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WELL INTERVENTION CASE STUDY OF WELL MG-1, LEYTE GEOTHERMAL PRODUCTION FIELD, PHILIPPINES

R. N. Colina, J. B. Omagbon, G. E. Parayno, R. P. Andrino, D. M. Yglopaz,
R. C. M. Malate, F. X. M. Sta. Ana and J. J. C. Austria

Energy Development Corporation
Merritt Road Fort Bonifacio
Taguig City, 1634 Philippines
e-mail: colina.rn@energy.com.ph

ABSTRACT

Production well MG-1 in the Mahanagdong sector of the Leyte Geothermal Production Field (LGPF), was worked over in 2009 to recover its production capacity that has declined due to mineral deposition and mechanical obstructions possibly caused by casing or liner damage. Two technologies – wellbore simulation and downhole video, became instrumental in guiding the course of the workover to its completion and maximize its results.

Wellbore simulation was conducted to predict the possible outcomes of different workover strategies or scenarios. Downhole video technology showed the actual condition of the casing and liner. This ensured the selection of the proper workover tools and application of appropriate strategies to address the downhole conditions.

Implementation of well intervention program have been enhanced and optimized with wellbore diagnostics reinforced by proper application of wellbore simulation and downhole video technology.

INTRODUCTION

Well MG-1 is the first exploratory vertical well drilled in the Mahanagdong sector of LGPF (*Figure 1*) operated by the Energy Development Corporation (EDC). The well was completed in September 1980 with a total drilled depth of 2335mMD (*Figure 2*). This production well was then hooked up to the Mahanagdong-A Power Plant that commenced its operation in 1997. Well MG-1 has already undergone four (4) mechanical workovers, all of which successfully regained the pre-workover output, from the time it was hooked up to the system.

During the first quarter of year 2009, a decline in the output of MG-1 was observed as reflected in the bore output history of MG-1 (*Figure 3*). Based on the historical discharge data of the well, steam flow remains stable but the trend of mass flow and water flow shows a decline of 16% and 20%, respectively, in just two months of operation. This development triggered the study as to what intervention maybe conducted to regain the sudden loss in capacity of the well.

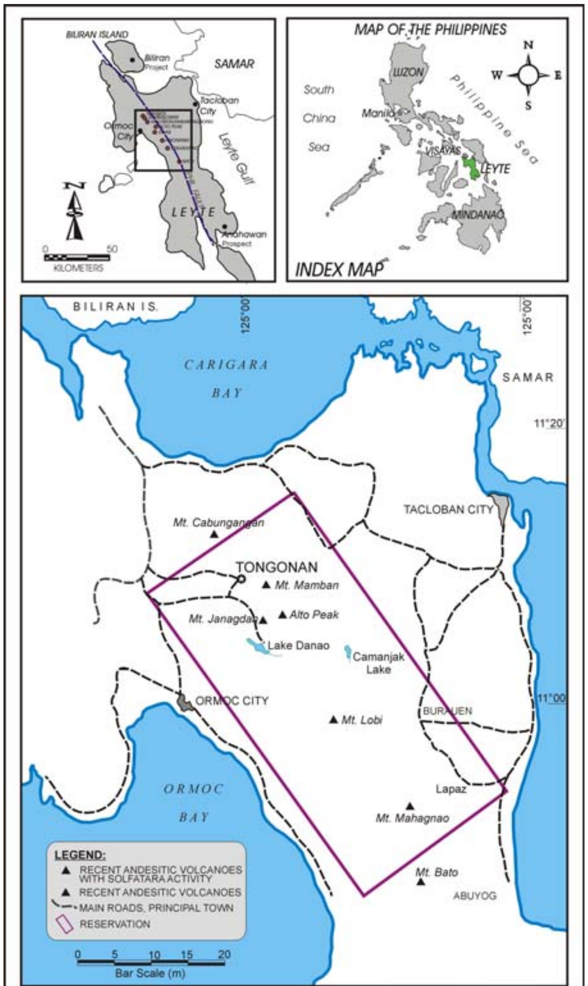

Figure 1. Location of the Leyte Geothermal Production Field, Philippines

Based on the study conducted, the apparent decline in output of MG-1 was attributed to mineral depositions occurring in the wellbore. This was rather expected of MG-1 as the chemistry of reservoir fluids of the well exhibits calcite over saturation. A mechanical workover was recommended to drill out the mineral deposits that evidently blocked the permeable zones of the well.

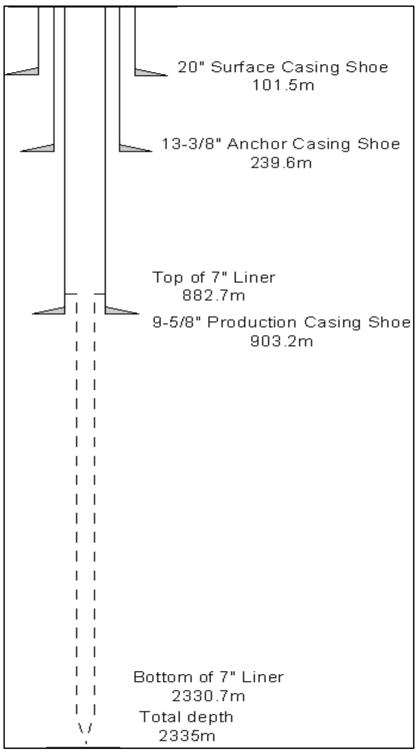

Figure 2: Well MG-1 casing profile.

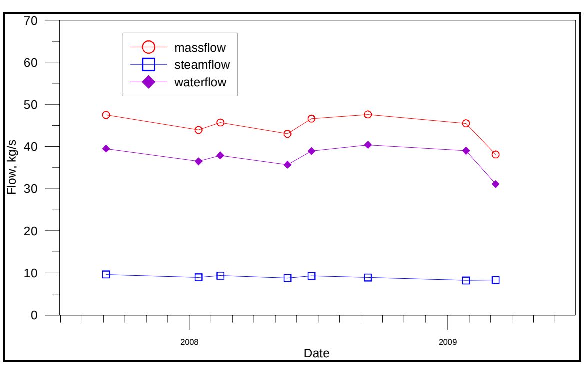

Figure 3: Well MG-1 bore output history

This paper summarizes the application of wellbore simulation and downhole video technology in the workover of well MG-1.

PRE-WORKOVER PREPARATIONS

In order to regain the capacity of Well MG-1, clearing of the wellbore, particularly the 9-5/8" production casing and 7" slotted liner, is the main objective of the workover. During the workover preparation stage, concerns were raised regarding the casing integrity of this 29-year old well. Review of the previous workover data showed that a recurring obstruction was being tagged at the shallow section, inside the production casing. This obstruction was believed to be mechanical in nature based on the two lead impression block surveys conducted in 1999. Upon pullout of the lead impression block, the edge of the block was found to be chipped off as shown in *Figure 4*.

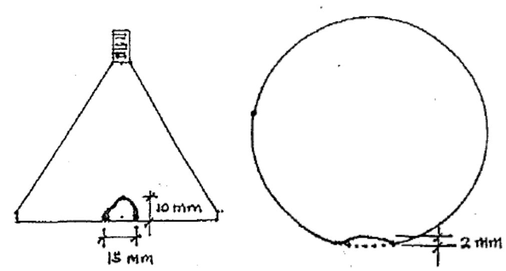

Figure 4. Result of the lead impression block survey showing the chipped off part of the block.

Considering the previous workover data, the age of the well and the result of previous lead impression block surveys, relining of the production casing is already anticipated.

Pre-workover Wellbore Simulations for MG-1

EDC utilized its wellbore simulation capability to assess the effect of relining the production casing on MG-1 post-workover output. Wellbore simulations tested the effect of several possible relining scenarios that may happen during the workover of Well MG-1. *Table 1* summarizes the results of wellbore simulation conducted by Omagbon (2009). The wellbore simulation was run at a commercial wellhead pressure of 1.35 MPag, an enthalpy of 1164 KJ/kg and a baseline mass flow of 42.6 kg/s.

Table 1: Summary of results of pre-workover wellbore simulation of Well MG-1.

	Scenario Simulated	Steam Flow, kg/s
0	Well cleared	11.0
1	Well cleared, relining from 250m to CHF	7.0
2	Well cleared, relining from TOL to CHF	6.0

Based on the pre-workover wellbore simulation, a successful clearing of the mineral deposits without relining improves the output of the well by 26%, recovering the original steam flow of MG-1 prior to its decline. Relining the shallow casing damage with 7" casing, assuming relining of the well will be conducted from CHF down to 250m to address the shallow casing damage, significantly reduces the expected post-workover output. Relining the production casing from the CHF down to top of liner

(TOL), if there is deeper casing damage, further reduces the expected post-workover output of MG-1. This significant reduction of the well output when the wellbore diameter is decreased is a typical result of low enthalpy wells. The result of the pre-workover wellbore simulation demonstrated the significant effect of relining on MG-1 output.

Considering the result of wellbore simulation, the workover program for well MG-1 was finalized; anticipating the worst possible scenario which is recurring obstruction at the shallow section. Thorough assessment of any obstruction that may be encountered in the hole was emphasized in the program. For any suspected mechanical damage encountered during the workover, a downhole video survey will be requested to check the actual condition of the wellbore. Based on the result of downhole video survey, the most appropriate bottom-hole assembly (BHA) will be assembled.

The Downhole Video Camera Tool

Downhole video services were provided by the Expro International Group Ltd. (Exprogroup). Two downhole camera systems were engaged during the workover of well MG-1: Standard HawkEye III® and the new ViewMax® camera. The former is Exprogroup's conventional down view camera system while the latter is a new camera system that provides a 360 degrees side-view image on the casing section. Specifications of the above downhole cameras can be found in the Exprogroup website.

WORKOVER SUMMARY OF WELL MG-1

Clearing of the 9-5/8" production casing down to the TOL went smoothly. The obstruction anticipated in the production casing at the shallow section was not encountered. However, during clearing of the 7" liner, an obstruction was tagged at around 1400 m. Attempts to wash down this obstruction proved unsuccessful as the clearing assembly could not penetrate beyond this depth. Also, an indication of metal to metal contact was already observed while trying to penetrate this depth.

Down view camera was run in hole to investigate the obstruction. A parted liner, as shown in *Figure 5* was found to be the cause of unsuccessful penetration of the clearing assembly. Careful inspection of the images showed loose pieces of metal.

In order to retrieve loose pieces of metal, a 6" junk magnet basket assembly was run in hole. Clearing of the liner continued beyond this depth until another obstruction was tagged. Downhole survey was again run in hole to check the obstruction. Based on the images found, relining with a 5" liner was recommended.

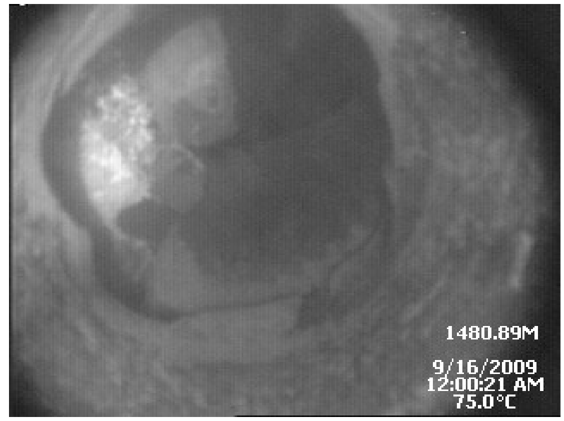

Figure 5: Liner damage found

The effect of running in a new 5" liner on the well's output was investigated using wellbore simulation. *Table 2* summarizes the results of the wellbore simulation conducted by Omagbon (2009) using different scenarios if new 5" liners were run in hole. Bottom feed contribution was assumed to be 70% of the total mass flow based on matching of previous flowing surveys of MG-1.

Table 2: Summary of result of wellbore simulations if relining of slotted liner will be conducted

	Scenario Simulated	Steam Flow, kg/s
1	Major feed contributing to the total flow and relining from CHF to TOL	6.4 – 7.8
2	No flow from bottom feed zone and reline from CHF to TOL	2.7

Based on the worst case scenario, where it was assumed that the bottom feed will not be contributing to the total flow and relining of the production casing will be conducted, a minimum of 2.7 kg/s steam flow can still be expected from the well. With this information, run in of the 5" liner was pursued.

The concern with regards to the integrity of the production casing at the shallow section was next investigated. A third downhole video survey, this time running in the down view camera in tandem with the side-view camera, was conducted to examine the actual condition of the production casing. *Figure 6* is the down view image of the shallow casing damage. A section of the production casing was milled off, exposing the cement portion between the production casing and the anchor casing. The image did not clearly show the extent of the damage at this depth.

Figure 6: Down view image of the shallow casing damage

Switching to the side view camera, a better picture of this section was obtained. As shown in *Figure 7* the anchor casing behind the cement layer is still intact with no apparent mechanical damage. Note that during this workover, this shallow casing damage was not tagged while clearing the 9-5/8" production casing. The question of whether this section will fail (caused by thermal expansion, erosion/corrosion, etc.) during production of the well was resolved by conducting a pressure test. The well was subjected to a squeeze pressure higher than the maximum shut pressure of the well. With the pressure holding, it was concluded that this section will not be a problem during production and relining of the shallow casing damage was no longer necessary. Thus, the relining scenario was avoided.

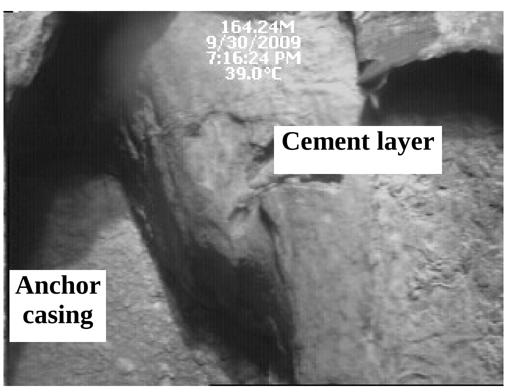

Figure 7: Side view image of the shallow casing damage

CONCLUSION

The results of pre-workover wellbore simulation during the workover preparation stage demonstrated the effect of relining the production casing on the post-workover output of Well MG-1. Furthermore, the result of the wellbore simulation became influential in the decision to run in the new 5" liners.

During the workover, where effective and timely decisions are necessary, the application of downhole video to investigate the actual condition of the casing or liner provided information that ensured appropriate tools were run in hole. For the case of the shallow casing damage, downhole video results became instrumental in the search for a different approach to solve the shallow casing damage issue. Without the side view image, the most apparent solution will be to reline the shallow casing damage to reestablish the casing integrity of MG-1, sacrificing the output of the well. However, because the anchor casing was found to be still intact, through the side view camera, the result of the pressure test sufficed to conclude that the shallow casing damage will not cause future problems.

ACKNOWLEDGEMENT

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