ISBN 978-602-52132-0-5

HIGH NCG WELLS INTERFERENCE TEST FOR HIGH NCG WELLS OPTIMIZATION IN SALAK GEOTHERMAL FIELD

Doniberatus Imantoro, Abu Dawud Hidayaturrobi, Risa Prameswari Putri, Ayu Anandya Utami

Star Energy Geothermal Salak Ltd.

e-mail: dzih@starenergy.co.id; Abu.Dawud@starenergy.co.id;
risaprameswari@starenergy.co.id; ayu.utami@starenergy.co.id

ABSTRACT

The steam cap has significantly developed in East Salak resulting to dry steam production and higher Non-Condensable Gas (NCG) content in the most of East Salak wells, particularly Pad A and M- wells. Nowadays, Unit-4 experienced frequent curtailment (loss generation) due to high-NCG steam supplied by Pad A wells. Steam blending (among high- and low-NCG wells) was initiated by shutting-in or throttling high-NCG wells in order to maintain NCG content in Unit-4 below the maximum Gas Removal System (GRS) capacity (2.25wt.%). Unfortunately, this method did not give consistent results due to NCG interference among Pad A and Pad M wells.

NCG Interference was first evaluated in 2012 by observing changes in NCG concentration of certain wells after new make-up wells were POP'd or the existing wells were shutted-in. Another NCG interference evaluation was conducted on January 2014 – May 2015 to observed the optimum operation setting of high-NCG well in Pad A. However, several well still showing uncertain connectivity and camouflage by interference with other wells (Julinawati et al., 2017). Thus, an ideal interference test is needed to fully understand the NCG interference of high NCG wells. The ideal condition mentioned here is the condition where we only change 1 well per event and monitor the changes at surrounding wells. The NCG interference test was completed in 31 days operation and comprehensively shows clear NCG interference among Pad A and Pad M wells. This test result is used as reference to develop operational guideline of high NCG wells in Salak Geothermal field.

Keywords: Non Condensible Gas, Salak, High NCG, Wells Optimization, Interference

INTRODUCTION

Salak is the largest geothermal field in Indonesia and the sixth largest in the world with an installed capacity of 377 MWe. Commercial operations commenced in February 1994 with total production 59,514 GWhr (110.4 MMBOE) through the end of 2016.

Production levels have been maintained at or above the rated turbine capacity for 17 years through periodic infill drilling and injection system realignment. Currently, there are 76 production wells, 22 injection wells, four (4) monitoring wells and eight (8) abandoned wells in Salak. And more new make-up wells will be required to maintain full generation up to the end of the current Energy Sales Contract (ESC) in 2040.

BACKGROUND

Frequent curtailment experienced in Unit 4 due to high NCG steam from Pad A reaching the power plant. NCG itself could decreased the electricity power generation by reducing the vacuum level of condenser (a.k.a. back-pressure unit). If the steam entering turbine have NCG beyond handling capacity, it will significantly drop the power generation.

Thus, one of the most important issue at Salak is the NCG management. The NCG content in produced steam are expected to increase as the steam cap reservoir develops. Steam cap in eastern Salak was developed faster than in western Salak. At East Salak, Pad A has the highest NCG content with the highest NCG content from A-4, >11%. The high NCG in A-4 interference to almost all wells in Pad A if the A-4 shutted-in. Furthermore, the unsuccessful workover at A-4 (late 2015) caused the well to be shut-in and prevented the NCG from being vented. This impacted the NCG content in the steam supply by Pad A to Unit 4.

Non-Condensable Gas (NCG) is gas that is not able to condense to the liquid phase. NCG content is measured on-site using Wet-Test Meter. The NCG content (gas to steam ratio) of well can be calculated by measuring total volume of a dry gas and total volume (weight) of condensed steam collected over period of time. The dry gas volume is measured using a gas flow meter (Wet-Test Meter) and steam condensate is collected in a bottle trap and measure the volume or weighed. The NCG content (wt.%) is simply yielded by dividing the gas volume (weight) with the total weight (gas+condensate) (Wijaya et al., 2009).

As the solution, steam blending (among high and low NCG wells) was initiated by shutting-in or throttling high-NCG wells to maintain the NCG content in Unit-4 below the maximum GRS capacity. However, this method did not give consistent results due to NCG interference (or interconnectivitiy) among Pad A and Pad M wells.

NCG INTERFERENCE TEST DESIGN

NCG interference test was proposed to give better understanding of interference on NCG wells at current conditions. The idea of NCG interference test is to set ideal condition in observing NCG changes by controlling production setting. The NCG interference test program has followed this particular workflow (Figure 1).

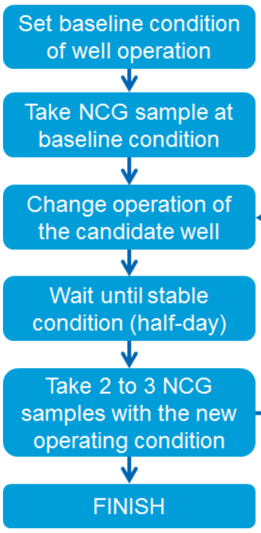

Figure 1. NCG Interference Test Workflow

First, set the baseline condition of wells. This step is very important to get the most reliable result. The NCG distribution on baseline condition will be used for analysis.

Second, change the operation condition of candidate well. The proposed conditions are venting through 10" SUV (commonly named production line), 3" (commonly named stimulation line), and 2" bypass SUV. Several things should be followed, such as:

1. Non-candidate wells should be strictly maintained at baseline condition.
2. There must be at least half-day retention time prior taking NCG samples in new operating condition.
3. Two (2) NCG samples is required to confirm the effect of operation disturbance

Repeat the workflow until all candidate wells have been tested.

There were 10 candidate wells chosen by the preliminary hypothesis regarding its relationship with A-4, which are: A-2, A-3, A-5, A-6, A-7, A-8, A-9, A-10, M-3, M-6. The sequence of the test considers well location on the field to minimize mobilization. Furthermore, in an attempt to minimize test duration, we also change 2 well condition within one day by turning the previous well candidate into baseline condition in the morning, then change the next well candidate into disturbance condition.

NCG INTERFERENCE EXECUTION AND RESULT

The first step is to set the baseline of operating well configuration and NCG of each well. The NCG content of all online wells at Pad A, M-3 and M-6 were sampled 1 day after the operation changes of the candidate wells. The NCG were measured for 2 to 3 days, before the well operation will changes again. Then, the NCG content was compared to the baseline condition. If there were increasing or decreasing trend after the candidate wells operation changes, then the online wells were concluded to have connection to the candidate well. Based on this NCG Interference Test, NCG of each well had respond specifically when the tested well put on shut-in or venting.

Table 1. Baseline Operating Well Condition, Test Well Condition & Initial NCG Content

Well	Baseline Well Condition	NCG content, wt.%	Test Well Condition
A-2	Fully open	2.2	Shut-in
A-3	Fully open	3.3	Shut-in
A-4	Shut-in	-	Shut-in
A-5	Venting through 3" to AFT	2.7	Venting through 10" SUV to AFT
A-6	Shut-in		Venting through 3" to AFT
A-7	Fully open	0.6	Fully Open
A-8	Shut-in		Venting through 3" to AFT
A-9	Throttled		Throttled
A-10	Shut-in		Venting through 2" bypass SUV to AFT
M-3	Throttled	3.9	Shut-in
M-6	Venting	5.9	Shut-in

Figure 2 shows that A-3 and A-5 respond directly to the change of operation in A-6. The green line is the event of A-6 changed operation condition from shut-in to venting through 3" to AFT. The NCG at A-3 and A-5 suddenly shows a drop.

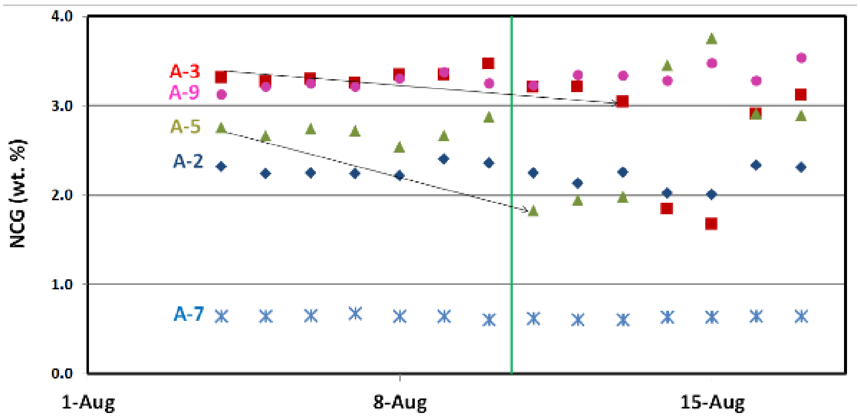

Figure 2. A-6 Interference Test Result

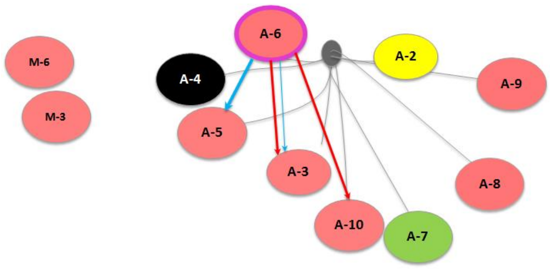

Figure 3. A-6 Interference Result Connection

This test concluded that A-6 interferred A-3 and A-5 (Figure 3). Further explanation of Figure 3,the blue line corresponds to result from 2016 NCG interference test and the red line corresponds to result from 2014 NCG interference evaluation. It means that for current condition, changing of operation in A-6 will impact on A-5 and A-3 NCG content. However, NCG interference between A-6 and A-10 that previously observed (from 2014 NCG Interference test) can not be analyzed due to those wells are currently in shut in condition.

In addition, the degree of connectivity can be classified into two types: strong and weak connection. After gathering all of the data trend, the simple statistical was used to make the classification. The assumption used is if the changes are more than Q2 of the population, then the connectivity is categorized as strong connection. Else, if it is less than Q2 of the population, then the connection is categorized as weak connection.

Table 2. NCG Interference Test Result

Source of Disturb-ance	Interfered wells	Baseline NCG (wt.%)	NCG after being interfered (wt.%)	% change
A-8	A-2	2.2	2.4	5
	A-3	3.3	3.5	6
	A-5	2.7	2.9	8
A-6	A-3	3.3	3	7
	A-5	2.7	2	26
A-5	A-2	2.2	2	10
	A-3	3.3	1.7	48
A-3	A-2	2.2	3	35
	A-5	2.7	2.9	9
	A-7	0.6	1	53
M-6	A-3	3.3	3.6	11
	A-5	2.7	3.8	41
	M-3	3.9	4.6	17
M-3	A-3	3.3	3.8	17
	A-5	2.7	3.6	34
	M-6	5.9	7.7	30
A-2	A-3	3.3	3.7	13
	A-7	0.6	0.8	25
Quartile 1				9
Quartile 2				17
Quartile 3				33
Quartile 4				53
Median				17

The full results of 2016 NCG Interference test shown in Figure 4.

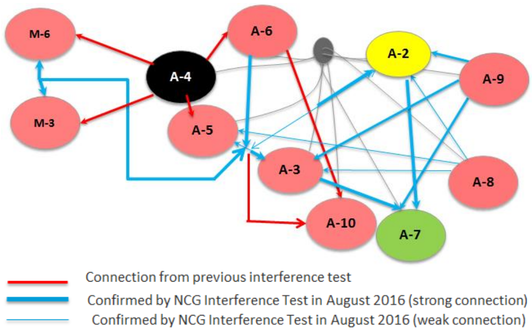

Figure 4 Salak NCG Interference Connectivity

The blue bold line represents the strong connection in NCG interference and the blue normal line represents the weak connection in NCG interference. For example, changing well condition of A-9 will significantly impact NCG content of A-2, A-3 and A-7. Figure 4 also explains that there is a change in source of interference. Previously, the source of interference is identified in A-4. A more complete account of A-4 interference can be found in Hidayatturobi et al., 2017 (this issue).

However, after A-4 shutted in, the source of interference change into A-5 and A-3. Both of them connected each other and will impact almost all of the surroundings if there is any changes in the operating condition.

NCG INTERFERENCE TEST ANALYSIS

Previously, some of the high-NCG wells were continuously put on venting to AFT and causing too many steam has been wasted. In addition, there is no any dedicated guideline on how to maneuver high-NCG well and what is the impact to surrounding producers when the well is maneuvered for logging or maintenance activities.

NCG Interference Test result shows the range of fluctuation in NCG content to other wells when specific well is maneuvered. This data then used to predict total NCG entering turbine by using simple chemical mixing concentration concept as follow:

$$\%NCG \text{ to turbine} = \frac{\sum(m_i \times NCG_i)}{\sum m_i}$$

, with:

m_i : steam rate of well i that contributes to power plant, kph

NCG_i : wt%. NCG of well i

By combining the information of NCG interference and NCG blending calculation, a solution to improve current condition by manuevering some of well condition in Pad A can be gencrate.

Table 3. Initial Well Operating Condition & Initial NCG Content in Pad A

Well	Well Status	Steam Rate to Power Plant, kph	NCG content, wt.%	NCG rate, kph
A-2	Fully Open	110	2.45	2.70
A-3	Fully open	210	2.84	5.96
A-4	Shut-in	0	10.00	0.00
A-5	Venting	0	4.17	0.00
A-6	Shut-in	0	4.20	0.00

A-7	Fully open	140	0.64	0.90
A-8	Shut-in	0	2.82	0.00
A-9	Throttled	120	3.30	3.96
A-10	Shut-in	0	2.80	0.00
Total			580	13.52

Initial total steam contribution from Pad A was 580 kph. And by using NCG blending calculation, Pad A give NCG contribution to power plant at around 2.33 wt.%.

Table 4. Recommended Well Operation Setting & NCG Content in Pad A

Well	Well Status	Steam Rate to Power Plant, kph	NCG content, wt.%	NCG rate, kph
A-2	Fully open	110	2.38	2.62
A-3	Fully open	210	2.73	5.73
A-4	Shut-in	0	10.00	0.00
A-5	**Throttled**	**150**	**1.38**	**2.07**
A-6	Venting	0	4.20	0.00
A-7	Fully open	140	0.62	0.87
A-8	Bleed	0	2.82	0.00
A-9	Throttled	120	3.30	3.96
A-10	Bleed	0	2.80	0.00
Total			730	15.25

Table 4 shows a recommendation of well operation setting and NCG content in Pad A after applying the setting. After A-6 put on venting, A-10 put into bleed, and A-5 put online under throttled condition, total steam contributed to power plant is 730 kph. There is 150 kph additional steam from A-5. NCG blending from Pad A to power plant reduces to 2.09% with new operating condition.

CONCLUSION AND RECOMMENDATION

2016 NCG interference test came up with several conclusions, such as:

- Clear understanding on interference connection between Pad A and Pad M.
- Source of interference change from A-4 into A-3 and A-5.
- Steam supplied to the power plan had less NCG content that will lead to less curtailment.
- Wells that previously venting, could be produced based on his behavior of interfering surrounding wells. It means that additional steam can be obtained by applying the most efficient operating condition.

The NCG interference test result afterwards could be used to generate new operation protocol to optimize the steam production in high NCG wells. The operation protocol included fully open, throttling and venting some of wells. This recommendation resulted in full generation of 65.7 MW in Unit 4 even with 1 Cooling Tower Fan (CTF) stop operation.

ACKNOWLEDGEMENT

We would like to thank Star Energy Geothermal Salak (SEGS) and Pertamina Geothermal Energy (PGE) for granting permission to publish this work, especially to Star Energy Geothermal Salak Asset Development Department for supporting us in making this paper.

REFERENCES

Paramitasari, H., Putra, F.J., and Hidayaturrobi, A.D., *NCG Interference Evaluation*, CGS Internal Report, July 7, 2015.

Julinawati, T., Paramitasari, H., Putri, R.P., Hidayaturrobi, A.D.,*Salak NCG Interference Evaluation to Enhance Steam Production in High NCG Wells*, IIGCE 2017, August 2017.

Wijaya, B.A., Suminar, A. R., Ganefianto, N., *Resource Management Geosciences Well Sampling Two-Phase Flow Standard Operating Procedure,* CGS Internal SOP, May 2009.

Salak Asset Development Department, *2016 Salak Geothermal Field Asset Development Plan*, GPO Internal Report, October 2016.

HIdayatturobi, A.D., Simatupang, C.H., Permatasari, H.M., Putra, F.J.,*Successfull High NCG Wells Optimization in Salak Geothermal Field to Maintain Unit-4 Full Generation*, IIGCE 2017, August 2017.