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IMPROVEMENT IN STEAM PRODUCTION THROUGH ORIFICE PLATE CLEANOUT IN THE CERRO PRIETO GEOTHERMAL FIELD

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ABSTRACT.

Since 1997, Latina and Calpine Corporation have been operating a total of 32 production wells in the Cerro Prieto geothermal field in Mexico. The decline in steam production in this field is caused by two mechanisms: a drop in reservoir pressure as well as by flow restrictions created by silica deposition. Based on recent drilling and well work-over results, the effect of the latter on the decline rate is found dominant. Silica precipitation by brine flashing can occur anywhere in the flow system such as reservoir, wellbore and surface equipment. The orifices, which cause a change in velocity profile, are vulnerable to silica deposition. The silica deposition usually reduce the diameter of the orifices. This, in turn, reduces orifice plate area, resulting in a decrease in the steam production rate. In effort to reduce steam decline rate, an aggressive orifice plate diameter cleanout program for the Latina-Calpine production wells was recently implemented.

The results obtained from this cleanout program indicate a significant decrease in overall steam decline rate. The results of decline rate with and without aggressive orifice cleanout are presented in the paper. The total amount of steam recovery per month by orifice cleanout is also discussed.

INTRODUCTION.

Presently there are about 130 production wells supplying steam to the three power plants with 620 MWe of capacity in Cerro Prieto Geothermal field. These wells are disposed in three areas with extension of 12 Km^2, named, Cerro Prieto I, Cerro Prieto II and Cerro Prieto III (figure 1). Some production wells have been producing for 25 years. Monthly production wells is about 4900 tons of steam and 7500 tons of water approximately. CPI production zone has been generating electricity along 25 years, and CPII and CPIII by 13 years.

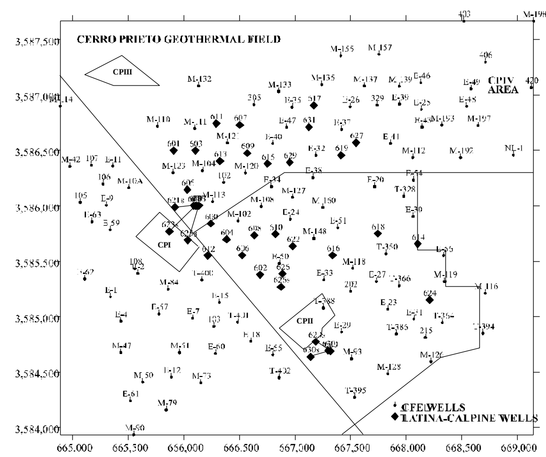

Fig. 1. Cerro Prieto Geothermal Field.

CPLatina-Calpine have a contract with Comisión Federal de Electricidad for supplying 1600 t/h of steam for this reason maintaining high steam level production in our wells is the main goal.

Production wells at Cerro Prieto geothermal field are producing from different reservoir conditions; like single phase water, two phase, and in some cases flowing from a dry steam phase (Lippmann et. al. 1989; Beall et. al. 1997) the geothermal flow fluids in Cerro Prieto are taking place through altered sandstones cemented by silica and calcite in less proportion (Halfman et. al. 1986; Ocampo et. al. 1997). Some process like boiling or dilution are occurring in some reservoir sections, the fluid in the reservoir is a sodium chloride type, with low concentration of bicarbonate and sulfate (Grant et. al. 1984; Truesdell et. al. 1997).

The steam production declination has been classified normally as results of four main causes: drawdown reservoir pressure, scaling in the bottomhole or main feed zones of the reservoir, scaling in the production casing, or in the orifice plate diameter in the surface installation (Arellano et. al. 1995; Ocampo et. al. 1998).

To recover the steam production rate it is necessary to cleanout the orifice plate, workover wells or drill new wells, this is to supply the necessary steam for the power plants.

ORIFICE PLATE CLEANOUT BACKGROUND.

The scaling found during the workovering of production wells at Cerro Prieto amorphous silica (SiO_2) usually has been identified in three different types: calcium carbonate (calcite), and metallic sulfides (Gutiérrez et. al. 1995).

Typical surface equipment of Cerro Prieto production wells is showed in the figure 2, observe how the flow rate wells are choked by one orifice plate located between the wellhead and the separator.

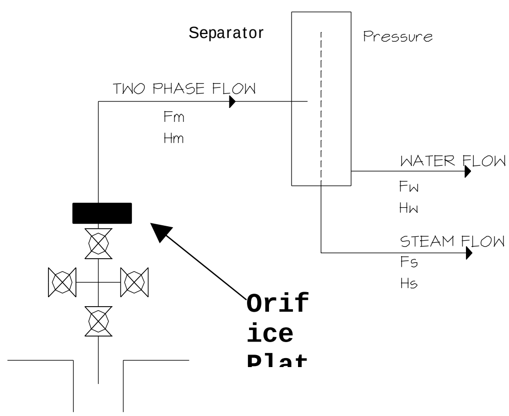

Fig. 2. Cerro Prieto typical surface well installation.

The Cerro Prieto brine has around 10,000-ppm solid solved. These solids when the fluid looses pressure, throw the orifice plates are deposited. The orifice place is reduced in its effective diameter, figure 3.

The production orifice plate cleanout is a task routine in the Cerro Prieto geothermal field wells, however, CPLatina-Calpine encourage and try to get efficient cleanout program to obtain much better steam production.

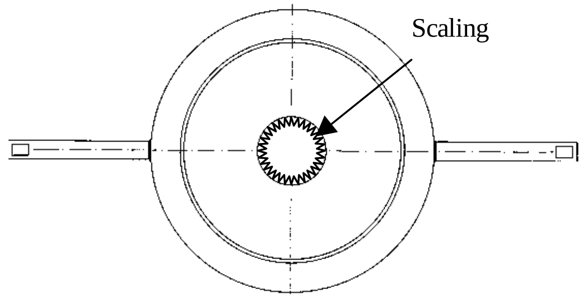

Fig. 3. Orifice Plate.

The 32 production orifice plate wells statistics of CPLatina-Calpine was analyzed from January '97 to April '98. An aggressive production orifice plate diameter cleanouts program was the result of this analysis. This program achieved an efficient of the 32 CPLatina-Calpine production wells.

Initial plan was applied from January '98 to August '98, where 193 orifice plates were cleaned. According to the interpretation of steam gain by each well a new program from September '98 to December '98 was established, this considered 103 cleanouts.

Table 1 shows the orifice plate diameter cleanout program, notice that from September to December, one well has been cleaned weekly and nine wells were cleaned monthly. From January to August , 13 wells were cleaned each two months, and 8 wells were cleaned every six months.

Table 1. 1998 Cleanouts CPLatina-Calpine wells.

Cleanout (week)	January-August	September-December
1		1
2	2	
3		1
4	5	9
5		1
6		1
7		3
8	13	3
9		5
12	4	2
13		5
14		1
24	8	

ORIFICE PLATE CLEANOUT RESULTS.

The total steam gain was calculated well by well, one preliminary estimation was done, most of wells reach steam gain average around 0.5 to 2.0 t/h by cleanouts. Table 2 shows the annual resume results of the 1998 cleanouts. The 631 recovered more steam gain , it was cleaned 4 time per month frequency.

Table 2. 1998 Annual steam gain.

Well	Total steam Gain (t/h)	Cleanouts number, 1998	Steam (t/h) gain
631	77.09	38	2.03
609	20.75	12	1.73
615	20.19	11	1.84
624	18.98	14	1.36
610	16.21	12	1.35
623	15.27	9	1.70
612	12.18	13	0.94
614	11.81	13	0.91
613	11.65	11	1.06
629	11.16	14	0.80
617	10.97	11	1.00
618	10.92	13	0.84
604	9.34	8	1.17
611	9.25	14	0.66
630	5.6	7	0.80
627	5.46	9	0.61
608	5.18	10	0.52
622	5.11	6	0.85
602	4.93	7	0.70
600	4.4	6	0.73
633	3.98	8	0.50
621	3.42	5	0.68
626	2.98	5	0.60
605	2.93	4	0.73
625	2.75	7	0.39
619	2.07	7	0.30
603	1.29	4	0.32
601	1.14	2	0.57
620	1.08	6	0.18
616	0.32	3	0.11
606	0	4	0.00
607	0	3	0.00

Additionally the table 3 and figure 4, show the monthly results of the steam gain by cleanouts.

Table 3. 1998 Monthly Steam Gain.

	Stea gain (t/h)	Cleantout Number	Steam gain average (t/h)
Jan	38.01	22	1.728
Feb	20.85	9	2.317
Mar	19.81	15	1.321
Apr	26.24	15	1.749
May	44.43	35	1.269
Jun	29.71	40	0.743
Jul	26.49	37	0.716
Aug	18.18	20	0.909
Sep	19.52	17	1.148
Oct	16.58	29	0.572
Nov	17.76	26	0.683
Dec	30.83	31	0.995
Total	308.41	296.0	14.15
Average	25.70	24.67	1.18

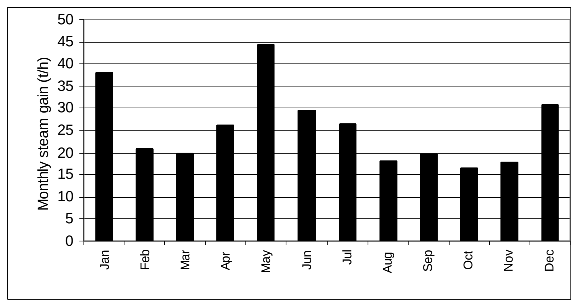

Fig. 4. 1998 Monthly Steam Gain.

The figure 5 shows monthly cleanouts distribution in 1998, the main number of cleanouts were made from May to December. This figure shows correlation with the information in relation to monthly steam gain (figure 4).

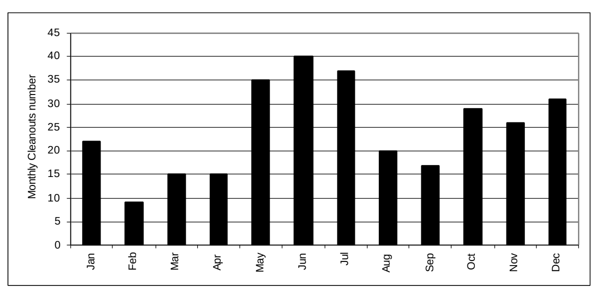

Fig. 5. 1998 Monthly Cleanouts Number.

The monthly average steam gain per cleanout is showed in the figure 6, from this figure we can see the months with better average were from January to

May ’98, the data in this figure does not show correlation with the information of figures 4 and 5. It points out that could be better to increase cleanouts frequency in all those wells that have high steam gain potential, like 631, 609, 615 and others.

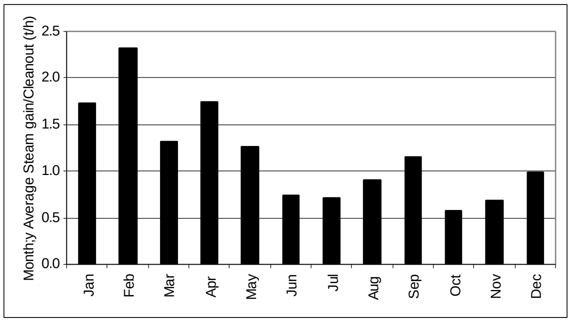

Fig. 6. Monthly Average Steam Gain/Cleanouts (t/h)

DISCUSSION AND FINAL REMARKS.

Since well 631 has been noticed with the highest steam gain was plotted, the steam daily production behavior from September ’98 to December ’98, the figure 7 includes two lineal curve fitting.

The dark square shows the steam production data after cleanouts , and the black circle shows the steam production behavior before cleanouts, The well 631 was cleaned about eight times during this period, the steam production always showed recovering after cleanouts.

The dash line fitting in the figure includes the steam production values recorded after cleanouts orifice plate diameter and the dark line fitting includes all the production steam data before cleanouts.

The difference between these fitting curves can be considered like the net steam gain recovery approximately, this diference showed for 631 besides from this figure is possible to observe as the behavior tendency changes with the cleanouts, therefore the cleanouts orifice plate diameters helps to decrease the steam production decline. Similar behavior was observed on wells like 609 and 615.

Since silica scaling is the main cause of the orifice plate diameter plugging, a graph was done with information of steam gain by each well and silica concentration. Circled area into figure 8, encloses most of Latina-Calpine Wells, that are producing brine from 650 to 800 ppm silica concentration with average steam gain from 0.5 to 2.0 t/h, this represent the 62.6 % of the cleanout wells. 631 well points out 850 ppm silica concentration and 2.0 t/h steam gain.

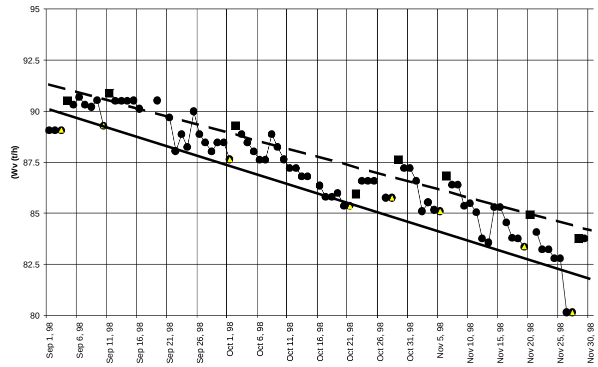

Fig. 7. Well 631 Steam daily production.

Considering information from 631 cleanouts, the offline time average for each cleanouts was 44 minutes, Assuming 86 t/h of steam average production, the steam amount have not been supplied during each cleanout is about 63 steam tons. Therefore, the total monthly steam not delivered is around 252 tons, approximately.

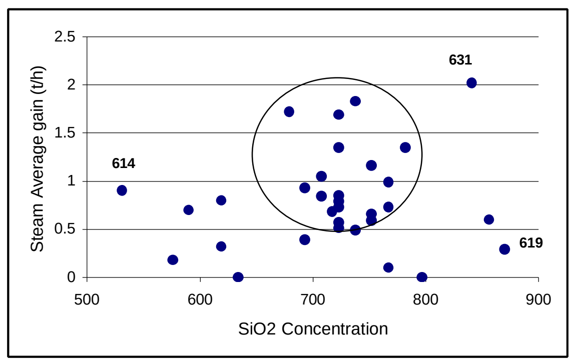

Fig. 8. Silica vs. Steam gain.

Table 4, includes the estimate cost for each cleanout, the total cost is about $ 156.00 USD.

Assuming the 296 cleanouts (table no. 3) , the total cleanouts cost per year could be around $ 4,617.60 USD.

Table 4. Cleanouts cost.

No.	Concepts	Cost
1	Not Delivered steam	$ 126.00
2	People salaries	$ 10.00
3	Ring Joint R-14	$ 20.00
	Total cost	$ 156.00

One possible alternative to reduce the cleanouts cost could be to use an inhibitor to control the silica scaling in the orifice plate diameter. There are some scaling inhibitor that are being used in some geothermal field to control the scale deposition. Hydrochloric acid process to minimize acid-brine incompatibility and Sulfuric acid in brine acidification have been using by UNOCAL at the Brawley and Salton Sea, California Geothermal fields, decreasing the flashed brine pH by about 0.3 units inhibits iron silicate scale formation (Gallup et all., 1997).

The use of any kind of inhibitors in CPLatina-Calpine wells to control the silica scaling, have to contend against the annual cost estimate of $4,617.60. Anyway the next step should be to probe an inhibitor in wells, and from this results to evaluate the best application option if it can compete to the traditional orifice plate cleanout jobs.

CONCLUSIONS.

1. Due to silica scaling deposited into orifice plate diameters of Cerro Prieto production wells, the steam production decrease as consequence of plugging. Several orifice cleanout programs, have been applied, from 1997 to 1998, in 32 CPLatina-Calpine producing wells. The results have allowed to select the best wells to gain steam.

2. The 1998 cleanouts orifice plate diameters, were 296. The total steam gain resulted on 308.41 t/h., and the monthly average steam gain was 25.70 t/h.

3. Two lineal curve fitting for 631 steam production behavior show the tendency after cleanout and before cleanout, the area between these two lineal fitting can be considered as steam gain.

4. Besides the 631 lineal fitting curve after cleanouts indicate significant decrease in steam decline production, same results were observed in 609 and 615 wells.

5. The results obtained from cleanouts orifice plate aggressive program, point out that it is possible to apply similar program on to 130 Cerro Prieto CFE production wells.

6. A brief economical analysis showed a cost of $156 USA for cleanout. It is assuming the actual way used to do a orifice plate cleanout.

7. The 1998 average cleanout steam gain resulted on 1.18 t/h, this represent 28.32 tons per day per cleanouts of benefit , this amount is adding to normal steam production.

8. There are some commercial silica scaling inhibitor tested in geothermal fields. Future plans could be to use some chemical inhibitor to control the silica scaling deposition, will be important to compare cost.

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