

ANALYSIS OF WORKOVER TECHNIQUES IN GEOTHERMAL WELLS OF CERRO PRIETO FIELD, MEXICO

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ABSTRACT

The Cerro Prieto is one of the biggest geothermal fields on production stage in the world; to present day there are about 150 production wells located in 15 km² area, producing a different mixture (water-steam) ratio [1]. These wells supplying about 5,600 metric tons of steam per hour, to four power plants installed with 720 MWe of total capacity. There are several factors causing a steam production decline in wells, but in Cerro Prieto Field one of most common is the silica scaling in both reservoir and pipes [1], [2]. Therefore, each year is necessary to realize from 12-15 workovers, [3], [4].

Additionally to workovering jobs in wells, others tasks like drill new wells, are making to recover and keep the steam flow rate required by power plants. Some workover techniques are usually manage to workover wells, these are cleaning the production casing, deepening the production zone, sidetrack, under reaming, etc, the workover selection type, depend of several factors like: pipes and reservoir conditions, workover risk, workover time and cost. This paper analyzes and discusses the workover wells techniques used in Cerro Prieto geothermal field and results obtained of the application of these.

1. INTRODUCTION

The Cerro Prieto geothermal field is located in the south part of the Salton trough about 20 miles South of the United States-Mexico border in Baja California, Mexico (fig.1). More than 250 deep wells have been drilled in the area. Present there are about 150 production wells that are feeding from different depth aquifer. To date the installed electrical power generating capacity is 720 MWe [5].

Due to the capacity installed and the declining steam production shown by the wells it was necessary to workover some wells and to drill some additional

wells to make up for the lost steam production, the last task are realized constantly [3].

2. GEOLOGICAL ASPECTS OF CERRO PRIETO RESERVOIR

The Cerro Prieto geothermal field exploitation through 24 years of commercial operation has utilized the alpha (α) and beta (β) reservoir for the Cerro Prieto I area and mainly the beta reservoir for Cerro Prieto II and III areas.

Toward the east of the exploitation zones, some authors have identified a deep reservoir named gamma (γ) [7].

Cerro Prieto II and III derive production from the beta reservoir which is deeper, and to some extent underlines the alpha reservoir. The distribution and depth of production is controlled by a northeast trending structural high. Silica and epidote mineralization and high temperatures (300 °C+) which delineate the top of the reservoir are also related to this structure. The average thickness of the produced reservoir in these zones is about 380 m. A fundamental lithological characteristic in these zones is the silica cement in the production sandstone [8].

At greater depth the “transition zone” has sandstones which contain both calcite and silica cement. The calcite cement increases with depth in calcite zone [9], [10].

3. CERRO PRIETO WORKOVER WELLS

The workover wells in Cerro Prieto geothermal field began in 1973, since this about 383 wells have been repaired in the field, Fig. 2, shows the well numbers repaired each year in Cerro Prieto. Every year, averages of 12 wells are repaired in Cerro Prieto field, for different, but the main cause is due to decrease in their steam flow rate delivered. Most commonly, a production decrease in geothermal wells in Cerro Prieto field is due to:

- Surface pipeline scaling.
- Mechanical damage in the wellbore (pipes).
- Entrance of cooler fluids to the producing reservoir.
- Reservoir scaling.
- Well scaling.

4. DIAGNOSTIC TOOLS THAT ARE USE TO ANALYZE PROBLEMS IN CERRO PRIETO WELLS

Today, the Cerro Prieto reservoir is undergoing thermodynamic and chemical changes such as boiling condensation, dilution and mixing. These changes are natural response to exploitation and brine reinjection [4]. Successful new well location and workover require that reservoir engineering in Cerro Prieto uses classical tools such as pressure and temperature logs (mechanical tools), production and enthalpy analysis, geology and mineralogy inspections and new tools like chemical and isotopes analysis, and electronic instruments (TPS: temperature, pressure and spinner electronic logs). The most important characteristics that are considered to rehabilitation of a well in Cerro Prieto field are: Mechanical conditions of the well, geological conditions, behavior of the wellhead pressure enthalpy and geochemical production data and analysis of pressure and temperature logs [2].

5. WORKOVER TECHNIQUES THAT ARE USE IN CERRO PRIETO WELLS

The most common techniques used until now for rehabilitation of wells in Cerro Prieto geothermal field have been the following:

- Cleaning of the silica scaling in casing (Cleanout).
- Under reamed
- Sidetrack.
- Deepening

Occasionally, it is necessary to install a less diameter casing inside of damage casing of high diameter, because, it shows a mechanical damage, like casing collapse and failures.

The under reamed technique has been used when the permeable feeding reservoir strata near to the downhole is scaled, both calcite and silica or with metallic sulfides, however this techniques was used sporadically in the past.

Comision Federal de Electricidad (CFE), who has general management of the geothermal field, realized a statistical analysis of workover results in Cerro Prieto through 1988-1991, the data obtained showed that using mechanical cleaning of the scaling in the casing, the steam flow rate production recovers, after

the workover, the 45 % of the initial steam flow rate produced by the well [1].

A workover compare analysis, from 79 workover of Cerro Prieto wells, through 1988 to 1994, Table 1, shows the results, these pointed out the best steam flow rate recovered by sidetrack and deepening techniques with 70 and 68 % (similar values), the less steam flow rate recovered correspond to clean out workover with 48 % [4].

An analysis of 17 workover realized in Cerro Prieto wells during 1995 to 1997, showed reduced steam flow rate recovers in all wells cleaned in theirs casing productions. Besides, almost all wells were producing from zones deeper than average traditional feeding zone (after repaired) recovered steam flow rate greater than 100 of the original steam flow rate. Table 2, shows some characteristics recorded from the wells that were deepened. The average depth of deepening realized in these wells during workover was 404 m and the steam flow rate average recovered was 95.5 % respect to the original steam flow rate produce [11].

6. WORKOVER WELLS CASES IN CERRO PRIETO FIELD

Figures 3 and 4 show the wells 609 and 625 completion including the silica profile estimated from caliper logs after these decline theirs steam flow rate until stop to flowing, both wells were repaired eliminating the silica scaling (cleanout) and deepening, The steam flow rate of these two wells was reduced as a consequence of silica scale, well 625 were repaired only two and half years after start its production stage. Figures 5 and 6 show the steam flow rate trends of both wells.

The workover cost of sidetrack can be about three or four times the deepening cost, The workover technique selected depend of several factors, such as steam flow rate recovery, workover cost, inversion return, etc.

7. CONCLUSIONS

The decline production in the Cerro Prieto geothermal field is caused mainly by two mechanisms: a drop in reservoir pressure as well as by flow restriction created by silica deposition in both reservoir and casing production.

Was analyzed the data obtained from workover realized in Cerro Prieto geothermal field through 31 production years, the most common workover techniques used have been mechanical clean of production casing (remove of scale), deepening, side track, and under reamed.

The statistical data from all these workover reveal the deepening and side track technique as the best steam flow rate recover alternatives, and cleanout as the worse alternative. Many wells had recorded steam flow rate recover high than 100 % respect to the original production after workover.

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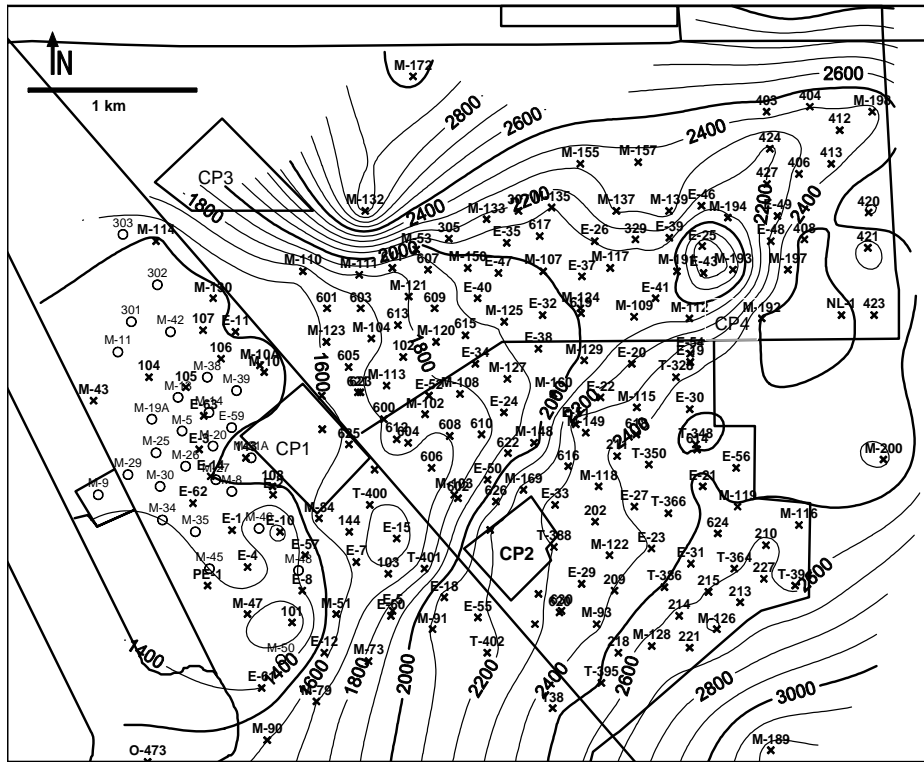


Figure 1 Cerro Prieto geothermal field locations

ANNUAL WORKOVER WELLS STATISTICAL

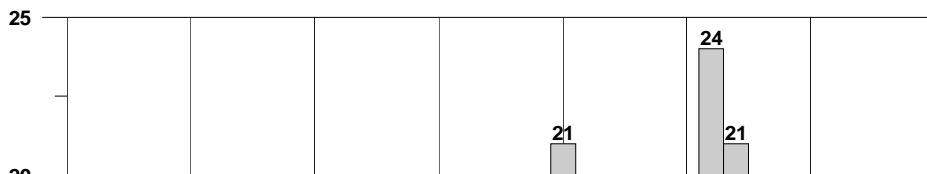


Figure 2 Annual Repaired Wells in Cerro Prieto Field

Figure 2 Workover annual statistical in Cerro Prieto geothermal field

Figure 2 Cerro Prieto field workover statistical for 1973 -2004

Workover Type	Workover Wells	Initial Average Flow rate	Average by Workover Well	% of initial Flow Rate
Side Tracking	29	69	49	70 %
Deepening	30	76	52	68 %
Cleanout	20	79	38	48 %

Table 1 Workover Type Statistical for 1988-1994 of Cerro Prieto field

Well	Deepening (m)	Thickness (m)	Workover Type	Steam recovery (% of Original)
603	1801-2312	511	Under reamed	95.0
605	1854-2190	336	Sidetrack	132.4
611	2135-2524	389	Deepening vertical	125.3
613	2028-2587	559	Deepening vertical	113.1
607	2075-2289	223	Deepening vertical	71.5
609	2158-2600	442	Deepening vertical	91.2
615	2154-2605	451	Deepening vertical	100.0
617	2310-2783	473	Deepening vertical	131.9
619	2545-3011	466	Deepening vertical	83.7
600	2025-2450	425	Sidetrack	69.2
604	2242-2648	406	Sidetrack	94.5
612	2026-2284	258	directional	92.5
606	2193-2560	367	Deepening Vertical and & 7" Ø blind liner installed	71.5
608	2041-2460	419	Deepening vertical	97.8
602	2025-2483	450	Deepening vertical	85.8
616	2705-2953	248	Sidetrack and 7" Ø slotted blind liner	86.3
618	2885-3335	450	Deepening vertical	81.2

Table 2 1988-1994 Cerro Prieto Deepened Wells Statistics

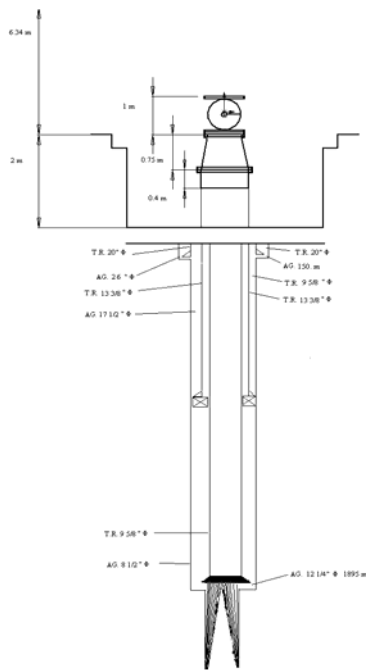


Figure 3 Completion of well 609 with silica scaling

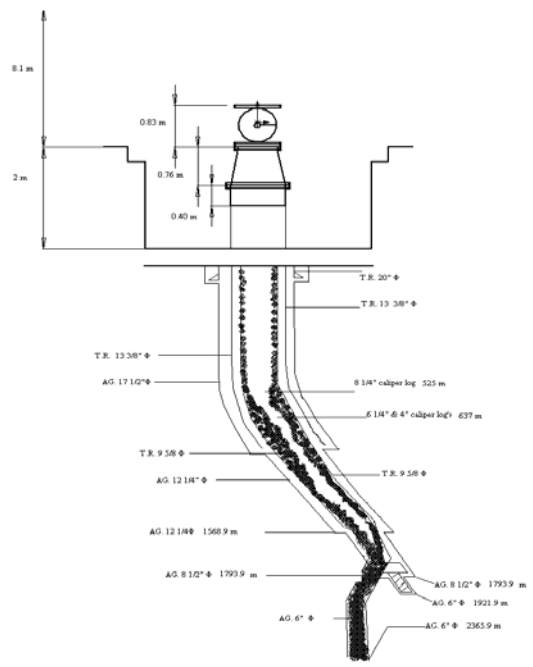


Figure 4 Completion of well 625 with silica scaling

Steam Production Behaviour Well 609

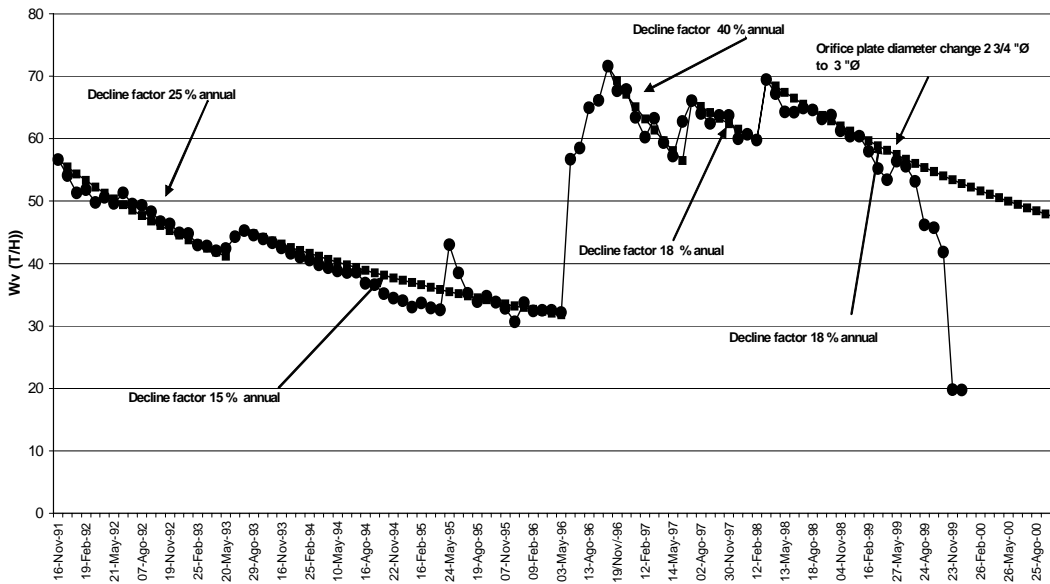


Figure 5 Steam flow rate trends of well 609

Steam flow rate behaviour Well 625

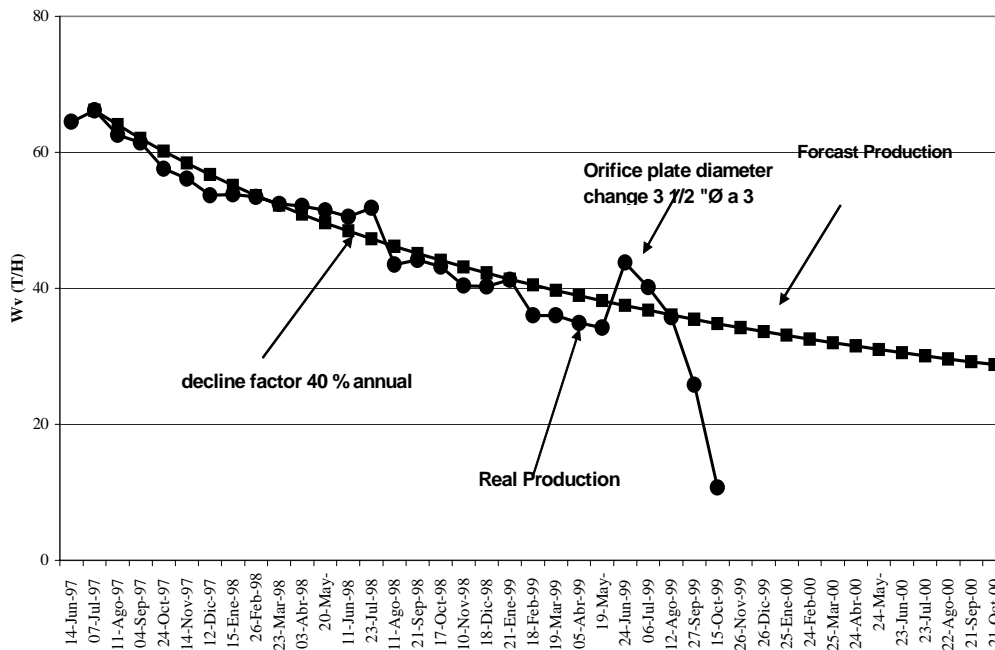


Figure 6 Steam flow rate trends of well 625