PRODUCTION IMPROVEMENT THROUGH SCALE REMOVAL BY JETWASH KAMOJANG GEOTHERMAL FIELD

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ABSTRACT

The Kamojang geothermal field, Indonesia, is a vapor-dominated system with a total installed capacity of 235 MWe. Kamojang currently has five power plants (i.e., Units I-V). Unit I generates 35 MWe, Units II-III generate 55 MWe each, Unit IV generates 60 MWe, and unit V generates 35 MWe. During more than 30 years of generation the production wells have decreased in production. This directly affects the steam supply to the power plants. The most important program to resolve steam availability is drilling a makeup well. Limited access and unsuccessful drilling of makeup wells during 10 years have become a problem for maintaining long-term production.

Generally, in the Kamojang field the decline of production is affected by hole problems or reservoir damage. Seven wells indicated a hole problem due to scaling such as KMJ-A, KMJ-B, KMJ-C, KMJ-D, KMJ-E, KMJ-F, KMJ-G, KMJ-H, and KMJ-I. In this case, hole cleaning aims to dissolve scaling that causes decline of production. Hole cleaning uses jetwashes (water blasting) with 45 and 90 degrees nozzles to clean the scale of the production casing and liner.

As a result, a total of seven wells have increased production after hole cleaning, gaining approximately 8 MWe. Additionally, steam through jetwash can reduce cost, time, and drilling makeup wells.

1. INTRODUCTION

The primary change that occurs in Kamojang is declining steam supply to the power plant. It is indicated by a steady production decline.

Currently, production decline in Kamojang is 7% per year. The strategy to solve this production decline is through drilling makeup wells, but there are problems due to limited land access, the success rate of drilling makeup wells, and the depleted reservoir conditions. Another option to maintain steam supply is by hole cleaning.

Scaling forms due to a dynamic production process in a wellbore, resulting in a declining production well and obstacle while logging tool survey.The Aim of hole cleaning is to clean the wellbore ofscaling with the result that steam supply is increased and the obstruction in the wellbore is cleared.

2. DATA AND METHOD

The technical evaluation of the well selection process for the hole cleaning program is performed by monitoring several reservoir and wellbore parameters:

2.1 Variants analysis of production wells

Variants analysis is a systematic process to identify variants or deviations of well production data, projected between natural declines and actual production data. The more variants or deviations occur, the more potential for possible hole problems in the wellbore or formation. The production deviation is closely related to the change in values of the two main production parameters i.e., C_{WB} (kg/s-bar) and PI (m^3).

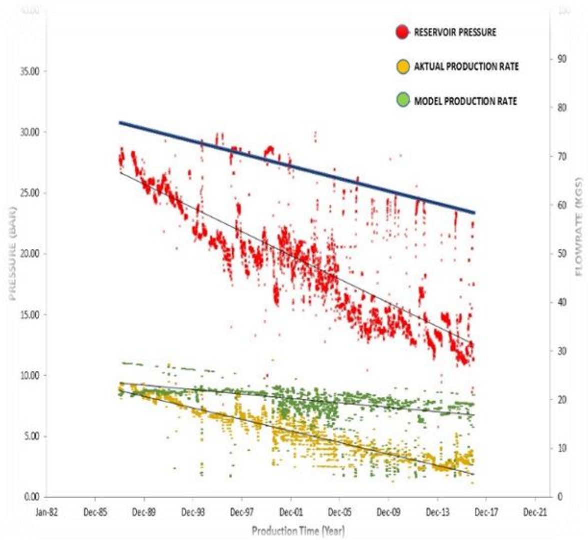

Figure 1. Production variants KMJ A

C_{WB} is a value that describes the condition of the wellbore. If C_{WB} shrinks during production, then it may indicate a change in the diameter of the wellbore, whether due to a scaling or a casing problem. The PI value describes the changing condition in the feed zone. By monitoring the trend of PI and C_{WB} values, a well can be identified as damaged in the wellbore or feed zone through its production variants.

The empirical approach used to identify changes in the value of C_{WB} (kg/s bar) and PI Prime (m3) refers to the formula developed by Acuna (Acuna, 2010):

$$(psi - \left(\frac{W\ vs}{PI}\right)^2 - WHP^2 = CWB\ W^2 \ldots\ldots(1)$$

where :

Psi	: Shut-in Pressure (bar)
WHP	: Wellhead Pressure (bar)
W	: mass rate (kg/s)
Vs	: Viskositas kinetic steam (bar-s-m^3)/kg
PI	: Productivity index (m^3)
C_{WB}	: Wellbore storage(kg/s-bar)

To calculate the natural production rate from C_{WB} and PI, the model used formulas which are the development of formulas (1)

$$W = C_{WB}^2\left(\left(\frac{P_{rg}^2}{A} - \frac{P_f^2}{C_{WB}^2}\right)^{0.5} - \frac{V_{rg}}{PI}P_{rg}\right) \quad (2)$$

defined by Eq.

$$A = \frac{1}{\left(\frac{1}{C_{WB}}\right)^2 + \left(\frac{V_{rg}}{PI}\right)^2} \quad (3)$$

This model is optimized to identify fluid flow in the wellbore and feed zone, so that it is possible to explain characteristics of the well deliverability curve in terms of the Productivity index (m3) and wellbore storage (kg/s-bar).

This application method is used in every Kamojang Geothermal well; for example, the case is seen in the well of KMJ A. The trend of continuously declining C_{WB} parameters is an indication that the well has a reduced inside diameter of the wellbore, either because of scaling or mechanical problems.

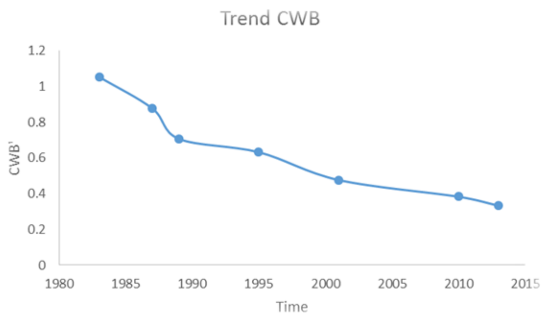

Figure 2. C_{WB} Trend of KMJ A

By applying a production variance method to the wells in the Kamojang field, 65% of production wells are found to be affected by damage to the wellbore or feed zone.

3. WELL INTEGRITY LOGGING

The next evaluation is wellbore checking with well integrity logging:

3.1 Go devil

Go devil is a tool used to observe the clear/open diameter of the casing. The Go devil size used is in accordance with the size of the production casing and well-perforated liner; this is intended to determine the depth of obstruction caused by scaling.

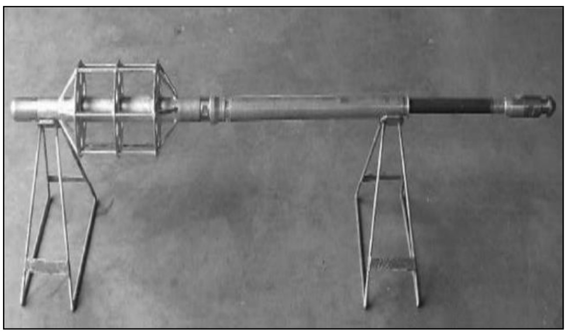

Figure 3. The Go devil used by PGE

Table 1. ID Casing & Go devils used

No	Casing Size	Godevil Size
	inch	inch
1	13 3/8	10, 8.5, 5.5 & 3.5
2	10 3/4	8.5, 5.5 & 3.5
3	9 5/8	8.5, 5.5 & 3.5
4	7	5.5 & 3.5

3.2 Impression Block (IB)

Impression block is a tool used to check the profile of obstruction in the wellbore. The size of the impression block used is adjusted to the size of the casing to be investigated.

Figure 4. Impression block tool profile

3.3 Scale catcher

Scale catcher is a tool used to collect scale samples from the wellbore.

The scale identification depth is based on the Go devil and Impression block.

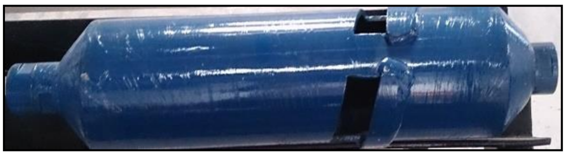

Figure 5. Scale Catcher

Figure 6 shows two examples of amorf silica, found in almost all wells, indicating constriction of the wellbore. Here is an example of the scale obtained:

Figure 6. Scale in production well

The presence of scaling causes significant decline of production.

Figure 7 shows the position of scale in the wellbore.

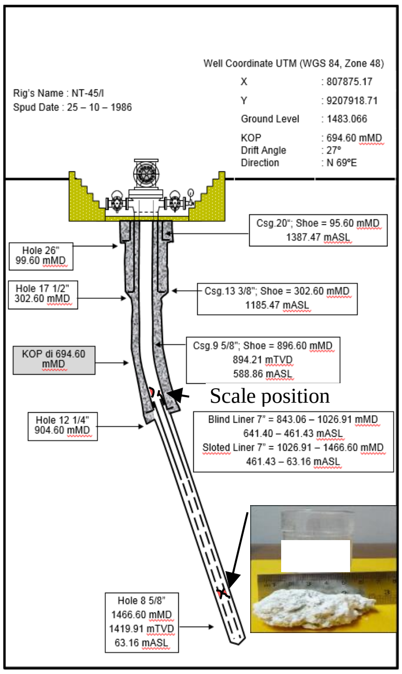

Figure 7. Well profile

4. PTS Flowing

PTS flowing logging aims to measure the contribution of each feed zone in the well before hole cleaning or an acidizing job. It can be used also to provide visualization of the casing diameter change due to scaling in wells by looking at the change of velocity response on spinner response.

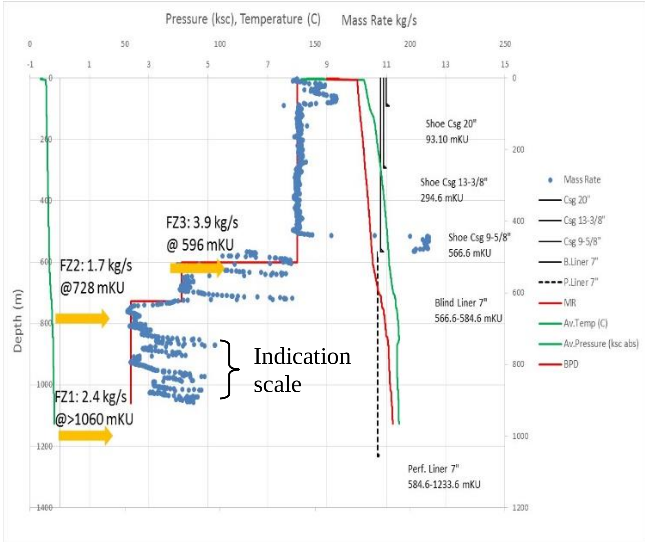

Figure 8. PTS flowing profile

5. Well Production Test

A well production test is done by a Modified Isochronal Test (MIT) with minimum operational WHP (Wellhead Pressure) setting at 4 WHP. It is proven that MIT is effective at saving the operational time of production tests. Data obtained is a baseline of productivity well before the hole-cleaning job.

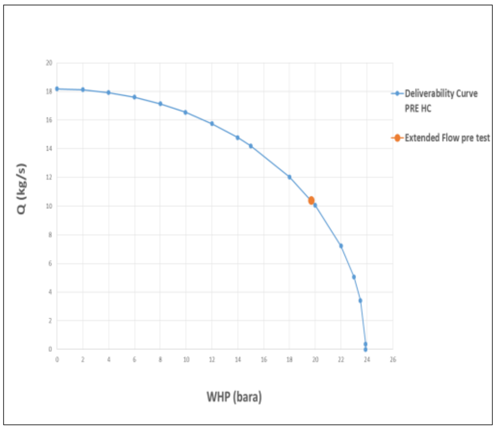

Figure 9. IPR MIT

6. Single Economics Calculation

Based on the technical evaluation obtained, well candidates for hole cleaning have the potential to increase steam; further evaluation is done by single economics.Single economics can be known as feasible or not. An indicator of a feasible program is determined by looking at the parameter of DPI (Discounted Profitable Index) minimum 1.3.

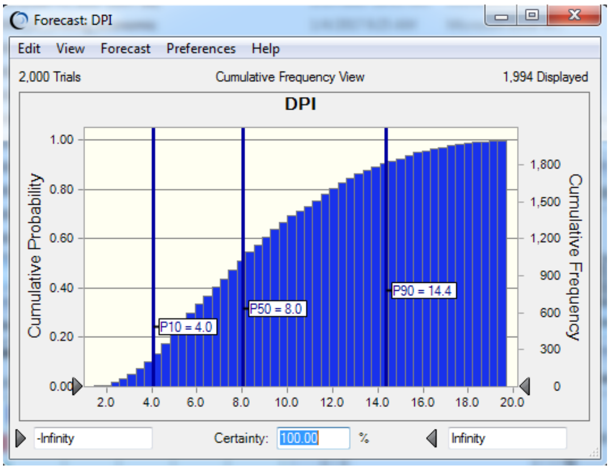

Figure 10. Single Economics Calculation

7. Candidate Well

We received the following 2017 technical and economic evaluation results of the candidate hole-cleaning wells:

Table 2. List of Hole Cleaning Candidates

NO	WELL NAME	PRODUCTION VARIANT ΔQ TON/HR	PRODUCTION VARIANT MW MW	DECLINE %/YEAR	GO DEVIL 8" (mKU)	GO DEVIL 5.5" (mKU)	GO DEVIL 3.5" (mKU)	SC SCALE	GAIN MW	ECONOMICS DPI (≥)
1	A 27	40.5	5.06	18%	519	621	882	silica amorf	2.7	1.3
2	B 1	29.74	3.72	18%	852	852	1006		2	1.3
3	C 6	27.36	3.42	6%	350	350	951	silica amorf	1.8	1.3
4	D 6	24.48	3.06	4%	797	1200	1200		1.6	1.3
5	E 2	20.74	2.59	11%	843	852	-	-	1.36	1.3
6	F 5	13.03	1.63	11%	802	1316	-	silica amorf	0.9	1.3
7	G 4	9	1.125	11%	843	995	995		0.6	1.3
8	H 3	7.74	0.97	15%	712	1474	-		0.5	1.3
9	I 5	0	0	4%	661	667	1175	Silica amorf	0	0

8. Operation Hole Cleaning

Hole cleaning is done by mechanical reaming and jet washing. It aims to clean the wellbore of the scaling formed inside a casing and perforated liner. The hole-cleaning program is as follows:

- Mechanical reaming using taper mill and flat mill with the size of 5.5 inch.
- Jet Washing using 2 types of nozzle:
- A 45-degree angle nozzle is used for cleaning the scaling in the target zone of the obstacle depth in the wellbore.
- A 90-degree angle nozzle is used to clean scaling in the perforated liner or feed zone depth.

Operation jet wash is done by a reciprocating procedure, especially in the feed zone depth, with as many as 3 repetitions.

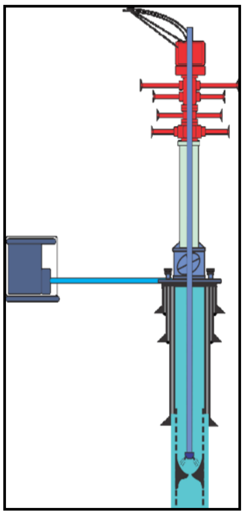

Figure 11.a Angle 45°

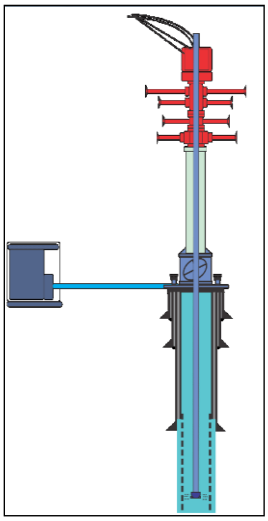

Figure 11.b Angle 90°

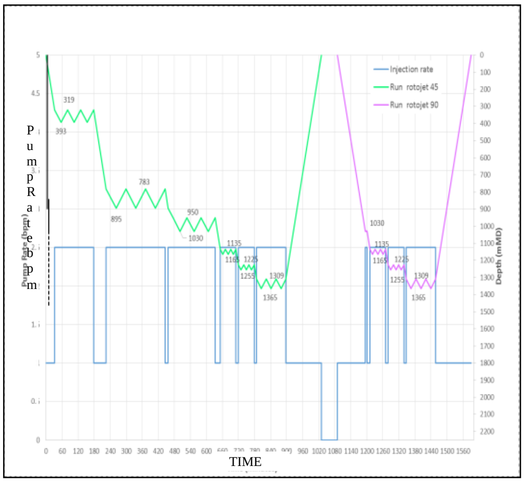

Figure 12. Jet Wash reciprocate graph

9. RESULT AND DISCUSSION

Hole-cleaning jobs were successfully done in 7 candidate wells, i.e., KMJ A, KMJ B, KMJ C, KMJ D, KMJ E, KMJ F & KMJ I. Well integrity and production tests were performed to know the well condition after the hole cleaning. An example result from KMJ F is:

- Well integrity.

Checking well integrity is done by running and logging go-devil.

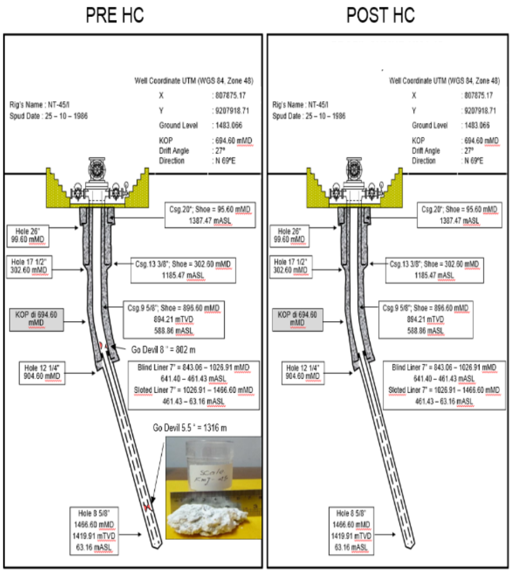

Figure 13. Comparison of hole condition profiles, pre & post hole cleaning

Post hole-cleaning logging results indicate that the scaling formed along the borehole was successfully removed, with the following data:

Table 3. Data comparison Maximum Clear depth well, pre & post hole cleaning

Go devil	MCD (Pre HC)	MCD (Post HC)
8.5 "	802 m	843 m
5 1/2"	1263 m	1442 M
3 1/2 "	1316 m	1442 m
1 1/4" x Nose 2 "	1348 m	1442 m

- PTS Flowing

PTS flowing is done to measure the change of Productivity Index (kg-s/bar) at the feed zone after hole cleaning. Here is a comparison of the data of PTS flowing at KMJ F:

Table 4. Comparison of PTS data flowing,pre & post hole cleaning

Parameter	Pre HC	Post HC
TKS	11 bar	23.34 bar
Flow di surface	5.5 kg/s	9.1 kg/s
Impeller	10 P	10 P
PI (kg/s/bar)	Pre HC	Post HC
FZ @1355 mKU	0.013	0.030

Comparison of PTS flowing data between pre-HC and post-HC (Figure) shows an increase of the productivity index (kg.s/bar) at 1355 mD (Major Feedzone). Based on spinner reading, it is known that the productivity of the well increased. Data indicate that before hole cleaning well KMJ F could produce 5.5 kg/s with operational WHP 11 bar, but after hole cleaning the well was able to produce 9.1 kg/s with operational WHP 23.34 bar.

- Production Test

Post-HC production test at well KMJ F was done by Modified Isochronal Test (MIT) in the same well headsetting.

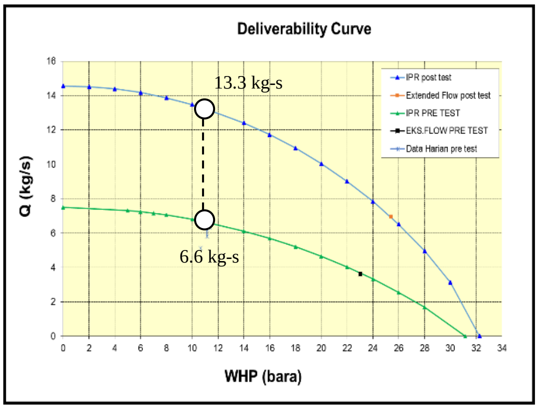

Figure 14. Comparison of MIT, pre & post hole cleaning test results

The post-HC production test shows a significant increase in productivity of wells of 6.9 kg/-s at an operational WHP of 11 bar.

Overall, based on pre-HC and post-HC well test results, hole cleaning effectively improves hole conditions and well productivity. The following are Total Cumulative Steam Gain Production Post-HC for wells that had hole cleaning done:

Table 5. Total Cumulative Steam Gain Production Post – HC

WELL	WHP	STEAM GAIN CALCULATION		
	OPERATION	Pre HC	Post HC	Gain
	bar	MWe	MWe	MWe
KMJ E	12	7	8	1
KMJ A	8.7	3.3	3.3	0
KMJ C	8.5	4.03	4.9	0.8
KMJ D	14	3.06	5.0	1.9
KMJ F	11	3	5.97	2.97
KMJ B	13	3.5	4.7	1.2
KMJ I	14	6.6	6.6	0
TOTAL				7.9

In summary, hole cleaning activities conducted in 7 Kamojang field wells were able to provide additional steam of 7.9 MWe and could effectively clean the scaling formed in the production casing and slotted liner. In addition to steam availability, hole cleaning positively impacted makeup well plans.

10. CONCLUSION

1. Hole cleaning is effective in removing the scaling formed in the production casing and slotted liners.
2. Hole cleaning effectively increases the productivity of wells, which in total can provide additional steam availability of 7.9 Mwe.
3. Hole cleaning has a positive impact on reducing the costs and needs of makeup wells as part of a steam availability field availability strategy.

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