Proc. 12th New Zealand Geothermal Workshop 1990

DECLINE ANALYSIS AT CERRO PRIETO I GEOTHERMAL FIELD

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ABSTRACT

This paper proposes the application of decline curve analysis methodology to Cerro Prieto I geothermal field.

In the visual analysis of the plot for exponential trend, an unsteady state of the reservoir was detected.

Fourteen wells were analyzed and classified in three groups according to their behavior. The percentage of annual declination vas calculated in 10.678 for budgeting and planning. In the other hand, 20.99% of annual declination was calculated for vells that may need a workover.

INTRODUCTION

The geothermal field of Cerro Prieto is located 18 miles south from Mexicali City in Baja California, Mexico.

The field under exploitation has an extension of 12 square kilometers, and it started its comercial operation in 1973 with two units of 37.5 MW each. Two identical additional units were incorporated in 1979, and one more of 30 MW in 1981 to reach 180 MW of installed capacity in Cerro Prieto I. Later in 1986 and 1987, Cerro Prieto II and Cerro Prieto III units started operating with 220 MW each. Today, the installed capacity is 620 MW, and there are aproximately 110 producer wells [Iglesias et. al, 1986; Quintero and Peña, 1989].

Four units with a capacity of 20 MW each are being planned for the next years.

This paper discusses a topic that has been analized in other geothermal fields, like The Geysers in The United States [Enedy, 1989; Sanyal et. al, 19891 but, there is not a report about the Cerro Prieto case: This article proposes the application of methods based on experience and historic information in order to estimate the declination of the steam production on the field, and the well performance. In the other hand, it may be a useful tool in the economic evaluation of future projects.

It is known that in the field itself there are different well behaviors produced by reservoir properties and structures. Other causes are attributed to the tasks of well drilling, finished, induction, and well development and operation.

In this study, the field of Cerro Prieto I is analized, considering that it is the oldest area in operation. Fourteen wells have been selected as representative of a reservoir clasified as liquid-dominant. The objective of that selection is to prove the method. In this way, it can be validated with the actual information in order to evaluate it, and its future use in Cerro Prieto II, III and IV.

DECLINATION

The economic evaluation of a geothermal field is strongly affected by its development planning. The number of production wells to drill for the project life has to be estimated , and also when and where they wil be drilled.

The declination in the productivity of the wells and reservoir are parameters to consider in the economic evaluation. The estimation of the declination is not a simple task, and the results not always are effective.

Decline curve analysis is a standard method used to evaluate reserves and field life in the oil and gas industry. In the geothermal case, the experience of Geysers shows that it is a valuable technique (Sanyal and Che, 1982; Sanyal et. al. 19891.

According with the analysis and applications of Sanyal and Che (1982, 1989), and Enedy (1989), the following considerations can be established:

*In general, there are two defined trends in decline analysis: exponential and harmonic.

Exponential decline is defined by:

$$-(1/W)(dW/dt) = D \qquad (1)$$

Where W is the steam production rate and D is the constant decline rate. A straight line on a log flow rate versus time plot represents an exponential trend.

.Harmonic decline is given by:

$$-(1/W)(dW/dt) = D(t) \qquad (2)$$

$$D(t) = bW \qquad (3)$$

Where b io a constant. It can be demonstrated that a straigth line on a (1/W) versus time plot represents an harmonic trend. According with Sanyal and Enedy (1989) a plot of log W versus cumulative production should be linear if the decline trend is harmonic.

*At the begining of the comercial exploitation of the field, or after significative changes in the reservoir, there is not a clear difference between the two trends. Later, when the steady state is reached, one of them is the dominant trend.

*The analysis are based in an historic series of static pressure records, and/or mass flowrate records at a constant flowing well head pressure. The static pressures are measured only occasionally, and the flowing well head pressure is usually not constant. Since, the decline rate of productivity is not truly reflected by the historic series of records. However; it is posible to have a good approach, normalizing the flowrate data to a reference pressure.

*The decline curves are adversely affected by close well spacing, and also with increases in mass withdrawal rates. this is denoted by small initial steam production and strong declination. In the other hand, ,could be a lag in the reservoir response with low well density, controlled operation, and by the value of the permeability-tickness product.

CALCULATIONS

In this study, fourteen vells of Cerro Prieto I were analyzed in their steam production thru the years of 1983-1987. The wells were selected in basis of their continuity in steam production and the steam/liquid relation.

The back-pressure equation used by Enedy to normalize the flowrate is expresed as:

$$W_n = (P_{ts}^2 - P_{tf}^2)^n W / (P_{ts}^2 - P_{std}^2)^n \quad (4)$$

where:
Wn= Normalized flowrate
W = Flowrate
Pts= Surface shut-in pressure
Ptf= Surface floving pressure
Pstd=Standard flowing wellhead pressure
n = exponent of back-pressure equation (0.5<n<1)

Geysers is a dry steam field. In Cerro Prieto geothermal field a deviation of 20% from the standar pressure can represent a variation in the order of 0.5% of the total fluid flowrate, but 5% in the steam production, according with:

$$R = (H_b - H_{l,f})/(H_{l,f} - H_{v,f}) \quad (5)$$

where R is the steam mass fraction, H_b the fluid enthalpy at the bottom of the well, $H_{l,f}$ the enthalpy of the flowing liquid at the separator, and $H_{v,f}$ the enthalpy of the steam at the separator.

The main problem is to evaluate in a exact way the bottom temperature. An energy balance does the asumption of saturated liquid at the well bottom, and geothermometry implies the estimation of the steam mass fraction. A deviation of 10% in the bottom temperature can produce a difference of 20% in the static pressure.

In this study the flowrate data were not normalized, because the actual temperature information was considered of poor confidence.

The exponential trend was selected, and the time was plotted versus log of steam flowrate for each one of the fourteen wells.

The visual analysis of these plots allowed to clasiffy the wells in three groups:

Group 1.- Wells with a defined trend in almost a full range considered (Figure 1).

Group 2.- Wells with a defined trend in a short range, with greater declination and with a production break and recuperation (Figure 2).

Group 3.- Stabilized wells that do not have a defined declination trend (Figure 3).

A lineal regression was executed for different ranges of each well in order to evaluate the coefficient for the equation:

$$\ln(W) = \ln(W_i) - Dt \quad (6)$$

where W is the steam production in kg/hr , t the time in months, and D the coefficient of declination.

The percent of annual declination was calculated as:

$$\%D_a = 100(1 - e^{-12D}) \quad (7)$$

The values calculated are shown in Table 1.

TABLE 1

WELL NUM.	RANGE MONTH	COEFF.	%ANNUAL DECLINATION
		GROUP 1	
M35	0-59	0.00923	10.48464
M42	0-59	0.00736	8.453209
M50	0-59	0.01171	13.10936
M130	0-59	0.01064	11.98649
M130	0-36	0.00849	9.686205
M90	0-41	0.00978	11.07349
M51	0-45	0.00866	9.870257
		GROUP 2	
M114	0-37	0.03534	34.55895
M21A	0-38	0.01026	11.58424
M20	15-37	0.02659	27.31825
M20	38-53	0.00926	10.51686

RESULTS

According to the values and the plot of the first group, the average annual declination was estimated as 10.67%, and the average behavior can be expresed by:

$$\ln(W) = \ln(W_i) - 0.00790\, t \quad (8)$$

For the second group, the average annual declination was calculated in 20.99%, and the average behavior by:

$$\ln(W) = \ln(W_i) - .02036\, t \quad (9)$$

An unsteady state was detected for the month 40 (may 1986).

CONCLUSIONS

1.- It is possible to develop a generalized approach analyzing the declination of the steam flowrate for budgetting and planning purposes, using selected wells (group 1) in a liquid dominant geothermal field.

2.- The zethodology can be used in order to identify vells that might need workover (group 2), and tormulate make-up well drilling programs.

3.- New power plants coming on line may complicate the decline curve analysis. This situation must be considered in future projects, and it is necessary to carry on more studies in well spacing and reservoir recharge.

4.- In the case of Cerro Prieto I, the use of the exponential trend might be conservative in the estimation of the well life, and a good approach for workover programs.

AKNOWLEDGEMENTS

The author wishes to thank Coordinadora Ejecutiva of Cerro Prieto, specially the Department of Studies for the access to the production information and the permission to publish this paper.

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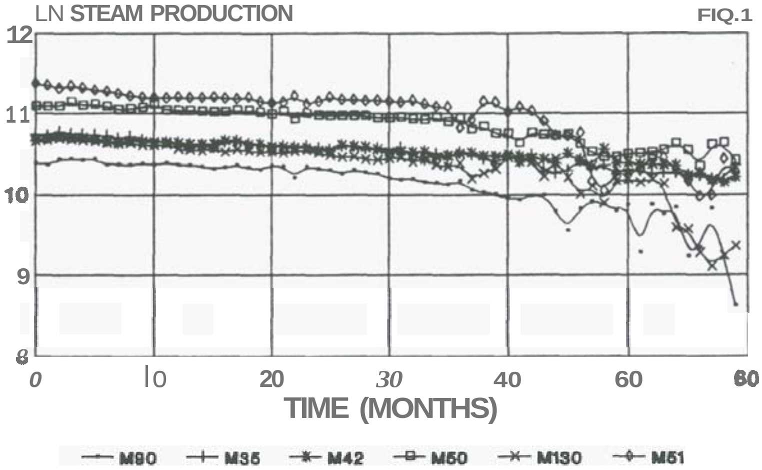
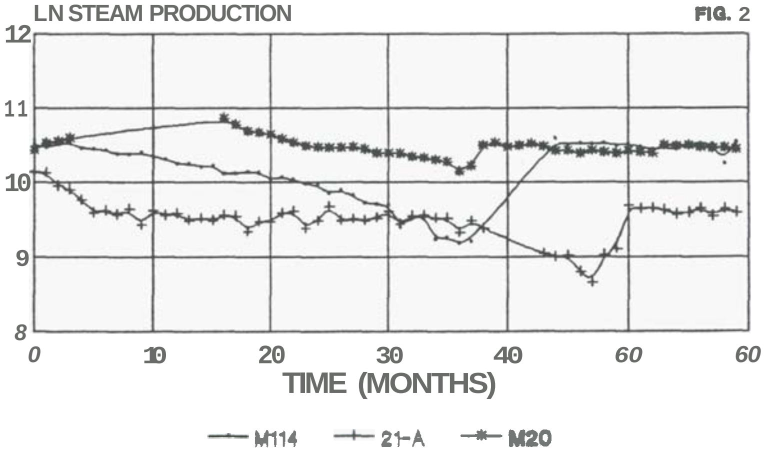
WELL M90, M35, M42, M50, M130, M51
LN STEAM PRODUCTION VS TIME

LN STEAM PRODUCTION FIQ.1



WELL M114, 21-A, M20
LN STEAM PRODUCTION VS TIME

LN STEAM PRODUCTION FIG. 2



WELL M29, M26, 19-A, M43, M25
LN STEAM PRODUCTION VS TIME

FIG. 2