CHALLENGES OF CEMENTING OLKARIA GEOTHERMAL FIELD

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ABSTRACT

Key words: Lower ECDs, foamed cement, lost circulation

Olkaria Geothermal field poses major challenges in cementing of well casings due to the fact that the area is highly permeable. The down hole temperature and pressure is high and the cement sheath between the annular and casing is prone to carbonation which leads to strength retrogression. This paper documents the analysis of cement consumption per field in the entire Olkaria field to emphasize on the problem of permeable formations and various measures taken to improve on cement slurry design and cementing practices to handle this problem. Current cement design to handle high temperature and high pressure systems is also presented including a case study of cementing a high pressure well, #OW-724V. Attempts to fight these challenges have been met with varying levels of success so suggested improvements to the current cement design and practices is also presented.

INTROCUCTION

Geothermal reservoirs in Olkaria geothermal field occurs in regions of high temperature gradients and fractured, highly permeable formations. To access these reservoirs, production wells are drilled and the steam is tapped to the surface where it is directly flashed to run turbines in order to generate electricity. The residual water is cooled and re-injected back into the reservoir.

The typical design of these wells is whereby the wells are drilled to depths of between 3000m to 3500m with the surface casing of 20” set at around 60m, intermediate casing of 13-3/8” set to around 300m and production casing of 9-5/8” casing diameter set at between 750m -1200m. Three primary cement jobs are performed in each of these wells: 20-in diameter surface casing, 13-3/8” diameter intermediate casing and the 9-5/8” production casing. The main aim of these cement jobs is to provide zonal isolation and to protect the casing from mechanical shock and corrosion.

To successfully tap geothermal resource, conditions of high pressure and high permeability has to be met. However, these desired conditions lead to several major challenges when cementing a geothermal well. These include:-

1. Performing many backfill cementing jobs due to highly permeable formations.

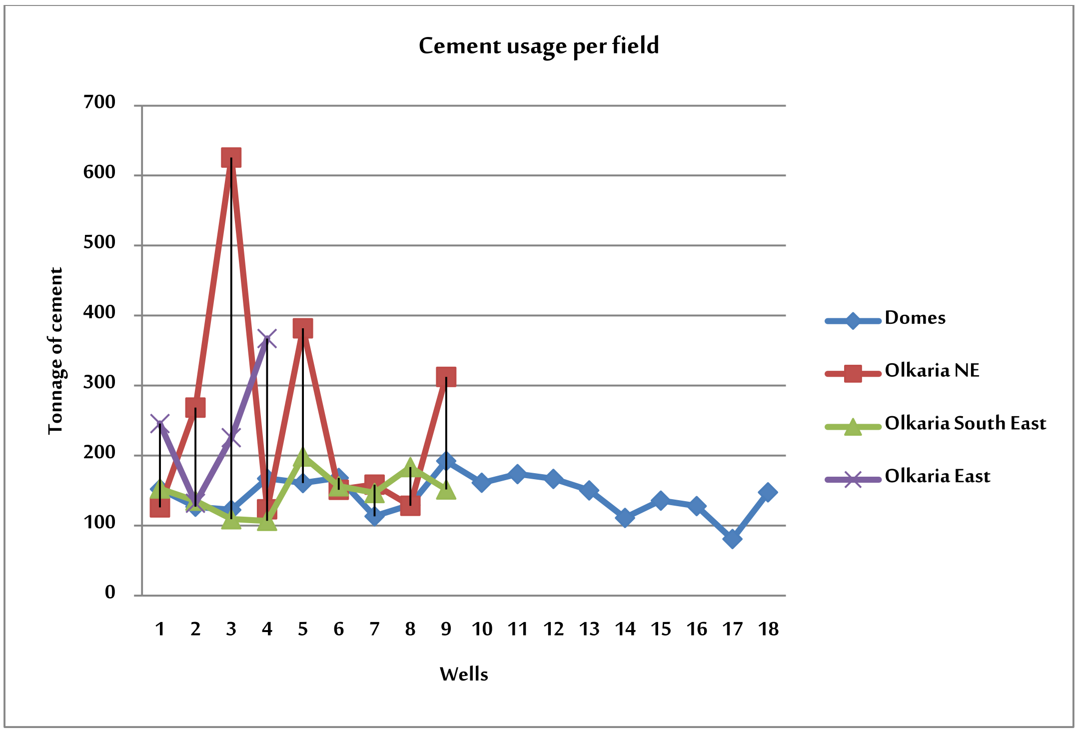
2. High reservoir temperatures has a direct effect on the hydration of cement leading to shortened thickening time of cement.

PERMEABLE FORMATION INFLUENCE ON CEMENTING

The current Olkaria Geothermal drilling plan focuses on four major regions:-

a) Olkaria domes
b) Olkaria North East
c) Olkaria East
d) Olkaria South East

Graph 1 below shows a representation of the cement consumption of the four Olkaria regions.



Graph 1: *Cement usage per field*

From the graph we see that the Olkaria North East field is the highest consumer of cement per well with an average consumption of 253 tons per well, followed by Olkaria East with an average of 242 tons per well, then Olkaria South East with an average of 149 tons per well and finally Olkaria Domes with an average of 147 tons per well.

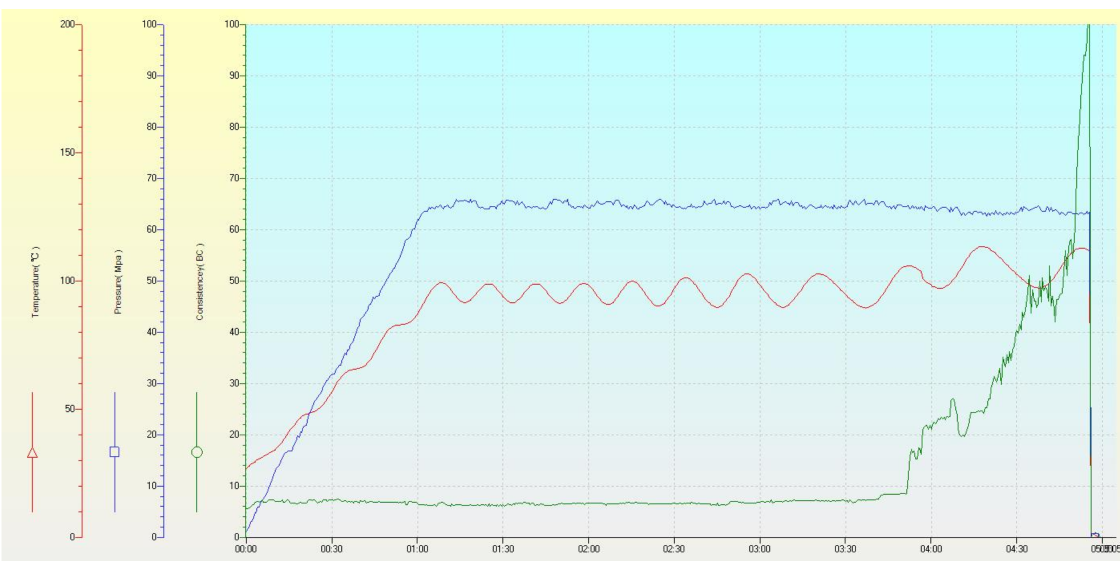
In cementing of these wells, a number of measures were taken during drilling and cement design stage in the attempt to reduce cement losses. While drilling, a lost-circulation material (LCM) was used in the drilling fluid so as to attempt to plug these loss zones.

During the cement design stage, an attempt was made to lower the equivalent circulating density of the cement slurry by using a low-density cement design through the addition of extender agents i.e. bentonite. In addition, we used mica flakes at 3% BWOC as a lost-circulation material

HIGH TEMPERTURE INFLUENCE ON CEMENTING

Temperature has a direct effect on the hydration of Portland cement and will shorten its thickening time. Maximum measured temperature at Olkaria field has been about 320°C. In an attempt to lower this bottom hole static temperatures (BHST), cold water spacers is circulated ahead of cement. In addition, retarders and fluid-loss additives are used to extend the thickening time and prevent premature hydration of cement slurries. Graph 2 below is a representation of a typical design of slurry for 9-5/8” casing with retarders and fluid-loss additive added so as achieve a thickening time of about four hours.

Test conditions: 95℃, 65Mpa, time to simulate down well condition 65 minutes



Graph 2: *Time to achieve 100 BC for a typical 9-5/8” casing slurry design*

CASE STUDY OF CEMENTING #OW-724V

Well Profile Table 1—Well Profile	
Surface casing	20-in. 94 # K 55 BTC set at 56.78m
Intermediate casing	13 3/8-in. casing 54.5# K 55 BTC set at 281.06m
Production casing	9 5/8-in. casing 47# , K 55 BTC set at 728.42m
Openhole	8 1/2-in., 728.42–3000m
Job cement volumes	15,858 liters scavange and lead
Job excess	120%

During the primary cementing for the 13 3/8" intermediate casings and the 9 5/8" production casings, standard lead and tail designs was used. This comprised of Mica flakes which is a Loss of circulation material (LCM), bentonite used as an extender to lower the equivalent circulating density (ECD), Retarder, fluid-loss agent and dispersant. For the 20" surface casings, no cement additive was required since it was set at a shallow depth.

The casing cement jobs were performed using the conventional method of cementing. After casing was on bottom, water was circulated to lower the bottom circulating temperature and also to condition the well bore to ensure proper bonding of cement with the formation. Once the job has begun, a large volume of freshwater spacer, usually 4000 liters, is pumped to provide additional cooling. This fresh water is followed by 4000 liters of scavenge of about 10 ppg, Lead of about 14.3 ppg and a tail of 14.4 ppg both totaling to 15,858 liters.

The main challenge of cementing this well, especially for the 9 5/8" casings was the very high pressures that were encountered. To handle this challenge, after pumping the primary job, we closed the BOP and WOC for 4 hours instead of the normal 8 hours to perform the backfill operation so as to create a high hydrostatic pressure of the cement column to balance the formation pressures. We also pumped a high density cement of about 1.7kg/l. A total of six backfill cementing operations were performed and the method proved to be successful.

CONCLUSION

The cementing of wells in Olkaria Geothermal field has been largely successful with the biggest challenge being the presence of highly permeable and fractured formation. Suggested future improvements to further handle this challenge include:-

- Use of high strength microspheres in the design of the cement slurry. This creates a light weight cement and at the same time maintain a relatively good compressive strength.
- Use of foamed cement. When properly executed, the process creates stable lightweight slurry, with low permeability and relatively high compressive strength compared to conventional cements.
- Cementing using inner string cementing method.

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