INVESTIGATION OF SILICA SCALE CONTROL PARAMETERS; A CASE OF OW-41 IN THE OLKARIA GEOTHERMAL FIELD

EDWIN WAFULA WANYONYI
G 296-03/2013

A Thesis Submitted in Partial Fulfillment for the Award of the Degree of Master of Science Geothermal Energy Technology, in the Institute of Geothermal Training and Research, Dedan Kimathi University of Technology

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February, 2018

DECLARATION

STUDENT'S DECLARATION

I declare that this thesis is my original work and has not been presented in any university/institution for a degree or for consideration of any certification.

Signature.....**Date**.20th Feb 2018.

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Supervisors' declaration:

We confirm that the work reported in this thesis was carried out by the candidate under our supervision as University supervisors

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ABSTRACT

One of the fundamental problems that affected the utilisation of the geothermal resource in Olkaria was the problem of silica scaling. A number of wells in Olkaria were faced with a very high risk of scaling and had to be isolated from the production system to manage this risk. This project aimed to devise a sustainable and effective way of mitigating the risk of silica scaling in the Olkaria geothermal project. The purpose of the study was to determine the various parameters that controlled the process of amorphous silica scaling and at what optimum conditions they needed to be maintained in to mitigate scaling. The specific objectives of the study were to investigate the effect of pH and temperature, ionic species concentration, salinity, enthalpy and scaling rate on amorphous silica scaling. The method used involved first collection of water and steam samples using standard methods for sampling two phase geothermal fluids for purposes of chemical analysis. The collected samples were then analysed in the laboratory using standard analysis procedures including titrimetric, spectroscopy and chromatography. The chemical data from this analysis was modelled using geochemical reaction and speciation programs like WATCH, Geochemists workbench and PHREEQC. The temperature of solution was seen to control the scaling conditions, with prograde solubility from 300°C to 100°C being simulated. The minimum temperature of separation to control silica scaling, based on a silica concentration of 442 mg/kg was 120°C. From the study it was seen that the pH influenced the solubility of the scale causing silica species. The effect of ionic species in solution on the amorphous silica scaling was shown. The lowest Saturation index was recorded in a 10 ppm Al ion solution with the highest Saturation index in a 0.6 ppm solution. It was seen that at between a pH of 5.7- 6.2 and with an Al concentration of 5 ppm, the amorphous silica saturation Index was at its minimum, hence describing the favourable conditions for operation. It was seen that the mineral saturation of amorphous silica gradually reduced as the salinity of the solution increased with the minimal saturation at salinity of 60,000 ppm solution. It was seen that the temperature of saturation was considerably higher at the highest enthalpy of 2660 kJ/kg and reduced considerably as the enthalpy was reduced with the lowest saturation temperature at an enthalpy below 2000 kJ/kg. The deposition rate at 950 ppm was 5.7 E^{-07} mm/ year compared to 5.7 E^{-08} at 300 ppm for pH 7 and 7.1 E^{-10} and 7 E^{-11} respectively at pH 3, this based on the first rate equation. Based on the second rate equation, the molecular deposition at 950 ppm silica was 9.03 E^{-11} mm/year compared to 9.0 E^{-10} mm/year at 300 ppm. It is therefore recommended that a test rig be developed to facilitate actual field tests based on the analysed parameters. Additionally it will be important to develop a pH control system as a way of managing scaling either by way of acid or alkali addition.