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Enhancing Geothermal Well Workover Planning Through Data-Driven Performance Evaluation

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ABSTRACT

Workover duration planning holds significant importance in minimizing non-productive time and preventing cost overruns. To achieve the optimal operational duration, it is imperative to acquire data pertaining to previous workover performances. This data encompasses various aspects, including the type and size of scaling, the length of the damaged casing, and the speed of the workover tool. By considering the similarity of well characteristics and challenges encountered, the distribution of this data can substantially enhance the success of workover planning. Regrettably, most often, the distribution of this data has not been adequately documented, resulting in heightened uncertainty and suboptimal workover planning. This, in turn, can adversely affect the accuracy of workover duration projections and overall operating costs.

A preliminary dataset of workover parameter durations is established based on the analysis of workover data encompassing the liquid-dominated field in Central Java. This paper strives to refine workover planning practices by collating a comprehensive workover database encompassing the liquid-dominated field in Central Java and fields exhibiting analogous characteristics. Through this endeavor, a substantial enhancement in the precision of workover planning is anticipated, contributing to heightened operational efficiency and improved cost-effectiveness.

BACKGROUND

The exploitation stage of geothermal wells is frequently marred by declines in production or injection rates. Addressing these challenges becomes imperative to restore and optimize the well's production capacity. One prominent technique utilized to achieve this is through workover interventions. These interventions encompass a spectrum of methods such as wellbore cleanout, milling, acidizing, and casing relining. The specific methodology chosen is determined during the workover planning stage, wherein the well's prevalent issues are meticulously evaluated. Beyond mere issue identification, the workover planning phase involves the formulation of comprehensive workover programs and the strategic allocation of operation durations.

Among the crucial components of workover planning, the meticulous determination of workover duration assumes paramount significance. Effective planning in this domain serves the dual purpose of curtailing non-productive intervals and circumventing cost overruns. To ascertain the optimal operational timeframe, the utilization of historical data derived from prior workover interventions becomes a necessity. This dataset encompasses a myriad of variables, including the nature and magnitude of scaling, the extent of casing damage, and the velocity at which workover tools are employed. Leveraging the congruity between well attributes and encountered challenges, the systematic distribution of this data emerges as a pivotal determinant in augmenting the efficacy of workover planning processes.

LEVERAGING HISTORICAL WORKOVER DATA

The optimal determination of workover duration relies on accurate historical data. The performance of previous workovers serves as a foundation for estimating the duration of new interventions. Factors such as the type and size of scaling, damaged casing length, and workover tool speed significantly influence the time required for successful wellbore interventions. A robust database containing such information is essential for informed decision-making during the planning stage.

Despite the importance of historical data, challenges persist in maintaining well-documented records. In many cases, the distribution of critical data, vital for accurate workover planning, remains incomplete or inconsistent. This lack of comprehensive documentation results in uncertainties that hinder effective planning. An endeavor to systematically document and organize data related to workover operations is thus crucial to ensuring reliable planning outcomes.

DATA SET ANALYSIS

To establish a reliable estimation of workover duration, it is essential to utilize a comprehensive dataset of recent workover operations. Workover data from offset wells with similar geological, reservoir, and operational characteristics are collected. This dataset includes the Daily Workover Report (DWR) from the previous year for six production wells and two injection wells. The use of offset wells helps ensure that the collected data is pertinent to the reservoir conditions under consideration.

The dataset is subject to rigorous criteria for analysis:

a. Daily Workover Reports (DWR) from the most recent year are included.
b. The dataset comprises workover records from six production wells and two injection wells.
c. The workovers across all wells were conducted utilizing rigs with uniform capacity.

The gathered workover data is statistically analyzed, focusing on the following parameters:

a. Rate of Penetration (ROP) during drilling operations.
b. Running in Hole (RIH) and Pulling Out of Hole (POOH) speeds.
c. Parameters pertinent to killing, quenching, and injectivity tests.
d. Wireline logging tool velocities.
e. Mud pump flow rates.

Rate of Penetration (ROP)

The Rate of Penetration (ROP) serves as a fundamental indicator in drilling and milling operations, denoting the speed of the drill bit or milling tool while reaming or milling. This document aims to establish a precise definition of ROP and its classification for workover operations. ROP is expressed in meters per hour (m/hr). In this paper, ROP is categorized into two distinct classes:

- **Hard Reaming.** Hard reaming pertains to reaming activities characterized by an ROP value of ≤ 15 m/hr. Data encompassed by the hard reaming classification are assumed to originate from workover operations that encounter wellbore zones with pronounced obstructions or thick scale deposits.
- **Soft Reaming.** Soft reaming refers to reaming activities with an ROP value exceeding 15 m/hr. Data corresponding to the soft reaming classification are presumed to originate from workover operations targeting wellbore zones with lesser obstruction intensity or thin scale deposits.

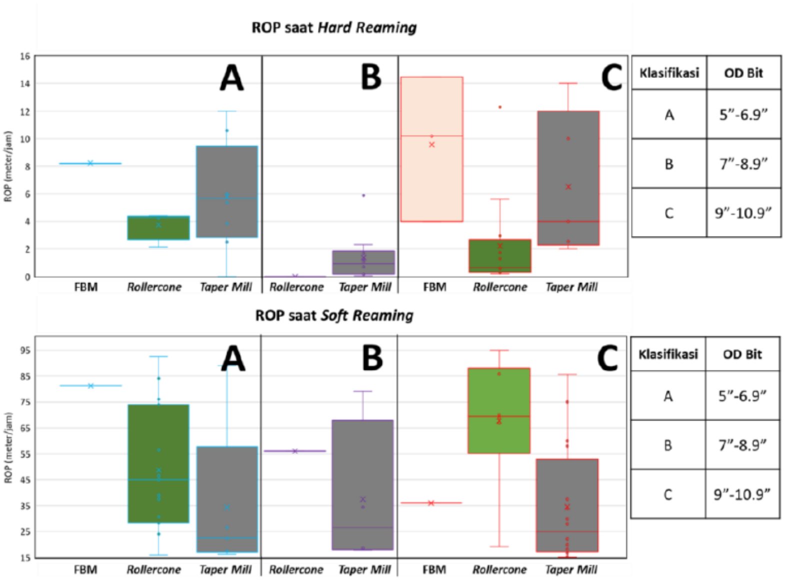


Figure 1. Distribution of ROP for Three Types and Three Categories of Bit Sizes during Soft Reaming and Hard Reaming

Analysis of RIH-M/U and POOH-B/O Speeds

The speed of RIH-M/U and POOH-B/O is generally influenced by several factors:

- Hoisting System Capability: The hoisting system of the rig used determines the force and speed that the drawworks can provide to lower or raise the drillstring. Additionally, the ratio between the fast line and the deadline can impact the speed and maximum load that can be handled during RIH and POOH (Al-azzawi & Al-Duleimi, 2010).
- Wellbore Profile and Inclination: The inclination and profile of the wellbore affect hole cleaning after reaming due to the friction experienced by the drillstring during RIH and POOH. The greater the wellbore inclination, the longer the time required for RIH and POOH operations (Elgibaly, Farhat, Trant, & Kelany, 2016).
- Rig Crew Efficiency in Making-Up and Breaking-Up Connections: The speed and experience of the rig crew in performing making-up and breaking-up connections influence the time required for M/U and B/O operations (Valdez & Sager, 2005; Mahmud & Elmabrouk, 2016).

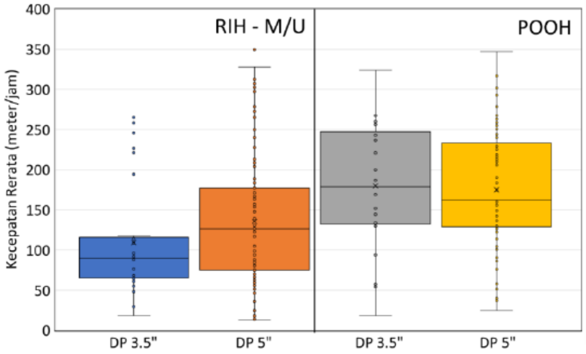


Figure 2. Distribution of RIH-M/U and POOH-B/O Speeds for 3.5" and 5" Drill Pipe Sizes

Analysis of Killing & Quenching and Injectivity Test Durations

The analysis of killing & quenching activities and injectivity tests in this study serves the following objectives:

- Determination of Killing & Quenching and Injectivity Test Durations: The primary aim is to ascertain the durations required for killing & quenching activities and injectivity tests. These assessments provide insights into the timeframes necessary for these interventions to effectively restore well performance.
- Evaluation of Required Mud Pump Flow Rates: Additionally, the analysis seeks to determine the optimal mud pump flow rates required during killing & quenching activities and injectivity tests. By understanding the flow rates essential for successful execution, operational efficiency can be enhanced. This involves an exploration of the statistical distribution of killing & quenching and injectivity test values. The dataset comprises a predominance of killing & quenching activities (52 data points) and injectivity test activities (12 data points).

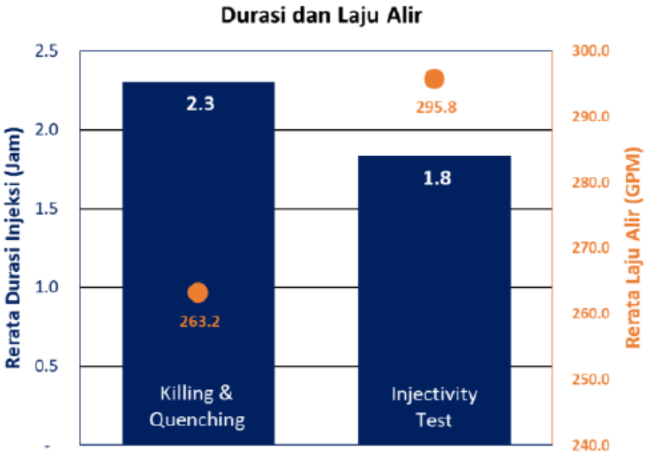


Figure 3. Average Duration and Flow Rate during Killing & Quenching and Injectivity Test

Analysis of Wireline Logging Speeds

The wireline logging speeds analyzed in this study encompass two key operations:

- Running In Hole (RIH) Logging Tool Speed: This refers to the speed at which the logging tool is lowered into the wellbore.
- Pulling Out of Hole (POOH) Logging Tool Speed: This pertains to the speed at which the logging tool is raised to the surface.

Several factors influence the RIH and POOH wireline logging speeds:

- Tool Type: Each logging tool serves distinct purposes and is associated with varying job durations. Downhole Video (DHV) tools are commonly employed for real-time wellbore assessments, while Pressure and Temperature Survey (PTS) tools are utilized to identify feed zones within the well.
- Type of Operation: PTS and DHV logging activities differ significantly in terms of their operational sequences. PTS logging involves three primary sequences (log down, log up, and stationary), wherein log down (RIH) and log up (POOH) speeds can be executed quickly after data collection during stationary periods. In DHV logging, both RIH and POOH activities exhibit relatively slower speeds compared to PTS logging due to concurrent video observation from the camera.

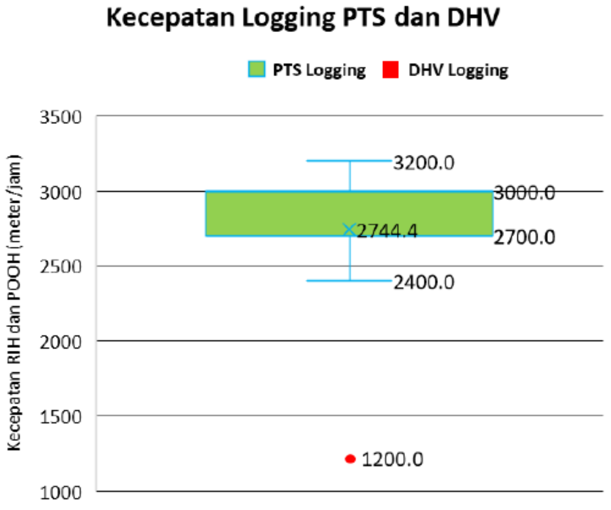


Figure 4. Distribution of Logging Speed Data

Pump Flow Rate Analysis

In this study, pump flow rate is defined as the volume of fluid supplied by the pump per unit of time (in GPM) for Killing & Quenching, Circulating, Acidizing, and Reaming activities. The analysis of pump flow rates in this study aims to:

- Determine the Distribution of Pump Flow Rate Values: The primary objective is to ascertain the distribution of pump flow rate values across Killing & Quenching, Circulating, Acidizing, and Reaming activities. This analysis provides insights into the variability of fluid supply rates during these interventions.
- Determine the Distribution of Pump Pressure Values: Additionally, the study aims to establish the distribution of pump pressure values for Killing & Quenching, Circulating, Acidizing, and Reaming activities. This analysis enables an understanding of pressure variations experienced during these operations.

The pump flow rates analyzed in this study encompass the following activities:

- Killing & Quenching
- Circulating
- Acidizing
- Reaming and Milling

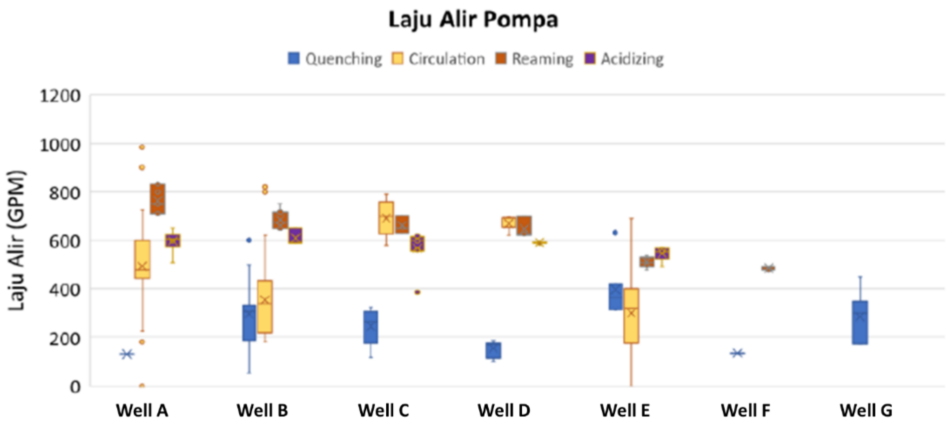


Figure 5. Pump Flow Rate Distribution

PRELIMINARY DATASET OF WORKOVER PARAMETER DURATIONS BASED ON ANALYZED DATASET

In the previous section, the processed and analyzed dataset culminated in a summarized presentation within Table 1, delineating the estimated durations associated with each workover parameter. This comprehensive tabulation stands as a crucial tool for assessing and optimizing workover strategies in geothermal operations. The discussion delves into the significance of this summarized data and its categorization into three distinct classes: optimistic, normal, and conservative. Each scenario represents a different projection of the time required for workover activities. The optimistic scenario suggests a best-case scenario with the shortest estimated duration, while the normal scenario reflects a moderate timeframe that considers typical operational conditions. Conversely, the conservative scenario provides an estimation under less favorable circumstances, accounting for potential challenges that may arise during workover operations.

Table 1. Categorized Workover Parameter Duration

Activity	Scenario			Unit
	Optimistic	Normal	Conservative	
RIH	278.5	157.2	65.5	m/hr
POOH	244	179	133	m/hr
RIH/POOH Wireline	2,770	2,330	2,100	m/hr
ROP of Reaming Operation	11	10.5	7.5	m/hr
Circulation Duration	1.8	4.2	5.8	hour
Acidizing Rate	1.5	1.5	1.5	hr/10m
Run on Stand	0.5	0.5	0.5	hr/stand
Quenching and Killing	0.6	1	6.2	hour
Injection Test	1	1.5	3	hour

Decision-makers can utilize the optimistic estimation as a best-case scenario for rapid interventions, while the conservative estimation aids in identifying potential bottlenecks and challenges that might extend the duration. This classification framework assists in devising contingency plans, optimizing resource allocation, and managing stakeholder expectations, ultimately contributing to improved project management and cost-effectiveness.

APPLICATION OF THE PRELIMINARY DATASET OF WORKOVER PARAMETER DURATIONS

The dataset of workover parameter durations, as introduced in the preceding section, constitutes a valuable resource for estimating the duration of workover operations. This dataset not only provides essential insights into the timeframes associated with various workover activities but also offers a foundation upon which accurate duration projections can be built. The adaptability of this dataset to harmonize with predetermined workover programs is a pivotal factor that enhances the precision and efficiency of operational planning.

Case Study

Well X is a liquid-dominated well that is afflicted by scaling issues. The well is slated for a workover procedure encompassing three stages as outlined below:

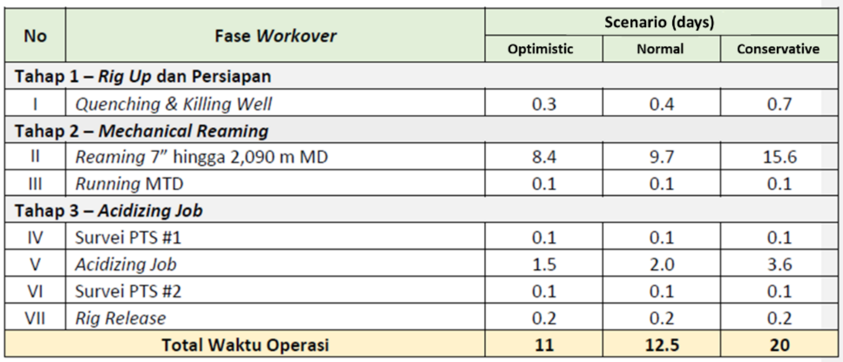
1. Stage 1 – Preparation and Rig Up
   This initial phase involves preparatory activities and rig mobilization to facilitate the subsequent workover operations.

2. Stage 2 – Reaming
   In this phase, reaming operations will be conducted with the aim of reaching the depth of the scale. The reaming process is crucial for addressing the scaling issues and restoring the well's productivity.

3. Stage 3 – Acidizing Operations
   The third stage involves the execution of acidizing procedures. Acidizing is employed to dissolve and remove scale deposits within the wellbore, thereby improving fluid flow and enhancing the well's overall performance.

The workover plan devised for these stages is outlined within the workover program. This program entails a meticulous breakdown of the stages. By aligning the workover data with the specific tasks outlined in the program, predicting the workover duration becomes straightforward. This prediction process employs the data from the plan to generate reliable time estimates for each task.

Table 2. Detail of Workover Duration Estimation of Well X



No	Fase *Workover*	Scenario (days)		
		Optimistic	Normal	Conservative
Tahap 1 – *Rig Up* dan Persiapan				
I	*Quenching & Killing Well*	0.3	0.4	0.7
Tahap 2 – *Mechanical Reaming*				
II	*Reaming* 7" hingga 2,090 m MD	8.4	9.7	15.6
III	*Running* MTD	0.1	0.1	0.1
Tahap 3 – *Acidizing Job*				
IV	Survei PTS #1	0.1	0.1	0.1
V	*Acidizing Job*	1.5	2.0	3.6
VI	Survei PTS #2	0.1	0.1	0.1
VII	*Rig Release*	0.2	0.2	0.2
Total Waktu Operasi		**11**	**12.5**	**20**

Figure 6 illustrates the estimated duration of well X workover activities in a visual representation of time (days) versus depth (m MD) across three workover activity scenarios.

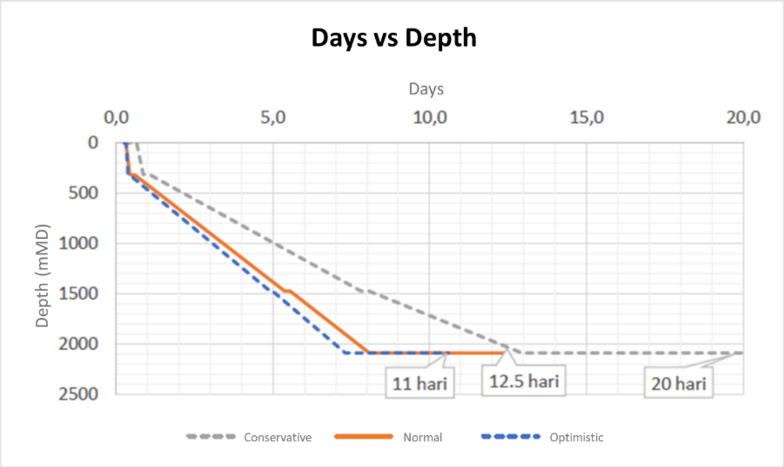


Figure 6. Time Curve of Well Workover Well X for Each Scenario

In conclusion, the estimation of workover operation duration for Well X exemplifies the integration of data-driven insights and strategic planning. By utilizing the workover parameter dataset and tailoring it to the program's specifics, geothermal professionals can enhance their ability to predict and manage workover durations effectively.

PATH FORWARD

To further advance workover practices in the geothermal industry, fostering a culture of data-driven decision-making and continuous improvement is essential. This entails an ongoing commitment to data collection, strategic planning, and the integration of technological advancements. These efforts will result in even more accurate and versatile estimations, benefiting not only individual projects but also contributing to industry-wide best practices.

REFERENCES

Dumrongthai, P., and W.M. Putra. 2015. "SW-CPDEP, Project Management Process for the Right Decision in Geothermal Field Drilling and Completion." *Proceedings World Geothermal Congress 2015.* Melbourne: IGA.

ELC. 2019. *Dieng and Patuha Feasibility Study Update Part B: Dieng.* Technical Report, Milan: Electroconsult.

Harijoko, A., K. Hapsari, Y.T. Wibowo, R.W. Atmaja, and M.I. Nurpratama. 2015. "The Sulfide Minerals Deposit in the Geothermal Pipes of Dieng Geothermal Field, Indonesia." *Proceedings World Geothermal Congress 2015.* Melbourne: IGA.

Harijoko, Agung, Ryusuke Uruma, Haryo Edi Wibowo, Lucas Doni Setiadji, Akira Imai, Kotaro Yonezu, and Koichiro Watanabe. 2016. "Geochronology and magmatic evolution of the Dieng Volcanic Complex, Central Java, Indonesia and their relationship to geothermal resources." *Journal of Volcanology and Geothermal Research* 209-224.

Isa, B., Y. Hartono, C. Jayanto, and M.W. Putra. 2017. "A non IPM Contract for Exploration Drilling in PT Sorik Marapi Geothermal Power." *PROCEEDINGS, The 5th Indonesia International Geothermal Convention and Exhibition (IIGCE) 2017.* Jakarta.

Marza, S., C. Setiawan, and M.N. Chabib. 2013. "Brine Management System for the Northern Injection Wells in Dieng Geothermal Area." *PROCEEDINGS, Indonesia International Geothermal Convention & Exhibition 2013.* Jakarta.

MEMR. 2017. *Indonesia Geothermal Potential.* Jakarta: MEMR: Geothermal Directory.

Muhammad, F., V. Agustino, D. Purba, D.W. Adityatama, R. Husnie, M.F. Umam, and R. Asokawaty. 2019. "Utilization of Multi-Criteria Decision Analysis (MCDA) in Selecting Contract Types for Geothermal Exploration Drilling Project in Indonesia." *PROCEEDINGS, The 7th Indonesia International Geothermal Convention & Exhibition (IIGCE) 2019.* Jakarta.

Ngothai, Y, N. Yanagisawa, A. Pring, P. Rose, B. O'Neill, and J. Brugger. 2010. "Mineral Scaling in Geothermal Fields: A Review." *Australian Geothermal Conference.* Australian Geothermal Conference. 405-209.

Nugraha, R.B., R.B. Putra, and Mulyadi. 2019. "Successful Operation of Clean Out Well With HWU at Wayang Windu." *PROCEEDINGS, 8th ITB International Geothermal Workshop 2019.* Bandung: Institut Teknologi Bandung.

Ohia, N., C. Anayadiegwu, and K. Igwilo. 2014. "A Review of Hydraulic Work Over Unit (HWU) Application for Well Repairs in Nigeria." *Petroleum & Coal* 56 (4): 331. doi:ISSN 1337-7027.

Pambudi, N.A., R. Itoi, R. Yamashiro, B.Y. Alam, L. Tusara, S. Jalilinasrabady, and J. Khasani. 2015. "The behaviour of silica in geothermal brine from Dieng geothermal power plant, Indonesia." *Geothermics* 54: 109-114.

Rose, K.H. 2013. *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition.* Wiley Online Library.

Sirait, P., T.T. Wibowo, and Elfina. 2013. "Work Over Sumur Produksi Lapangan Panas Bumi Dieng (in Indonesian)." *PROCEEDINGS, Indonesia International Geothermal Convention & Exhibition 2013.* Jakarta.

Suryanta, M.R., C. Cease, C.H. Simatupang, D.K. Hadi, and G. Golla. 2015. "Production Improvement Through Scale Removal by Condensate Injection in Darajat Geothermal Field Indonesia." *Proceedings World Geothermal Congress 2015.* Melbourne: IGA.

Utami, W.S., N.R. Herdianita, and R.W. Atmaja. 2014. "The Effect of Temperature and pH on the Formation of Silica Scaling of Dieng Geothermal Field, Central Java, Indonesia." *PROCEEDINGS, Thirty-Ninth Workshop on Geothermal Reservoir Engineering.* Stanford, California.

Wilson, D.R., J. Gilliland, and A. Austin. 2015. "Broaching, an Effective Method of Wireline Intervention for Calcite Scale Removal." *Proceedings World Geothermal Congress 2015.* Melbourne: IGA.

Yoan, M.R., A. Wijaya, and M. Thasril. 2013. "Lesson Learn of Workover Mechanical Program in an Injection Well at Dieng's Geothermal Field." *PROCEEDINGS, Indonesia International Geothermal Convention & Exhibition 2013.* Jakarta.