

Effective Calcite Reaming with a Drilling Rig for Menengai High Temperature Wells

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Keywords

Calcite, scaling, inhibitor, reaming, quenching, aerated, recover, work-over, cooling

ABSTRACT

Formation of calcium carbonate (calcite) is a major scaling problem that occurs in geothermal fields around the world leading to decline in well output and impacts on power plant production. In Menengai high temperature wells calcite scaling has been a cause of decline in production of some wells.

There are several methods that can be used for the management of calcite scaling and rehabilitation of affected production wells. For Menengai wells, injection of chemicals to inhibit scaling and mechanical reaming with a drilling rig (2000HP rig) has been done. For the reaming, quenching of the well is done before the master valve is disassembled and the temporary well head is mounted before mechanically reaming with an 8½ inch bit assembly with 6½ inch drill collars and 5 inch drill pipes to the 9⅝ inch casing shoe. This assembly is pulled out before running in 6¼ inch bit assembly with 5 inch drill collars and 3½ inch drill pipes. Reaming is done to about 5 metres off the 7 inch liners landing depth. The main drilling fluid is aerated water and foam. At the bottom the well is circulated and the well unloaded. The quenching of the well prior to reaming could lead to well failures, especially casing damage due to the sudden change in temperatures by injecting cold water into wells at high temperatures of about 300°C. The quenching of wells also affect the formation temperature. For wells that take long to recover, this would be detrimental especially if the wells are in production.

This paper looks at a method that involves reaming of calcite without cooling the well by allowing it to flow and thus self-clean. The paper looks at the modification of equipment from what has been previously used to suit for the work and the method for cleaning the calcite while discharging the deposits to the silencer. The paper looks at design of equipment, drill string and drilling fluid and a general work-over program for a well in production (connected to the power plant) that should not be quenched.

1. Introduction

1.1 Calcite Formation

Calcite is a crystalline form of calcium carbonate (CaCO_3) and is an abundant secondary mineral in geothermal fields worldwide. The deposition of calcium carbonate from a geothermal fluid is a major problem in a number of geothermal fields, mainly due to plugging of geothermal wells.

Upon boiling, dissolved gases present in the liquid phase are strongly partitioned into the vapour phase. At the initial flashing stages the concentration of carbonate ions in the water increases rapidly. Therefore, if by boiling a small amount of steam is lost, a large amount of CO_2 escapes from the liquid phase to the steam phase, causing an increase in pH and carbonate ion concentrations, so calcite is rapidly precipitated at the beginning of flashing. This condition favours the deposition of calcium carbonate in a well and will, in time, obstruct the geothermal fluid flow. The deposition is found in wells above the flashing point.

1.2 Calcite deposition in Menengai Wells

Drilling in Menengai geothermal field commenced in early 2011. Most of the wells drilled are located in the central area of the field with most of these wells drilled for the 1st phase of power production.

MW01 was the first well drilled in Menengai. The well sited and drilled within the central area of the Menengai field has had challenges with calcite scaling necessitating reaming with drilling rig twice. The first work over was done in June 2012 and the second work over done a year later in July 2013. In addition to the work overs injection of calcite inhibitor has also been done on the well

1.3 Effects of Calcite

Calcite deposition in geothermal wells has these effects:

- a) Decrease in reservoir pressure thus decreased well head pressure
- b) Solid deposition thus plugging flow both inside and outside of the well bore
- c) Damage to well infrastructure especially the casings and the well head equipment
- d) Variation in composition of the geothermal fluids, increased cold water recharge leading to decline in the temperatures of the well.

1.4 Menengai Wells Design

Menengai wells are regular well design;

- 26 inch surface hole drilled to 80 metres and cased with 20 inch casing and cemented back to the surface
- 17½ inch anchor hole drilled to 400 metres and cased with 13⅜ inch casings. The casings are cemented back to the surface.
- 12¼ inch diameter hole is drilled to casing depth of 1000-1400m, with the 9⅝ inch production casing set and cemented back to the surface.
- The 8½ inch main hole is drilled to the well target depth. 7 inch slotted liners are site inside the production casing shoe and landed at the bottom.

2. Detection of Calcite Deposition in Wells

The decline of well output or a drop in wellhead pressure is the first sign to indicate probable calcite deposition. This is further confirmed by running down hole logging tools.

Caliper logging tools and Go-devil tools are commonly used to determine the location and thickness of deposition. Caliper logging tools are equipped with an electric motor to open the arms once the tool has been lowered into the hole. The arms centralize the tool in the well, and the position of the spring-loaded arms is sensed through variable resistance. This technique requires quenching the well with cold water because of the temperature limitations of electrical cables and tools.

Go-devil is the second technique used to survey high-temperature wells. This method is unaffected by high well temperatures.

Wire baskets of different diameters are used to log deposits in wells

3. Methods of Managing Calcite Scaling

3.1 Mechanical Reaming

This involves use of a rig with a drill bit or scraper. The bit removes the deposits inside the well bore and the same is lifted to the surface with the use of a drilling fluid. The method does not remove the deposits in the reservoir and could lead. This needs a complete rig system. The method utilizes circulation fluid to remove the calcite to surface as shown in Figure 1. The 12¼ inch bit is used clear to the top of liners then the 8½ inch bit is used to clear inside the liners with a check valve as part of the drill string to avoid return flow through the drill string due to high pressures.

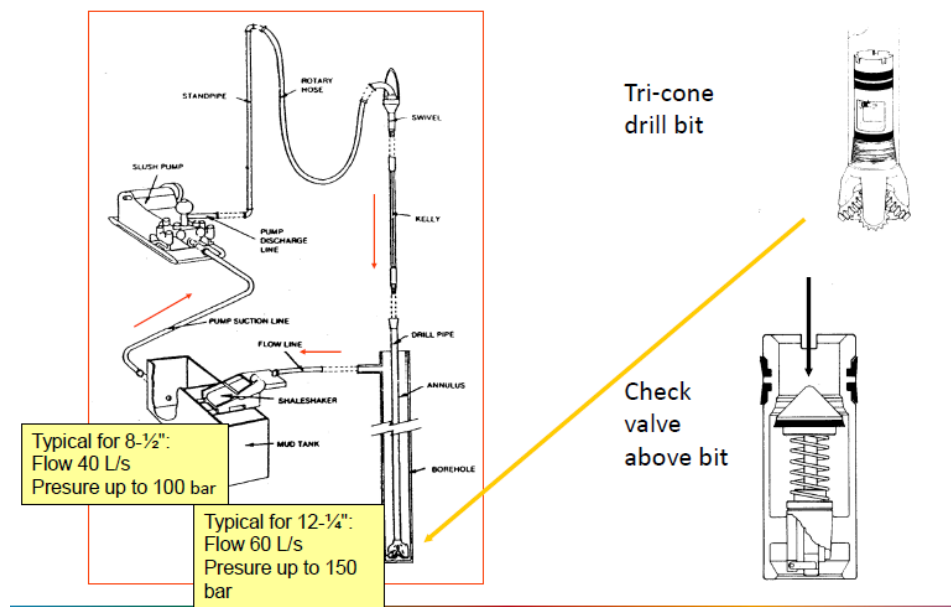


Figure 1: Calcite reaming with drill string

3.2 Chemical inhibitors

By injecting a chemical inhibitor down hole some forms of scale deposits are greatly reduced. The inhibitors reduce, delay or prevent deposition of calcite. The inhibitor acts by preventing adhering of crystals to a surface or dissolving the crystals and thereby stopping their growth. This system needs coiled tubing with a dosing plant as shown in Figure 2.

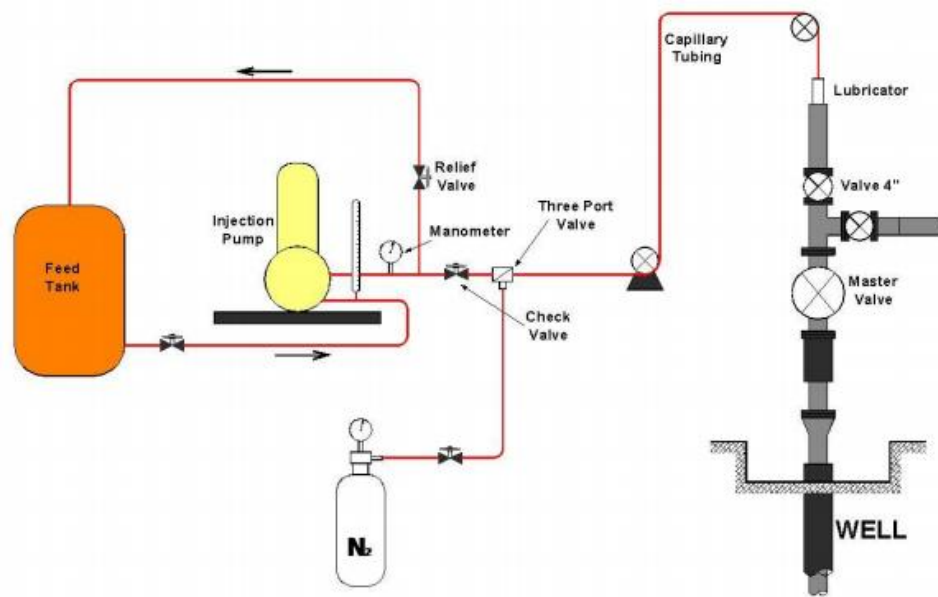


Figure 2: Chemical Inhibitor System

3.3 Adjusting flashing depth

By adjusting well head pressure the flashing point in the wells can be adjusted so that deposition does not occur in the well bore. This could be adjusted to occur on the surface where the scaling can be easily managed.

3.4 Acid Cleaning

By use of hydrochloric acid, the calcite is dissolved and thus cannot be deposited in the well bore.

4. Menengai Calcite Reaming Program

For the previous work overs that had been done at Menengai, the program has been:

- I. The site is cleared of discharge equipment and water line re-connected to the site
- II. A rig moved to site and rigged up including all the systems
- III. The well is quenched, master valve is removed before a blowout preventer is installed on top of the well head
- IV. Run in hole with an 8½ inch bit, reaming, rotating at a low RPM to the top of liners. Circulate at the top of liners to ensure the well bore is clean.
- V. Pull out of hole the 8½ inch bit assembly then run in hole 6-1/8 inch bit assembly to ream inside the slotted liners to the clear depth
- VI. Circulated aerated water and foam to circulate the reamed calcite back to the surface
- VII. Once at the bottom, unload the well to self-clean
- VIII. Quench the well prior to pulling out of hole and laying down the drill string
- IX. Nipple down the blow-out preventer and re-install the master valve
- X. Rig down in preparation to move to a new site

Shortcomings of this method of work over have been;

- I. A high capacity rig (2000HP) is mobilized for work that requires far less capacity rig
- II. Takes a long time to mobilize (14) days for an operation that lasts less than 7 days. It takes another 14 days to demobilize
- III. Higher consumption of fuel, water and more labour requirements
- IV. Well quenching causes damage to the well casings and well head due to thermal cyclic
- V. Impossible on sites with steam gathering system in place
- VI. Damage to rig equipment like BOP rubber parts, mud pump parts due to the high temperatures
- VII. The well takes time to recover to its original temperatures before it flows

5. Improved Reaming Method

The effective method for reaming the Menengai wells would be reaming the wells while they are discharging to a silencer pipe to minimize thermal cyclic as shown in Figure 3.

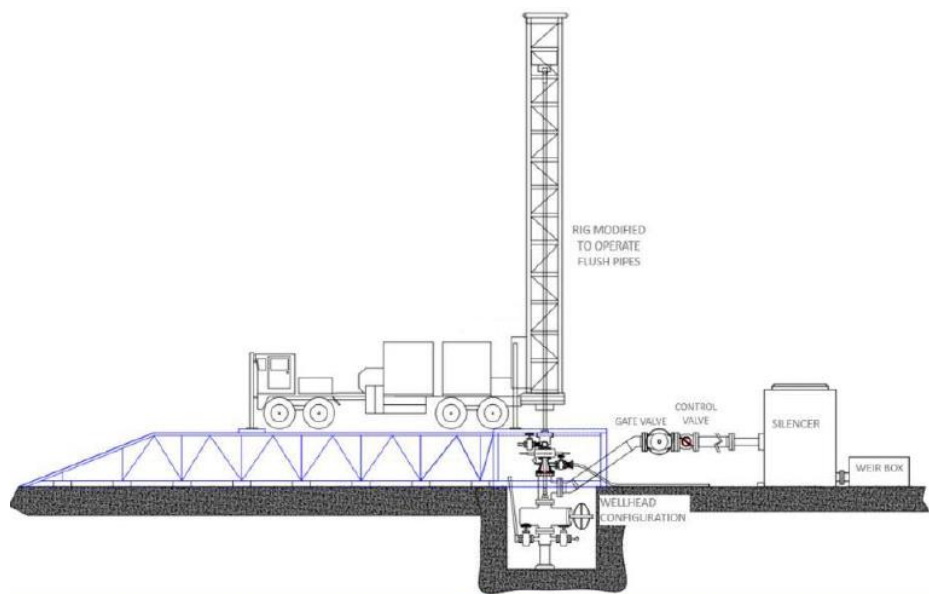


Figure 3: Rig set up for effective reaming

A truck mounted rig is used. This rig is faster to mobilize and has sufficient capacity to lift the drill string for the work over. The rig is placed on a steel substructure to get the desired clearance above the ground. A high pressure pump is connected to the kill line if need to pump water in the well arises. The BOP rams are made with metal seals with a condensing chamber to contain high pressures and cool the returns while the well is discharging. The drill pipes in use have outside flush to ensure proper sealing by the stripper while running in and pulling out without opening the rams that would lead to kicks and blow outs.

Advantages of this method include;

- I. No quenching of the well is required
- II. Faster rig move, in less than 2 days
- III. Less crew requirements
- IV. Minimal damage to rig surface equipment
- V. Less water requirements

- VI. Less foot print area requirements, thus can be done on sites with steam gathering systems in place

6. Conclusion

For safe and costly work over operations at Menengai field;

- I. Caliper logs and go devils will be used to gather data prior to the work overs
- II. Use of truck mounted rigs for the operation
- III. Use of flush pipes to enable work overs without pumping in the well
- IV. Modify the blowout preventer to withstand high temperatures

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