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Workover Challenges Using Hydraulic Workover Unit in Dieng Geothermal Field

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ABSTRACT

Dieng Geothermal Field is situated in Central Java at around 2,000 masl and the Dieng Unit 1 Power Plant has been operating since 2002. The existing power plant configuration in Dieng Geothermal Field is 1 x 55 MW, but currently producing less due to the several problems in its wells. The most common problem in Dieng Geothermal Field is the severe scaling in the production well that decreases the wellbore diameter, thus reducing the geothermal fluid produced from the reservoir.

A workover campaign has been designed to overcome the scaling problem in the most effective and economic way. There are several challenges in performing workover in Dieng Geothermal Field, such as the presence of the existing production facilities, the high hardness of the mineral scale, and casing damage through the course of the production. A proper workover method with fit-for-purpose rig is significant to ensure a successful workover operation.

This paper examines the challenges in performing workover in the wells in the Dieng Geothermal Field, both from technical and non-technical aspects. The decision-making process of selecting Hydraulic Workover Unit as the preferable workover equipment in some wells in Dieng Geothermal Field is also discussed, including the advantages and disadvantages of using Hydraulic Workover Unit to perform the workover.

1. INTRODUCTION

Dieng Geothermal Field is a high temperature water-dominated geothermal field situated on Dieng Volcanic Complex (elevation ±2,000 masl). It is about about 90 km west from the capital city of Central Java, Semarang and about 80 km northwest of the city of Yogyakarta. The Dieng geothermal field is formed by a set of volcanic range composed by quaternary volcanic rocks. It comprises of three systems, Sileri hydrothermal system (20 wells), Sikidang hydrothermal system (27 wells), and Pakuwaja hydrothermal system (Harijoko, et al. 2016). The potential of geothermal energy from this field is around 400 Mega Watt (MW) (MEMR 2017). The existing power plant configuration in Dieng Geothermal Field is 1 x 55 MW, but currently generates around 39 MW.

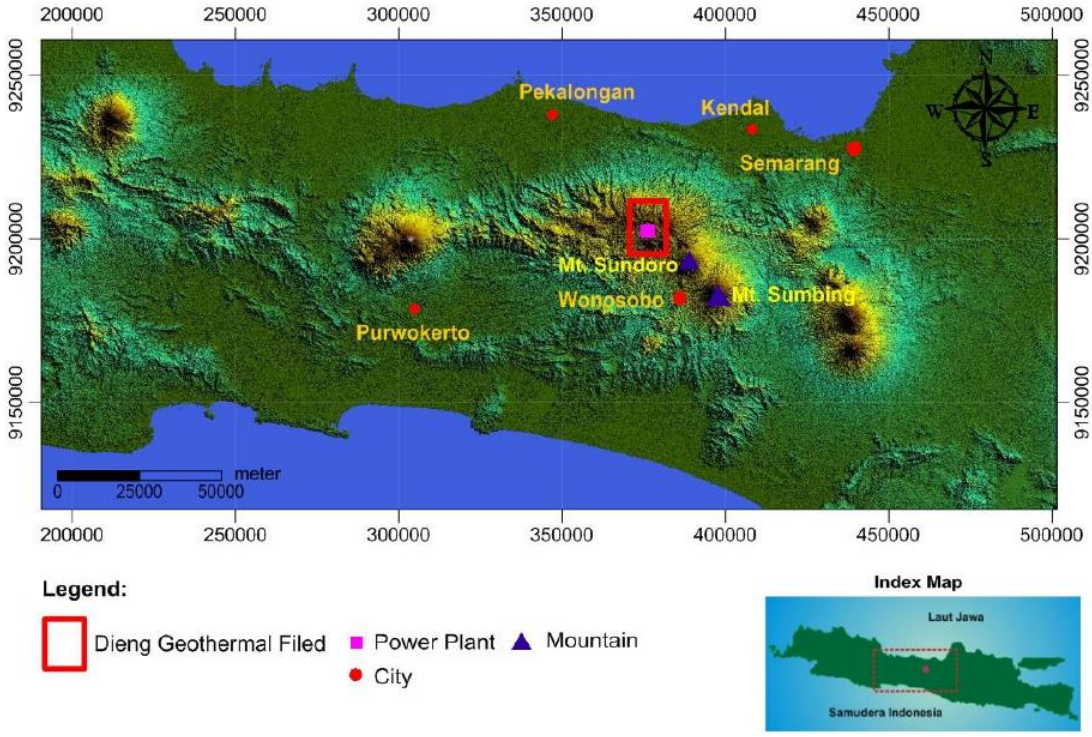


Figure 1. Location of Dieng Geothermal Field (Utami, Herdianita and Atmaja 2014)

2. OBJECTIVES

The purposes of this paper are as follow:

- Summarize the process of designing workover activity for three wells in Dieng Geothermal Field;
- Highlight the process of assessing and selecting the Hydraulic Workover Unit (HWU) instead of workover rig or small rig;
- Summarize the advantages and disadvantages of using HWU for geothermal well workover;
- Provide brief high-level summary of the workover execution using HWU;
- Discuss and summarize lessons learned obtained from the workover activity.

3. COMMON PROBLEMS IN DIENG GEOTHERMAL FIELD

Dieng Unit 1 currently rated at 60 MW_{gross}, but at this time of writing is generating in the range of 38-45 MW. The fluctuation of the Dieng's production is mainly caused by power plant issues, limitation in brine reinjection, and wellbore problems instead of reservoir decline (ELC 2019). Several production wells in Dieng have significant production decline, and some even have been inactive for years, mainly caused by casing failures and/or downhole sulphide scale. Several wells are also having their production zones blocked by junk or fish from initial drilling or well logging operation.

3.1. Casing Failures

Scaling and corrosion are known as a common problem in geothermal industry. There are metal losses observed on the 13-3/8" or production casing. Magnetic Thickness Detector (MTD) surveys were carried out and revealed severe metal losses in some areas of the production casing that might indicate leak on the casing. Casing leak in geothermal may cause groundwater intrusion to the wellbore, reducing the temperature, or even cease the production of the well. Other casing damage mechanism are fatigue failure or casing implosion due to heated trapped water in the cement.

3.2. Mineral Scale Deposition

Dieng geothermal field is a water-dominated system which has high salinity temperature, and enthalpy. Since the first unit operation in 2002, the main problem is the scaling deposition on surface production facility, and inside production and injection wells. Scaling in the production wells resulting a significant well production declining that occurred due to reduction of diameter of hole size. From the analysis of scaling sample hand specimens and XRD, dominantly the results of scaling samples are sphalerite (ZnS) and galena (PbS). The factors triggering the sulphide scaling formed are (Sirait, Wibowo and Elfina 2013): deep-seated reservoir, high chloride content (high salinity), high H_2S content, and high reservoir temperature.

Sulphide scaling formed in production wells is occurred by the pressure shifting at the boiling point which can cause pH increasing This event is generally formed in the casing diameter shifting or in the casing shoe. Basically, the pH changing is due to the simultaneous release of carbon dioxide (CO_2) gas and the result of hydrolysis of carbonate ions. Both of these processes also trigger the deposition of heavy metals (Fe, Zn, Cu, Pb, etc). Heavy metals are usually formed in brines that have high temperatures and are carried as chloride complexes (Ngothai, et al. 2010).

The decrease of production has caused steam supply to the plant decline significantly. In these recent years, some of the production wells declining up to 80% of production well initial capacity. Therefore, immediate actions are needed to improve the production of the wells, one of them is workover.

4. WELL REMEDIAL PLANNING

To recover Dieng's productivity, it is important to have a fit for purpose workover planning. Five phase of project management was applied to correctly identify the project objectives and planning (Rose 2013, Dumrongthai and Putra 2015). Figure 2 shows the five phases of designing the workover activity along with deliverables for each phase. It was decided that the main objectives for the project were:

- Recover power plant electricity generation;
- In doing so, it had to be conducted in a short period of time to achieve production target.

As of the late 2018 and early 2019 there was no identified power plant or surface facility problems that decreased the productivity, the main culprit was the declined steam production of some wells, and also the injection capacity reduction of some reinjection well. The time constraint for the workover was also limiting the possible well remedial activity, making casing failure remediation not feasible to be performed in such a short period of time. Thus, the workover activity to be performed were as follow:

- Mechanical wellbore cleaning to remove mineral deposition;
- Stimulation of the reservoir zone to improve steam production or brine reinjection.

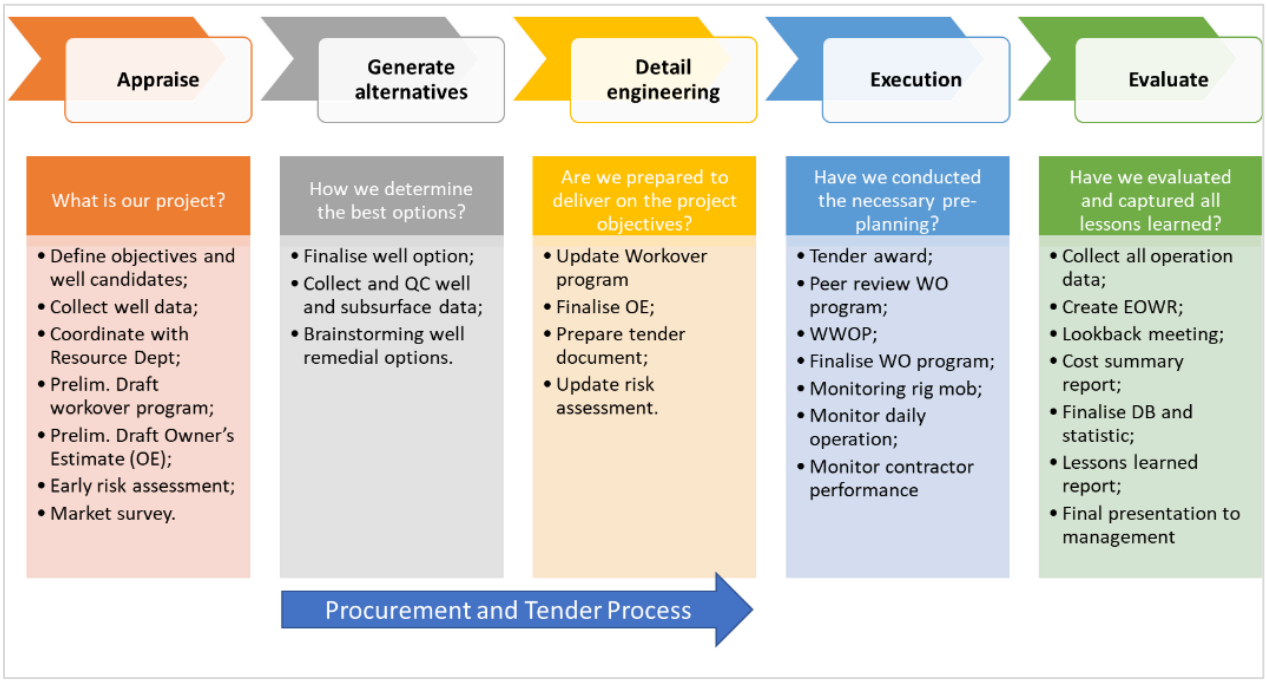


Figure 2. Five phases of project management were applied to design the workover program in Dieng Field.

4.1. Well Candidates

One production well and two injection wells (Figure 3) were selected for the workover for the following reasons:

- There was no sudden decrease in well production, only gradual production decrease over time, indicating wellbore diameter reduction due to scale deposition instead of casing leak or collapse. Therefore, it was deemed suitable for immediate workover without having to do casing leak remedial.
- The decreasing injection capacity of the reinjection well will limit steam production as the condensate and brine could not be disposed and will affect electricity production (Pambudi, et al. 2015). Therefore, it is important to periodically cleanout reinjection well from silica scale. Well clean out for injection well was predicted to have less risk, as there is little to no possibility of steam kick to occur while still impacting the production capacity of the power plant.

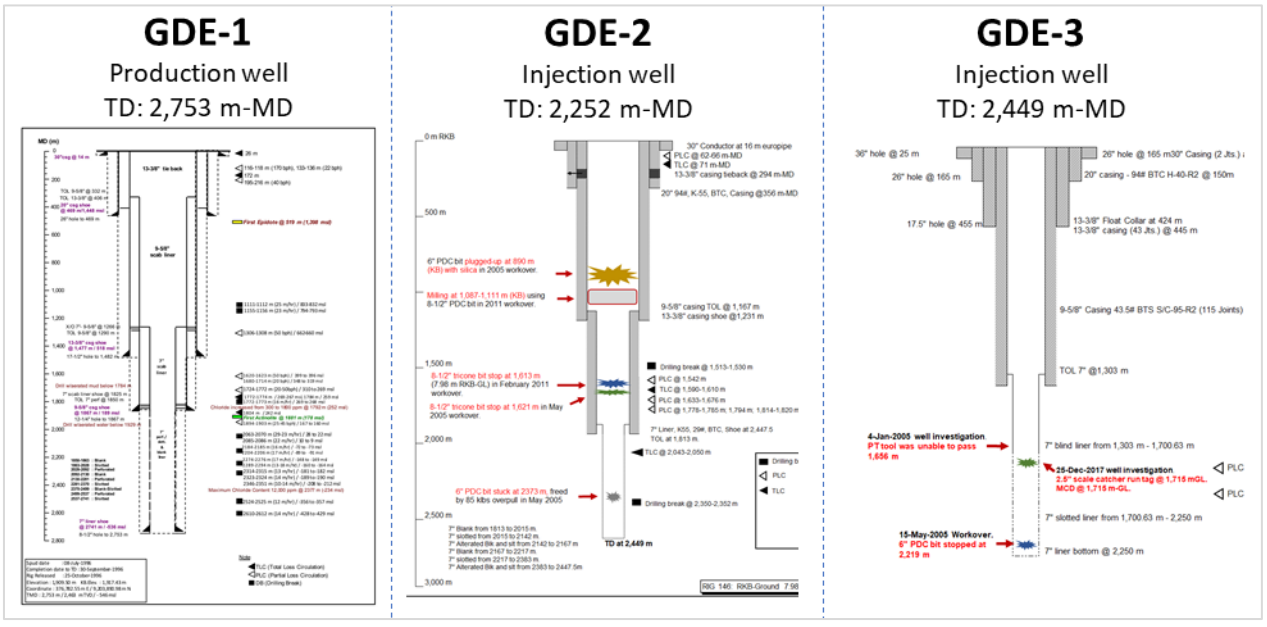


Figure 3. Well schematics of GDE-1, GDE-2, and GDE-3 wells.

Most of the production wells in Dieng Geothermal Field possess wellhead and master valve that are sticking out 2.5 m from the ground. This posed a problem for workover, as the total height of the wellhead, master valve, and Blow Out Preventer (BOP) will be around 6.1m.

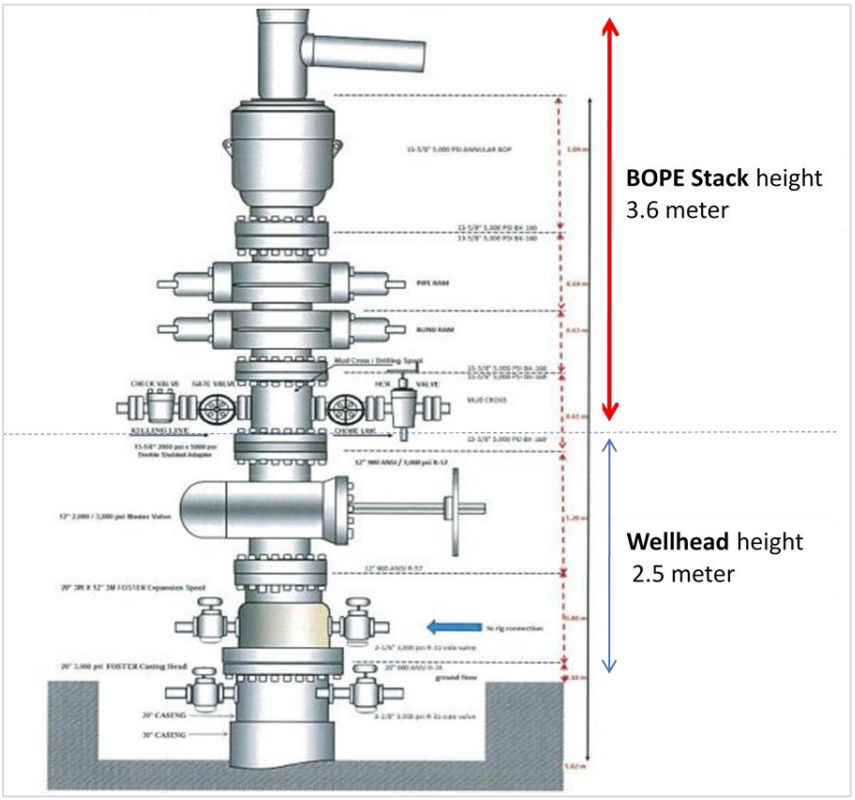


Figure 4. Typical wellhead, master valve, and BOP configuration for workover in Dieng.

4.2. Well Remedial Method

Several wellbore cleanout methods were considered during planning process (Table 1).

Table 1. Well remedial alternatives assessed during planning.

Method	Advantages	Disadvantages
Liquid Jetting Tool (e.g. Roto-Jet™) with coil tubing	Compact, quick to deploy, lower cost compared to using rig, more effective than regular hot water injection (Suryanta, et al. 2015).	Require routine well intervention for an effective result, unable to go through complete scale blockage in the wellbore.
Broaching with wireline unit	Compact, quick to deploy, lower cost compared to using rig.	High risk of tool string stuck, highly dependent on wireline or slickline operator, limited cleanout size (Wilson, Gilliland and Austin 2015)
Mechanical reaming with Drill Pipe (DP) and Drill Bit using rig / HWU	More effective than broaching and liquid jetting, able to breach complete scale deposition, higher overpull capacity (Nugraha, Putra and Mulyadi 2019).	Significantly higher cost, require well pad / site preparation prior to rig up.

It was then decided to use mechanical reaming using drilling rig / HWU after considering the following aspects:

- GDE-1, GDE-2, and GDE-3 were not routinely cleaned out, therefore it was possible that there was complete wellbore blockage that would render broaching and liquid jetting ineffective.
- Past experiences from Dieng and other geothermal field shows that well broaching, well washing, and liquid jetting are not satisfying enough to recover well productivity (Nugraha, Putra and Mulyadi 2019).
- At this time of writing, these three wells are not identified with casing leakage issue. Therefore, there will be no casing tie-back or re-liner operation to be carried on these wells.

5. RIG SELECTION PROCESS

After the cleanout method was selected, the next step was to determine the rig type to carry out the workover operation.

5.1. Rig Selection Criteria

Several criteria to determine the rig type to used are as follow:

- Readily available in the market;
- Short mobilization time to Dieng;
- Low operational cost;

- Does not require or minimum site preparation during workover execution;
- Able to withstand maximum load of wellbore cleanout bottom-hole-assembly (BHA).

Based on the preferred workover method discussed in section 4.2, there were three types of rig considered for the workover:

- 550 HP rig
- 750 HP rig
- 460K Hydraulic Workover Unit (460K HWU)

Assuming the mechanical reaming was about to reach 2,700 m-MD (the total depth of GDE-1, the deepest of the three), the BHA load analysis is described in Table 2:

Table 2. Drill string weight calculation for GDE-1 workover.

BHA Configuration	Activity description	Load on air (lbs)
BHA #1	Cleanout 13-3/8" casing to the top of 9-5/8" liner (@ 332 m-MD) with 10-5/8" bit, 4-3/4" DC, and 3-1/2" drill pipe (including block, hook, top drive, and drag).	33,375
BHA #2	Cleanout 9-5/8" casing to the top of 7" liner (@ 1,266 m-MD) with 8-3/8" bit, 4-3/4" DC, and 3-1/2" drill pipe (including block, hook, top drive, and drag).	74,073
BHA #3	Cleanout 7" casing to the bottom of liner (@ 2,741 m-MD) with 5-1/2" bit, 4-3/4" DC, and 3-1/2" drill pipe (including block, hook, top drive, and drag).	162,785

The maximum load that must be borne by the rig is 162,785 lbs during running BHA#3 to clean 7" liner to the bottom of the liner at 2,741 m-MD. Therefore, any rig or unit that would be used should be able to withstand that load while still provides adequate overpull capacity. One of the challenges faced during the rig selection is the rig or unit availability, as at the time there were only four units available (Table 3). Even from the four rig units assessed, one unit (Rig 550 B) has been in a cold stack condition for years and would not be ready on time.

Table 3. The available rig / workover unit during workover planning.

Comparison	Rig 550 A	Rig 550 B	Rig 750 A	HWU 460
Unit type	Truck Mounted Rig - 550 HP capacity	Truck Mounted Rig - 550 HP capacity	Truck Mounted Rig - 750 HP capacity	Hydraulic Workover Unit
Location	Eretan, Indramayu Est. distance 328 km	Cirebon	Duri, Riau Est. distance 1,859 km	Narogong, Banten Est. distance 444 km
Last operation	2015 (PT Pertamina EP Aset 3)	**COLD STACK**	2017 (Chevron Pacific Indonesia)	2018 (Geo Dipa Energi)
SKPI and SKT EBTKE	Not valid	**COLD STACK**	Valid Migas, SKPI EBTKE on process	Valid EBTKE (SKPI and SKT)
Last inspection	2015	**COLD STACK**	2017	Need clarification
Number of load	55 loads (ready for geothermal work in Dieng)	30 loads (minimum loads)	55 loads (ready for geothermal work in Dieng)	33 loads (ready for geothermal work in Dieng)
Estimated mob and rig-up duration (days)	75	n/a	38	22

Comparison	Rig 550 A	Rig 550 B	Rig 750 A	HWU 460
Operation days per well estimation (from spud to release)	7	n/a	7	11
Estimated operation cost (IDR) per well	1,383,200,000	n/a	1,941,096,108	2,326,398,096
Mob-demob (IDR) total	n/a	n/a	9,500,000,000	3,840,000,000
Moving inter well (IDR)	n/a	n/a	2,904,000,000	2,908,831,920
Mast capacity (lbs) - 80%	240,000	Data not available	400,000	272,000
Substructure capacity (lbs) - 80%	120,000	Data not available	188,000	184,000

Table 3 shows that 460K HWU, 550 HP Rig, and 750 HP rig assessed were adequate to carry out the planned workover, even though 550 HP rig have a relatively limited Margin of Over Pull (MOP) compared to 460K HWU and 750 HP rig. However, another critical factor is the wellhead height condition in Dieng that requires 550 HP and 750 HP rig use pony sub to accommodate wellhead, master valve, and BOP (Figure 5), while substructure of 460K HWU is enough. Other supporting factors were that the HWU requires minimum preparation on the wellpad and does not require the adjacent producing wells to be shut down. These factors outweighed the fact that tripping speed HWU is inferior compared to double-jointed rig such as 750 HP rig.

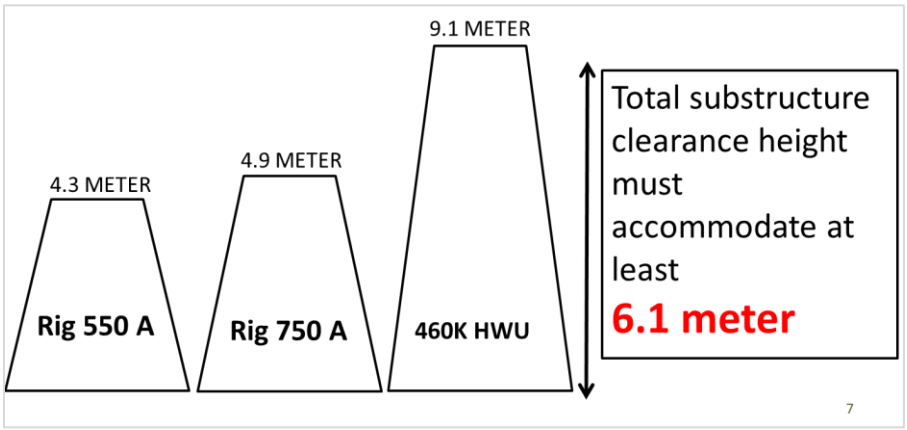


Figure 5. Substructure clearance illustration for 550 HP rig, 750 HP rig, and 460K HWU.

5.2. Rig Contract Type

To keep up with the very tight schedule, the bundled contract procurement process was used. This was meant to simplify and accelerate the procurement process while at the same time keeping the cost from rising too high as often in the case of Integrated Project Management (IPM) contract type (Muhammad, et al. 2019, Isa, et al. 2017).

5.3. Hydraulic Workover Unit (HWU)

HWU (Figure 6), or widely known as snubbing unit, is a hydraulically powered small equipment commonly used for workover. To be used for geothermal workover, HWU requires some modification such as substructure fabrication so that the weight of the workover unit will not rest on the wellhead. The unit was powered by two hydraulic power packs that worked in turn. The challenge of using HWU is that only one power pack can be used at a time, thus if somehow there is a need to change power pack unit, then the operation must cease for at least 1 hour to dismantle and reassemble the hydraulics.

Another consideration in using HWU is the time required in pipe connection process. It is well known that HWU connection process takes longer time compared to conventional rotary rig. This is due to HWU picks up the single pipe from pipe rack, while in conventional rotary rig, 750 HP in example, picks up pipe in double stand (two joints of pipe already connected) from standing pipe racking area.

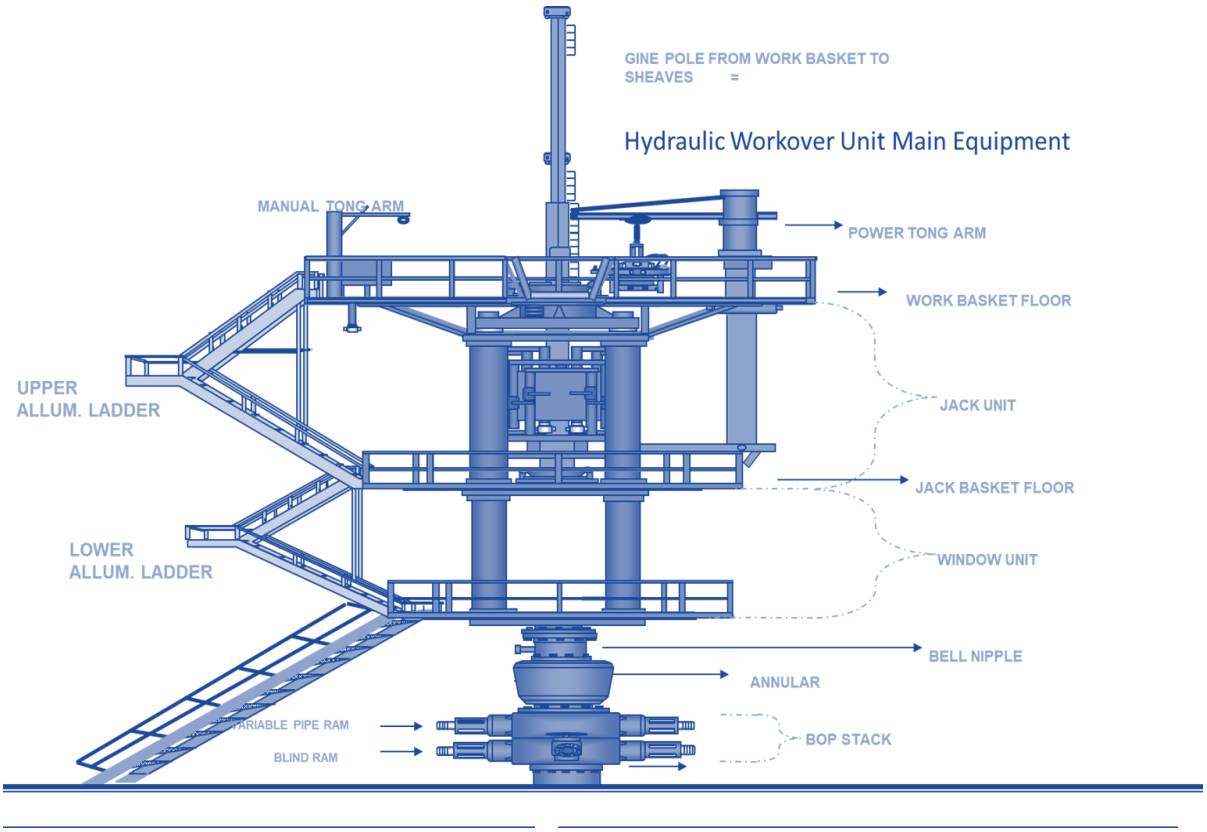


Figure 6. HWU schematic. Note that substructure where HWU sit is not shown. Modified from Nugraha, Putra, & Mulyadi (2019).

6. WORKOVER OPERATION

The workover objectives were to remove mineral scale deposition in the wellbore and to stimulate the reservoir zone by fluid oscillator for production well and acidizing for reinjection wells (Figure 7). The tripping time assumption used for the 460K HWU is 9 joints per hour, or around 90 m/hour. This assumption was based on the similar HWU performance in other geothermal field in Java island, which is around 12 joints per hour with some contingency plan to accommodate hard reaming of the scale. The tricky part of the workover planning phase was that the location of the mineral deposition was not really known, as there were no data below the last observed depth by previous well investigation.

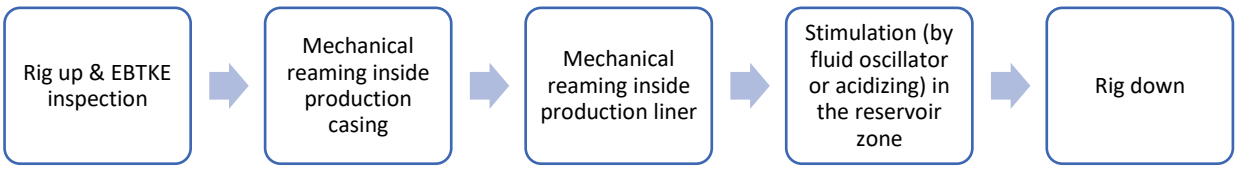


Figure 7. Work sequence in Dieng workover using HWU.

6.1. GDE-1 Workover Performance

GDE-1 is a production well with sulfide scale deposition problem commonly found in production well in Sileri Area. It was expected that the reaming in GDE-1 would take a while due to its high hardness value. Figure 8 shows the days versus depth curve of GDE-1 well. GDE-1 was the first of the three wells, so there was some learning curve to be expected. Even though the tripping time was apparently faster than the planning, but the mechanical reaming of the sulfide scale took a while, ranging for couple of hours in the same depth.

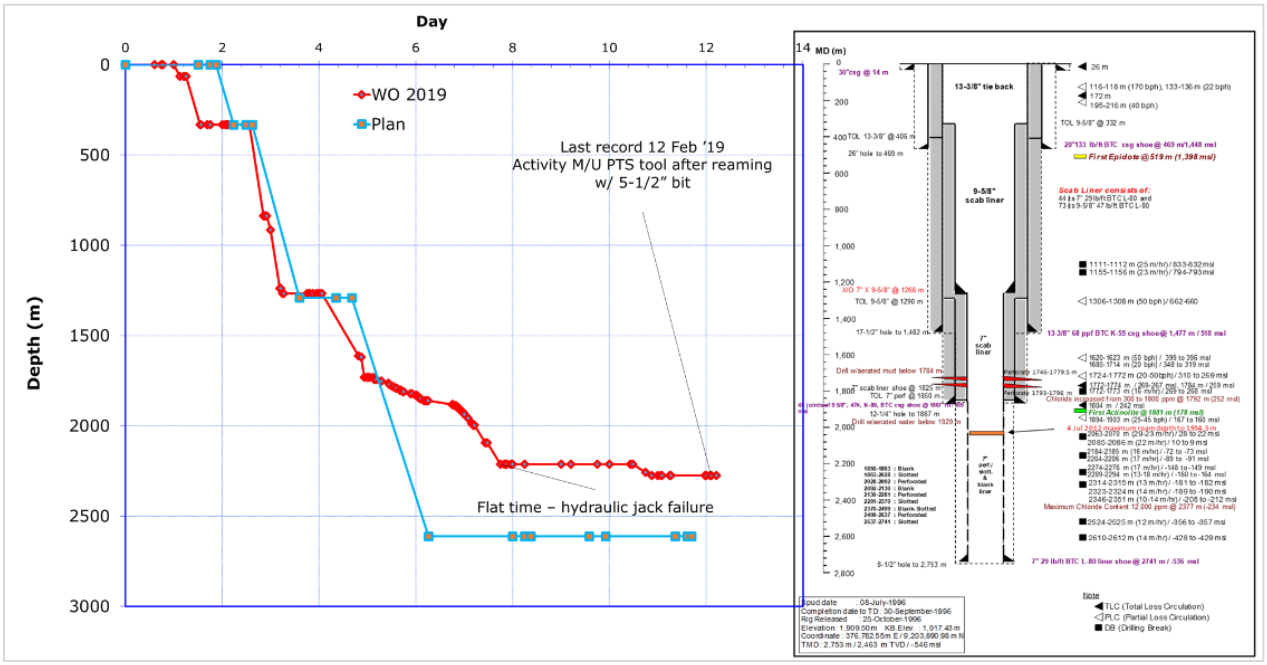


Figure 8. Days vs Depth plan and actual of GDE-1 well.

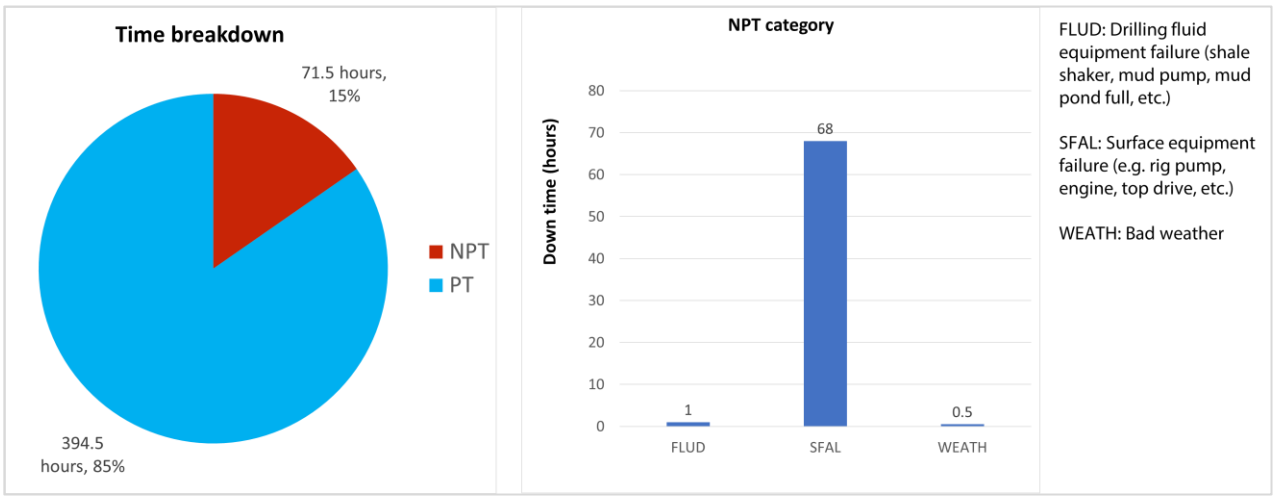


Figure 9. Operation time breakdown.

Figure 9 shows the operation time breakdown. The flat time on the days versus depth curve was caused by hydraulic jack failure, the main hoisting mechanism of the HWU. The reaming at 7" production liner was stopped at 2,200 m-MD, as there is no zone of interest anymore. Note that the original plan is to drill to well total depth (TD).

6.2. GDE-2 Workover Performance

GDE-2 is an injection well with common silica deposition blocking its wellbore. Even though silica from brine is not as hard as sulfide scale especially when wet, but this pose its own problem, as there are possibilities of bit balling during reaming. This is due to soft and squishy nature of silica deposition when wet, and in turn will reduce ROP and might even lead to stuck pipe. This can be mitigated by ensuring proper hole cleaning, regular sweep with hi-vis mud, and limiting the RIH or ROP speed. Figure 10 shows the planning vs actual depth curve, and Figure 11 shows operation breakdown of GDE-2 workover. The power tong was having problem during GDE-2 workover, which in turn decreasing the RIH speed due to slower DP connection time. It was even slower than RIH speed in GDE-1 despite being the second well in the workover campaign (Figure 12).

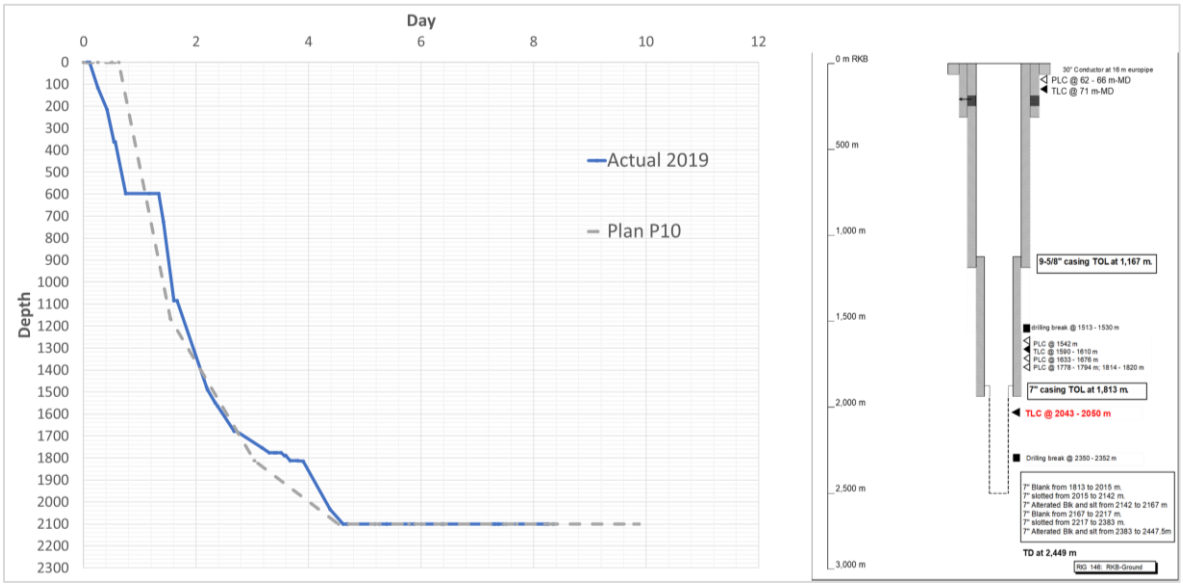


Figure 10. Days vs Depth plan and actual of GDE-2 well.

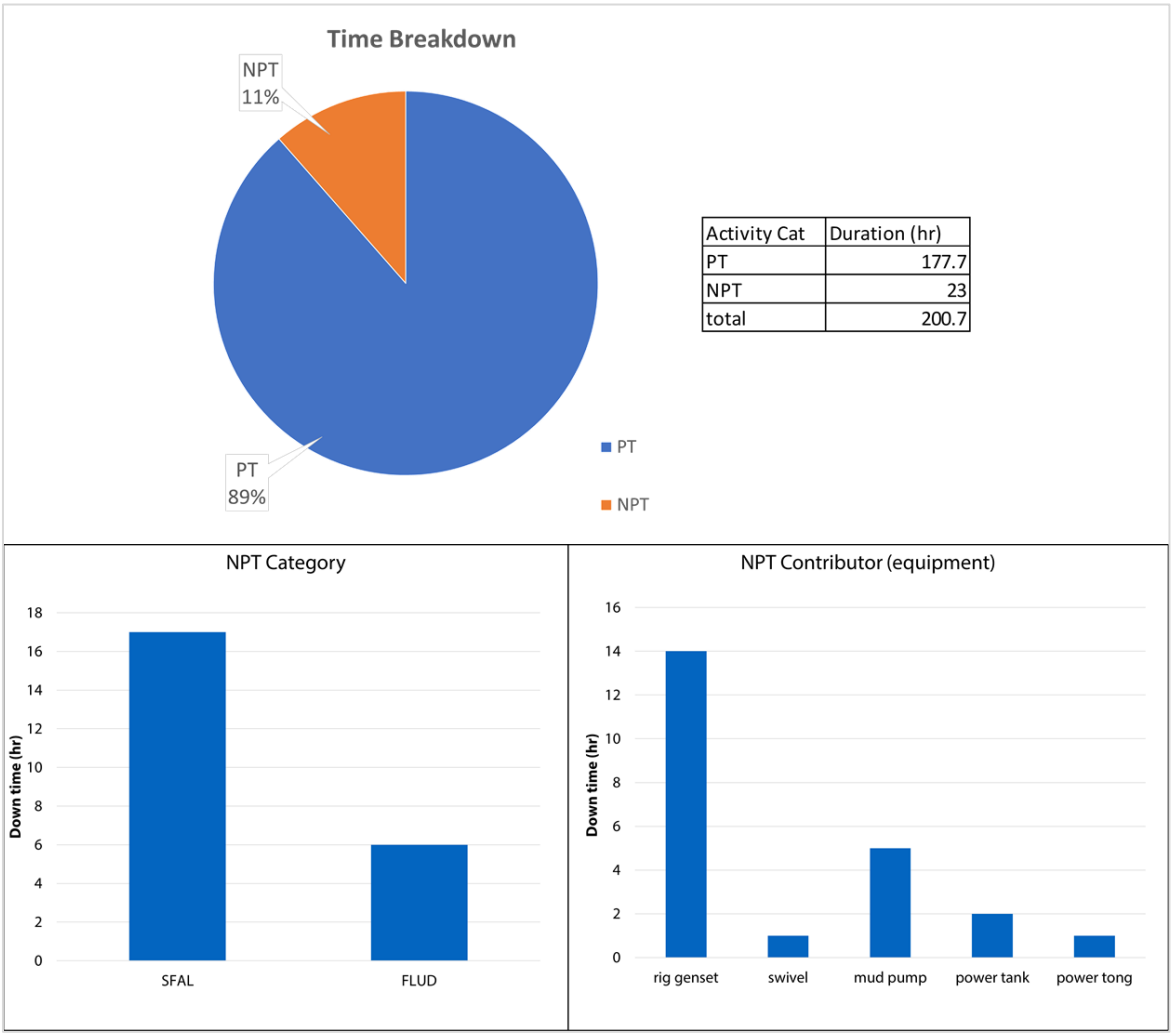


Figure 11. Operation time breakdown of GDE-2 well.

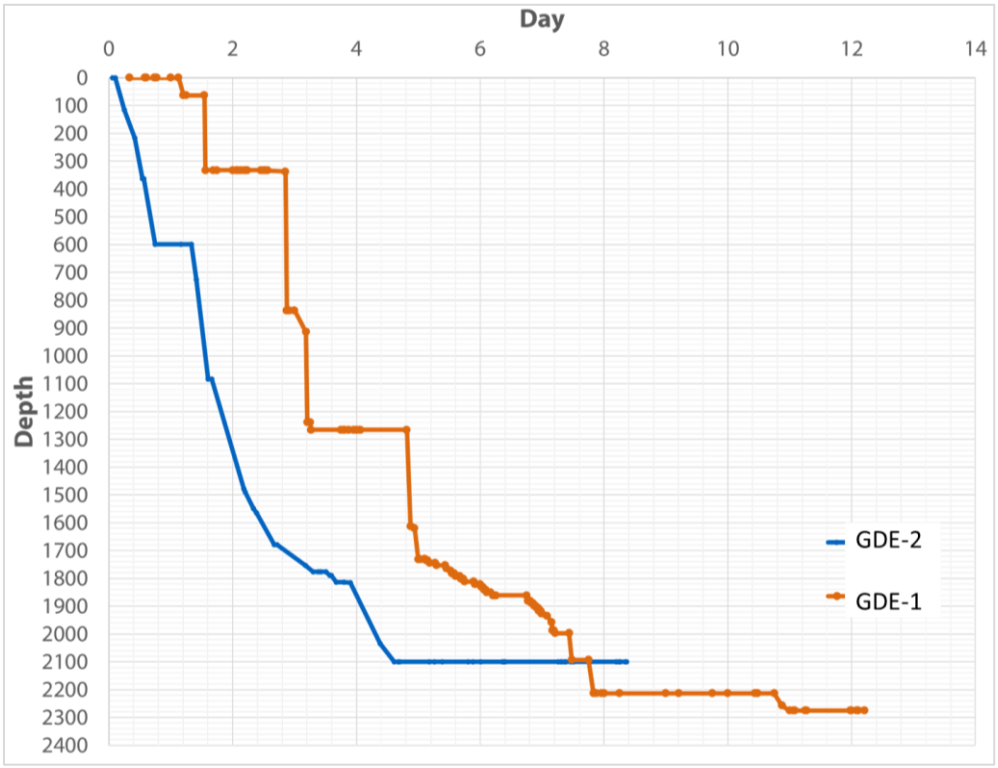


Figure 12. Depth curve actual GDE-1 and GDE-2

7. SUMMARY AND LESSONS LEARNED

There are several highlights from this study:

1. The most common wellbore-related problems in Dieng Geothermal Field are sulfide scaling in production wells, silica scaling in injection well, and casing leak / collapse.
2. The cause of the wellbore problem must be correctly identified to design a fit-for-purpose and cost efficient well remedial program.
3. Mechanical reaming using drill pipe and drill bit is proven to be more effective than other methods (e.g. liquid jetting or broaching) to remove scale inside the wellbore. This conclusion is derived from GDE's experience and also confirmed by similar experiences from other geothermal field operators in Indonesia.
4. For average depth of Dieng wells, 460K Hydraulic Workover Unit (HWU) is able to provide a cost-efficient solution for workover or well remediation that does not require casing milling or casing re-lining. Otherwise, a bigger rig (e.g. 750 HP rig) is required.

The advantages and disadvantages of using 460K HWU are summarized in Table 4.

Table 4. Advantages and disadvantages of using 460K HWU for mechanical reaming geothermal well

Advantages	Disadvantages
Lower cost compared to bigger conventional rig.	Longer make-up and connection time.
Require less site preparation.	Slow RIH speed compared to bigger conventional rig.
Higher chance for operating without requiring adjacent well to be shut down.	Can only run 1 joint DP at a time.
Moderate overpull capacity and pumping rate.	Lower torque.
	Maybe required to fabricate substructure first if the contractor does not have experience working in geothermal workover.

The lessons learned from the workover campaign are as follow:

1. Power pack is the main component of HWU. Even though Workover Unit came with two power packs (one operates, one standby as backup), but only one can operates at a time. When it is time for power pack maintenance, changing power pack takes at least one hour. This down time has to be considered during planning.
2. Lower tripping speed of HWU should carefully be taken into consideration during planning phase; whether it is still more economic to use slower HWU instead of using more expensive but faster 550 HP or 750 HP rig.
3. Proper and regular hole cleaning during mechanical reaming in injection well in Dieng is highly advised, especially when loss circulation is observed.
4. Regular well logging and well investigation will be a great help as workover team can accurately identify the scale thickness and depth, thus making the workover planning more optimum.

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