MANAGING THE CYCLING EFFECT ON WELL EPT-L/1

Erwandi Yanto[1], Kristina Emeralda Cici[1], Gamal Hastriansyah[2], Fernando Pasaribu[2], Marihot S.P. Silaban[2]

PT. Pertamina Geothermal Energy

Skyline Building, 19th Floor, Jakarta Pusat, Daerah Khusus Ibukota Jakarta 10340

erwandi.yanto@pertamina.com ; kristinaecici@pertamina.com

Keywords: *Cycling, multiple feed zone, throttling, well head pressure drop.*

ABSTRACT

The cycling effect is an impact that shows that the minimum pressure required by a well to remain stable in production is not achieved. The root cause of the cycling effect in a well is the presence of multiple feed zones which have difference pressure, enthalpy and permeability. This root cause can be concluded from data acquisition such as a PTS Shut-In survey and down-hole sampling. In the case of Well EPT-L/1, the cycling effect causes the well to not produce. It will always experience a pressure drop if produced with a minimum pressure of 8 barg in conditions of up to 60% throttling and when the pressure is less than 8 barg, the pressure in Well EPT-L/1 will slowly reduce. Thus, the operational pressure to produce the well should be a minimum of 8 barg.

1. PRINCIPAL THEORY

1.1 Cycling Effect

The cycling effect in geothermal wells is a condition when the well suddenly stops flowing after discharging for a time and the mass flow, enthalpy and WHP dynamically change with constant settings at wellhead and the control valve.

1.2 Root Causes

The cycling effect is caused by the presence of two significant feeds of different enthalpy and permeability. One of the feeds has poor permeability such that it cannot sustain continuous flow. Cycling is also possible without the presence of a steam zone due to a deep, high enthalpy, low permeability feed that discharges intermittently (Grant, et al, 2011).

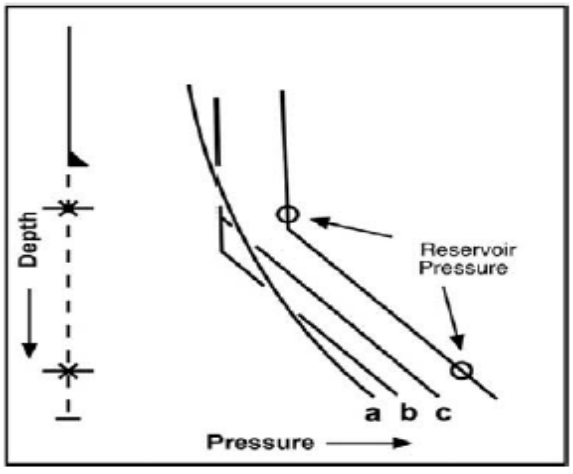


Fig 1. Pressure profiles in a cycling well (Grant, et al., 2011).

In this case, cycling effect occurs when the well is discharging which affects the steam supply to the power plant for a few days.

2. WELL INFORMATION

2.1 Well Profile

Well Name : EPT-L/1
Formation Type : Volcanic
Max Deviation : Vertical
(max 7.99 deg deviation)
Wellhead Connection : 3-1/8" 3000K (R-31)

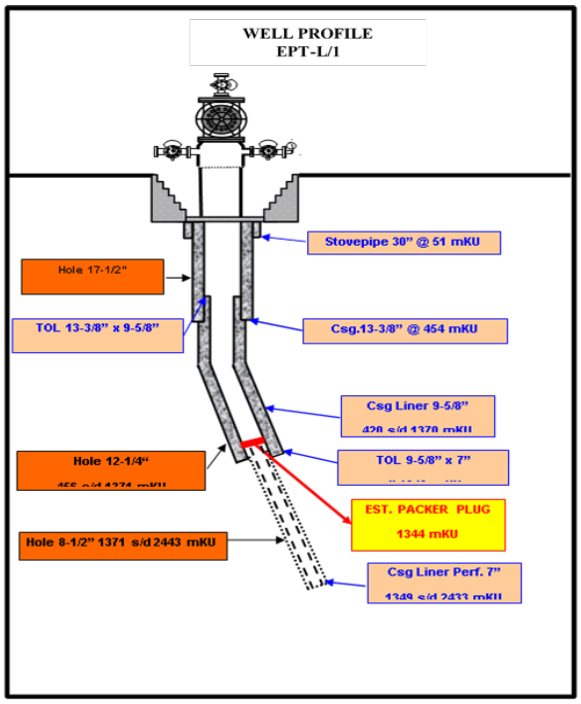


Fig 2. Profile EPT-L/1

2.2 Reservoir Information

Reservoir information is acquired by a PTS survey during production of the well. Pressure, temperature and feed zone contribution are essential for characterizing the reservoir. Pressure, temperature, and feed contribution are shown in Table 1 below.

Table 1. Reservoir Well EPT-L/1 Based On PTS Flowing

Depth (mMD)	P_{wf} (bar)	P_r (bar)	T_r (deg-C)	Mass Flow (kg/s)	PI (kg/s/bar)	Enthalpy (kJ/kg)	Contribution (%)
2300	30.9	72.2	278.4	18	0.4352	1229	75%
2050	26.7	53.0	262.7	2	0.0761	1148	8%
1370	16.2	33.2	249.3	4	0.2359	2700	17%

2.3 Geological Setting

Karaha Geothermal Field is associated with the Quaternary Volcanic Deposition, which consists of Lava and Pyroclastic (Tuff) rocks which are Andesitic-Dasitic, Lava and Volcano-Clastic. This sequence is locally intruded by the body of the Diorite Intrusion and covers the sedimentary complex of the Landscape Formation.

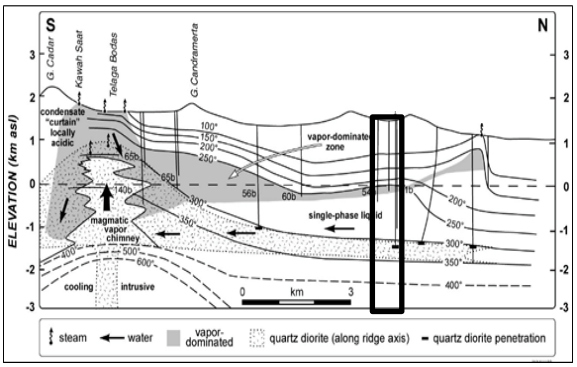


Fig 3. Geological Setting Area

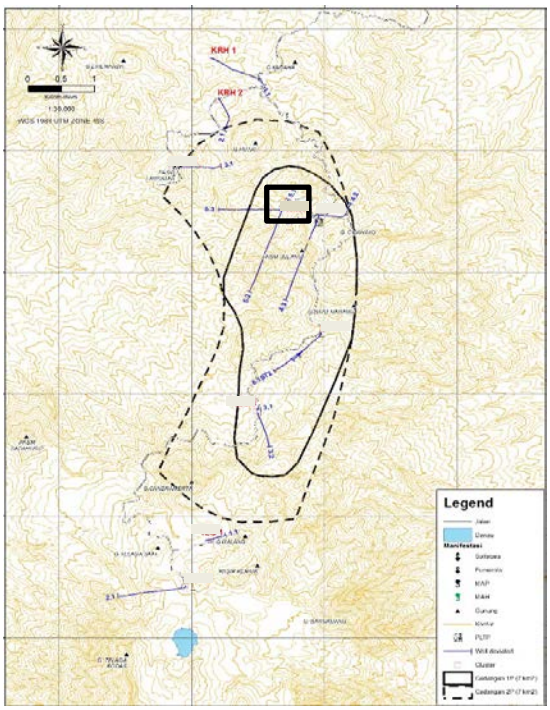


Fig 4. Map Location of EPT-L/1

3. DATA AND ISSUES

3.1 Chronology of Sudden Decrease in WHP at EPT-L/1

- A decrease in well head pressure suddenly below 1 barg.
- Cold water intrusion has occurred at the next well (KRH 5-2) so it is feared that something similar will happen at KRH 5-1 well.
- The decrease of WHP can be hypothetically due to: multiple feed zone with difference of pressure and enthalpy.
- Furthermore, surveys should be undertaken such as a PTS survey and downhole sampling in this well.

3.2 Field Operational Data

Well characteristics has been observed during a production period of well EPT-L/1 including WHP, Throttling Valve setting and production.

Plots of the data for Well EPT-L/1 show that this well has been periodically cycling the WHP with a relatively constant throttling percentage.

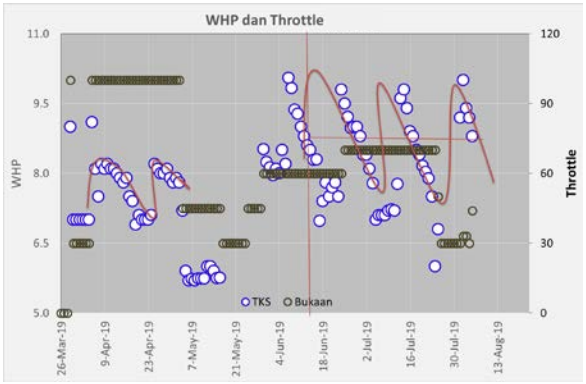


Fig 5. WHP and Throttling Data vs Time of EPT-L/1

The characteristic behavior of Well EPT-L/1 are cycling every 2-3 weeks and recovery for 3 days.

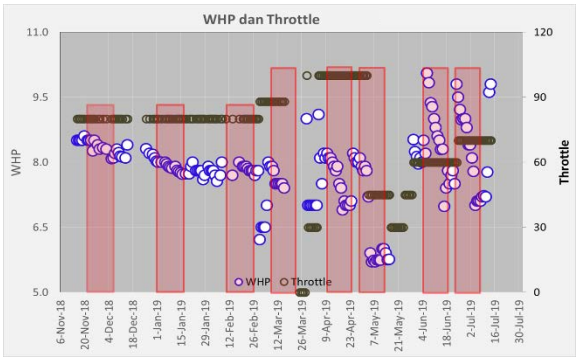


Fig 6. Cycling Period of EPT-L/1

The peak of the cycling effect is a suddenly lowering of wellhead pressure of EPT-L/1 down to lower than 1 barg so that this well cannot flow to the plant.

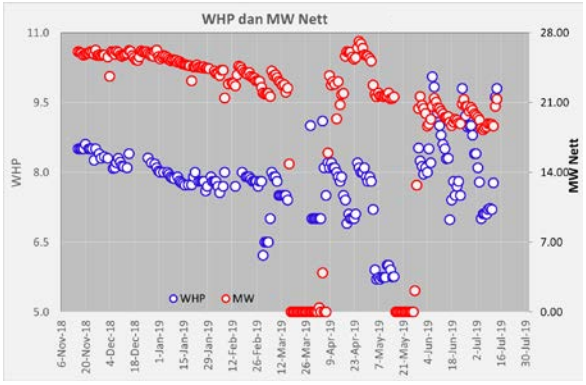


Fig 7. Production History of EPT-L/1

Based on the picture above, it can be seen that when the WHP of EPT-L/1 goes down there is a decline in generation and vice versa. Several survey has been conducted to identify the causes of these phenomena.

4. RESULTS AND ANALYSIS

One of the best ways of identifying the root cause of the sudden lowering of WHP at EPT-L/1 is well measurement.

The types of well measurement which have been conducted are :

- Well Completion Test
- P&T and PTS
- Downhole Sampling

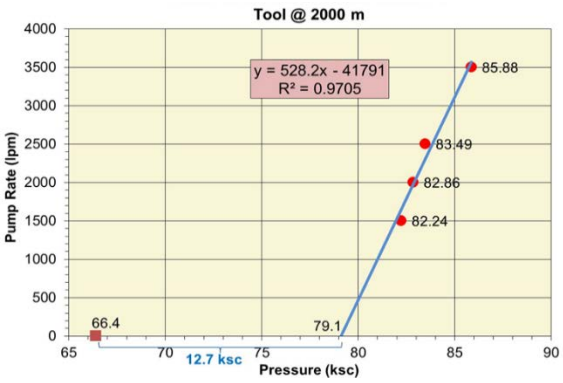


Fig 8. Well Completion Test EPT-L/1

4.1 P&T Shut In

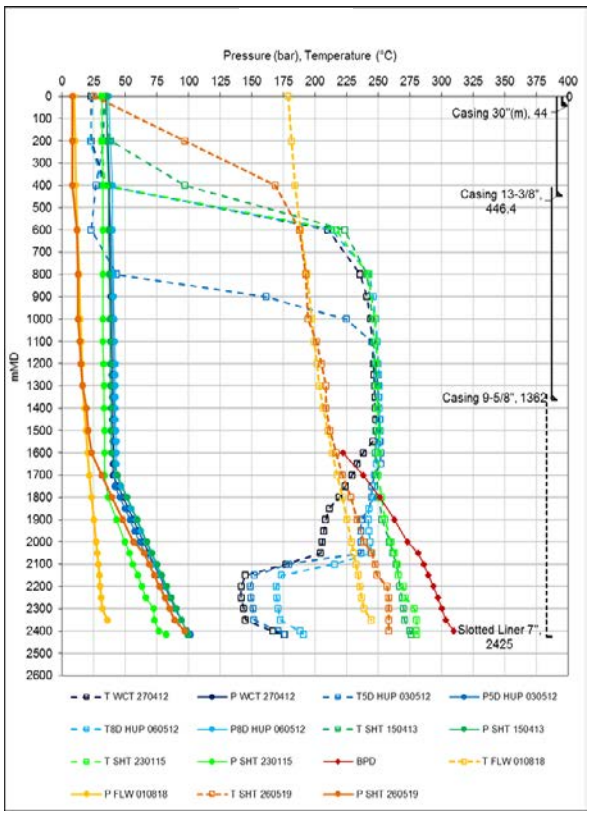
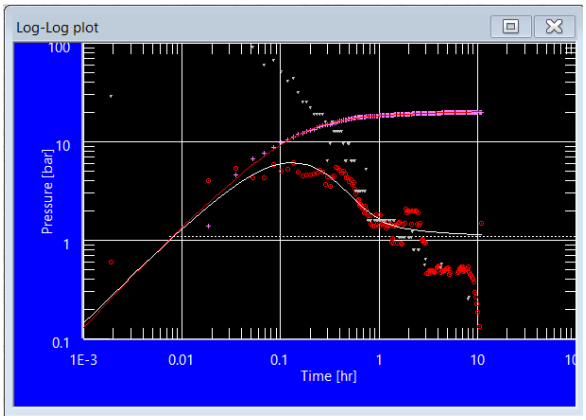


Fig 9. P&T Shut In EPT-L/1

The P&T Shut In test, which was conducted on 26 May 2019, shows :

- Maximum temperature of 258.24^0 C at 2400 mMD
- Maximum pressure of 96.79 barg at a 2400 mMD.



Standard Water Test

Well = Vertical
Reservoir = Homogeneous
Boundary = Infinite

Pi = 66.9518 bara
k.h = 34600 md.m
k = 0.173 Darcy
Skin = 2.06
C = 1.45E-5 m3/Pa

Default values are used!

Injectivity Index (lpm/ksc)	WHP (Bara)	Power (MW)
528.2	9	6.3

Fig 10. Pressure Transient Analysis of EPT-L/1

4.2 PTS Shut In

The PTS Shut In measurements were made with a WHP of 22 barg but there was leakage in the top lubricator and flange top valve. The maximum temperature is 254.74 deg.C at a depth of 2380 mMD, the maximum pressure is 97.73 embers at 2380 mMD. Steam flowing to the surface follows the BPD curve which coincides with the temperature measurement curve.

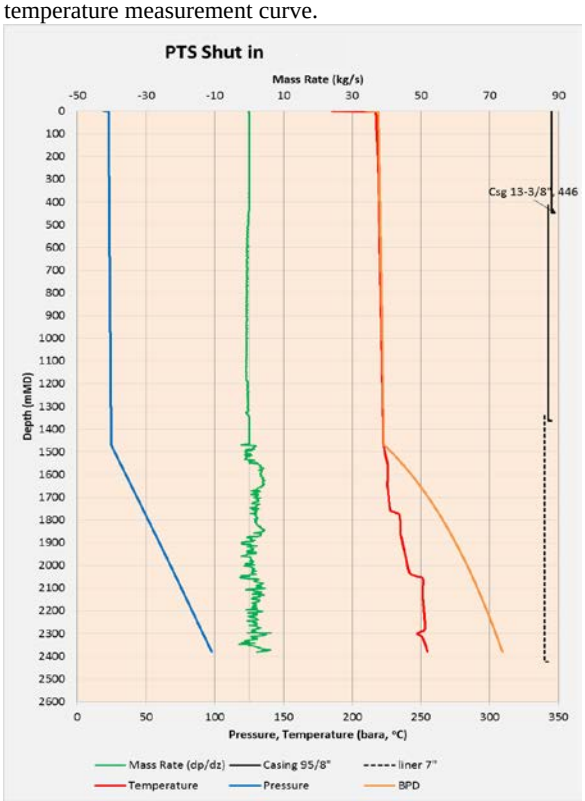


Fig 11. PTS Shut In EPT-L/1

Based on the measurement results from the spinner, the following information is obtained:

- Depth 0 - 426 mMD there is no flow, it appears there is little flow at that depth range
- Depth of 426 -1440 mMD shows a slight deflection in the spinner, which is likely due to the early flashing zone where steam flows to the surface.
- Depth of 1440 - 2380 mMD, no visible flow with great intensity.

This analysis suggests that there is no cold water inflow (casing damage) into the well or even steam cap appearance in this well.

4.3 PTS Flowing

A PTS Flowing survey of EPT-L/1 was conducted before the occurrence of the lowering WHP under production of this well.

Based on the survey, the following information was obtained :

- Feedzone is at a depth of 1370 mMD, 2050 mMD, and 2300 mMD
- Feedzone at 1370 mMD was taken from Well Completion Test data during Workover.
- Readings at depths of 0-400 mMD may not be good because of differences in casing thickness and actual data
- The reading at a depth of 1370-1730 mMD is probably not good because of the wellbore washout

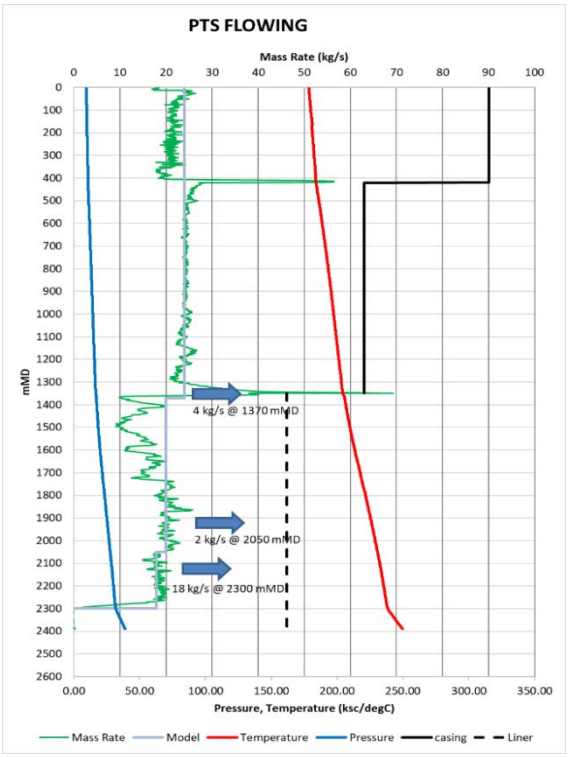


Fig 12. PTS Flowing EPT-L/1

Overall, there are significant differences among those 3 feed zones, especially in their contribution. The lowering of pressure inside the wellbore is probably related to some phase changes (Grant and Bixley, 2011):

(a) When those zones are flowing. The lowest zone draws down and the two-phase column between the zones collapses.

(b) Only the upper zone is discharging and the well discharge is dry steam. Pressure at the lower zone recovers until the water level rises to the upper feed zone

(c) Water is then entrained into the discharge, initiating discharge of the lower zone. The liquid column in the wellbore flashes, the wellbore unloads, and the cycle continues.

4.3 Downhole Sampling

- The sampling job was conducted with a WHP of 22 barg

- The sampling intervals were at depths of 2300 & 1500 mMD and 600 ml per collection was taken.

- Sample 1 at a depth of 2300 mMD was 600 ml with pH 10
- Sample 2 at a depth of 2300 mMD of 600 ml with pH 10 (acidified)
- Sample 3 at a depth of 1500 mMD of 500 ml with pH 10

Based on the sampling result it can be concluded that there is no cold water inflow or gas content in the fluid influencing the boiling point and most importantly the test confirms there is no casing damage such as is present in the well next to it.

4.3 Wellbore Model

Before cycling, the setting of the WHP in EPT-L/1 is at 8-10 barg, which is expected to produce a greater steam flow and so that the WHP does not drop quickly.

The operational WHP to discharge the well was simultaneously selected from wellbore modeling.

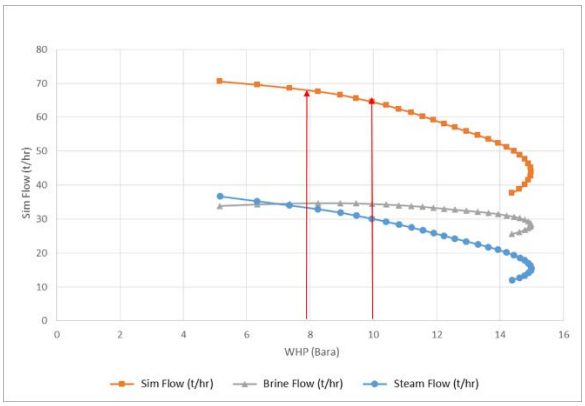


Fig 13. Wellbore Model EPT-L/1

5. CONCLUSION

- From tests (Completion, Transient, P&T, PTS) and downhole sampling analysis it can be concluded that there are multiple feed zones in Well EPT-L/1 at 2300 mMD, 2050 mMD and 1370 mMD. The upper feed zones at 1370 mMD has a greater contribution and permeability than the feed zone at 2050 mMD, which is typically the cause of

cycling events. The lower feed zone only contributes when the discharge pressure is low enough to accommodate the permeability of minor feed zones below.

- On the other hand, the analysis confirms that there is no cold water inflow (casing damage) into the well or even the appearance of a steam cap in this well.

- The operational WHP of EPT-L/1 is set at 8-10 barg, which is expected to produce greater steam flow and also so that the WHP does not drop quickly, even though the optimum WHP of the well is 5-7 barg. The operational WHP was chosen based on trial and error during the production.

ACKNOWLEDGEMENTS

The authors would like to gratefully acknowledge PT. Pertamina Geothermal Energy as the company we work for, and the Reservoir Management Team who have fully supported the author to publish the paper.

REFERENCES

Grant, M.A., Bixley, P.F. and Syms, M.E., 1979: Instability in well performance. Geothermal Resources Council, Transactions Vol 1979.

Grant, M.A., Bixley, P.F and Syms, M..E, 1979:Geothermal Reservoir Engineering, 2nd Edition, Elsevier Inc, USA.

Haukwa C.B., O'Sullivan M.J., A Study of Cycling in Geothermal Wells, Auckland University.

Horne, R.N., Grant, M.A., Gale, S., "Well testing on Geothermal Reservoir Engineering, Stanford, 1978.