plant was commissioned and was further expanded by 20 MW in 2007, thus the total generation capacity increased to 56 MW. With the increasing number of wells that needs to be treated, it was decided to determine if a more economical scale inhibitor would be applicable to the Lihir geothermal system.

2. METHODOLOGY / DESIGN

The objective of the test was to determine alternative inhibitors in the market that can be used for the Lihir's unique geochemistry and determine its cost effective dosing concentration wherein inhibition is achieved.

The experimental design was similar to the testing done by SKM but instead of cutting out a production well from the system and by passing it to a discharge silencer to measure the changes in output, we opted to conduct the test on an online production well and monitored the change in power generation.

2.1 Antiscalant Products

The working inhibitor being used was from Ashland Australia which was composed of a polyacrylate combined with phosponates and 2 other active compounds. It is brown in colour and has a specific gravity of 1.1.

Nalco Australia provided two chemicals for testing, namely Scaleguard 84614 and pHreedom 5200M. The active ingredient of Scaleguard is sodium bisulfate. It is a straw colored liquid, having a pH of 4-6 and a specific gravity ranging from 1.24 to 1.28. pHreedom 5200M is a phosphonomethylated diamine salt, which is a clear light yellow liquid, with a pH of 4.2 and a specific gravity of 1.17 to 1.21.

2.2 Inhibitor Screening

Prior to conducting the field test, the commercial inhibitors were laboratory tested to determine the inhibition efficiency. They were compared with the current inhibitor being used at the Lihir Geothermal field and bench marked against a known working inhibitor from the Philippine Geothermal field.

A modified National Associated of Corrosion Engineers (NACE) test procedure on the determination of the calcite inhibitor efficiency was used to rank the inhibitors.

2.3 Well Selection

Due to the unique nature of the Lihir fluid chemistry, wherein it contains very high sulfate concentrations (~ 30,000 ppm), it was difficult to simulate the mineral saturation indices. The well tested needs to have a similar chemistry as that of GW17, a known calciting well which was the site of the original antiscalant trials.

Figure 1: The figure shows GW55 and the Antiscalant System being used

From the well considered, GW55 was deemed the best candidate since it already has a new antiscalant system that can be easily operated (Figure 1) and it has a similar chemistry as that of GW17 (Figure 2).

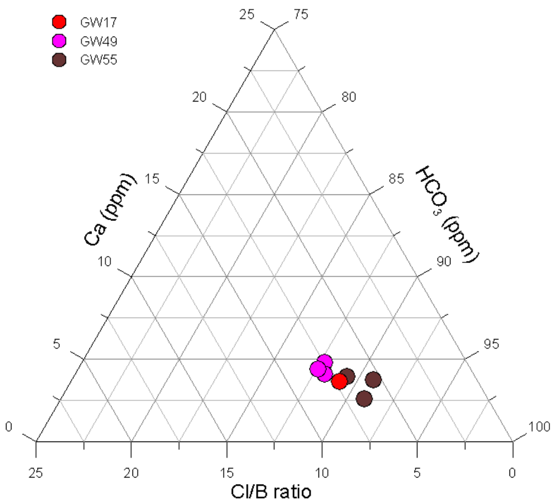

Figure 2: Relative Chemistry of GW17, GW49 and GW55. (known calciting wells)

2.4 Antiscalant Dosing System

The chemical was introduced into the well through an armored ¼" tubing pumped with a Milton Roy metering pump. The tubing was set below the flash point of the production well. The inhibitors were pre-mixed on 1,000 liter containers for the different dosing concentrations.

2.5 Test Design

The approach taken on the antiscalant trial was the determination of the relative performance of Nalco chemicals against the current inhibitor being used, which was proven to be effective at 30 ppm dosing concentration on previous trials.

The test was divided into three parts. The first part was the baseline data collection, wherein the calcium concentration was monitored while using a proven inhibitor.

The second part was the dosing trials, where the inhibitors to be tested were dosed at different dosing concentrations for short durations.

The third part was the optimization run. Once the effectiveness of the inhibitor was assured, specific dosing concentrations were tested for longer durations.

Since we were testing on an online production well, we are unable to stop inhibitor injection without jeopardizing geothermal power generation. At any time during the testing, if the calcium concentration falls below 30% of the baseline level, the dosing would shift back to the working inhibitor.

2.6 Well Monitoring

The wellhead pressure and the geothermal power generation were monitored throughout the trial period. Consequently, periodic tracer flow measurements were conducted to determine any significant changes in the well's mass flow

2.7 Sampling

Regular brine sampling was carried out every two (2) hours through the use of a mini silencer. Samples were then filtered and acidified onsite. A mini silencer was used to normalize the sample collection process instead of a separator.

2.8 Analysis

Brine samples were analyzed colorimetrically onsite for Calcium using the Calmagnite method on a portable Hach spectrophotometer. Samples were also sent to the Newcrest Assay Laboratory for comparison.

3. RESULTS

The result of the laboratory trials and pilot testing is as follows:

3.1 Inhibitor Ranking

Inhibitor samples were sent to the EDC laboratory for inhibition efficiency determination. The samples were tested as received and after being subjected to elevated temperatures.

Based on the laboratory results (Table 1&2), pHreedom 5200M and Scaleguard 84614 showed good calcite inhibition on synthetic brines before and after subjecting the chemicals to elevated temperatures that mimics the temperature of application.

Comparing the same dosing concentrations, the inhibitors can be ranked with pHreedom 5200 having the highest inhibition efficiency, followed by Scaleguard 84614 and then the Lihir working inhibitor.

3.2 Pilot Test Results

The pilot testing started with the baseline calcium data collection from GW55. A calcium concentration of 70 ppm was observed while dosing the working inhibitor at 30 ppm. A 50 ppm calcium level (approximately a 30% drop in concentration) was considered as the threshold of effective inhibition.

Table 1: Inhibitor Efficiency of As Received Samples

Inhibitor Efficiency (%)	Dosing Conc. (ppm)		
	5	10	20
Working Inhibitor			
Run 1	72.40	91.30	97.6
Run 2	76.40	87.40	88.8
Ave.	**74.40**	**89.35**	**93.2**
Scale-Guard 84614			
Run1	94.80	97.50	94.0
Run 2	93.40	92.30	91.1
Ave.	**94.10**	**94.90**	**92.5**
pHREEdom 5200M			
Run 1	93.80	94.90	96.2
Run 2	91.40	99.60	99.0
Ave.	**92.60**	**97.25**	**97.6**

Table 2: Inhibitor Efficiency of Thermally Treated Samples

Inhibitor Efficiency (%)	Dosing Conc. (ppm)		
	5	10	20
Working Inhibitor			
Run 1	84.00	95.90	95.4
Run 2	73.80	89.20	92.3
Ave.	**78.90**	**92.55**	**93.8**
Scale-Guard 84614			
Run1	96.70	95.70	92.5
Run 2	94.00	94.20	94.5
Ave.	**95.35**	**94.95**	**93.5**
pHREEdom 5200M			
Run 1	91.50	99.10	92.4
Run 2	96.60	100.00	99.8
Ave.	**94.05**	**99.55**	**96.1**

The dosing trials commenced with a 20 ppm dosing concentration of Scaleguard 84614 for an 8 hour shift per day for 3 days, followed by a 10 ppm dosing, then a 5 ppm dosing. During this part of the testing, no calcium concentrations were observed below 50 ppm (Figure 3). However, the wellhead pressure dropped while on the last leg of the 5 ppm dosing trials, thus prompting the immediate shift to the working inhibitor at 30 ppm dosing.

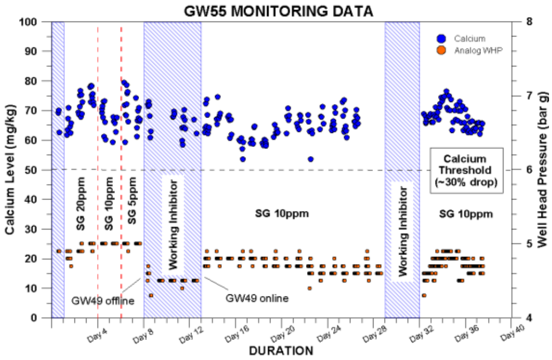

Figure 3: GW55 Antiscalant Trials Monitoring Data

After evaluation of the data, we noted that the wellhead pressure monitoring was affected by the change in the wells contributing to the steam gathering system. The drop in WHP pressure was caused by the cutting out of GW49.

We then proceeded with the 24 hour continuous dosing of Scaleguard 84614 for 14 days at 10 ppm dosing concentration. No significant drop in calcium concentration was noted, but a declining well head pressure trend was observed. In order to alleviate any doubts in the results, a verification run for 7 days at the same dosing parameters was done to confirm the results.

In addition to the wellhead pressure and calcium monitoring, tracer flow measurements from GW55 before and after the trials showed a consistent mass flow of 45-46 tph, indicating no detrimental effects of using the new inhibitor.

With the positive results from the initial inhibitor trials and due to economic considerations, further optimization runs at lower concentrations and pilot testing of pHreedom 5200M was discontinued.

4. CONCLUSION

From the laboratory tests, Nalco Scaleguard 84614 and pHreedom 5200M were both effective inhibitors. From the pilot testing, Scaleguard 84614 was proven to be effective at 10 ppm dosing concentration on a Lihir geothermal production well.

Based on the current market price of the inhibitors, a 73% cost saving was calculated by changing from the current working inhibitor to the pilot tested Scaleguard 84614.

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