2013-2015 ACID JOBS PERFORMANCE ANALYSIS ON ESP WELLS IN FIELD-Y, INDONESIA

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ABSTRACT

Matrix acidizing is a method to restore oil and gas production by increasing the near-wellbore permeability by means of dissolving acid-soluble materials. Pertamina Hulu Energi Offshore North West Java (PHE ONWJ) has conducted 8 acid jobs on ESP wells in Field-Y between 2013 and 2015 in an attempt to restore field production. During the acid deployment, the ESP was left in place (downhole). In fact, we also switched on the ESP to unload the spent acid, although spent acid pH value should be higher (more neutral) because the initial acid has already reacted with the formation (soak period = 4 – 6 hours). However, given the general knowledge that acid is corrosive to metals (which make up most of ESP components), it is a big concern for PHE ONWJ if such an acid jobs program without prior ESP-pullout could cause ESP failure post-stimulation. This paper attempts to analyze the effect of acid jobs on ESP components integrity and field production performance. Afterwards, this paper discusses some approaches that PHE ONWJ believes to be applicable to observe any need for periodical acid job in the field.

INTRODUCTION

PHE ONWJ, which is a Production Sharing Contractor of the Government of Indonesia, operates several fields (all offshore of the North West Java Province). In Field-Y alone, 24 of the 25 active wells are produced by means of ESP (Electrical Submersible Pump) lifts. The main producing zone is the carbonate Baturaja formation, so that the acid stimulation fluid selected is 15% HCl. In the first acid job of 2013 on Well-1 which was completed without any Y-tool, the acid was bullheaded into the formation through coiled tubing out the Sliding-Sleeve Door above the pump, while the ESP still remained downhole. Despite the general knowledge that metals corrode in such strong acid, the production rate tripled and the ESP still ran even three years since the acid job.

Using that particular well's high success level as the benchmark for other wells' acid jobs program in the field, seven more wells were acidized in 2015. The same practice of deploying the acid while the ESP still remained downhole was applied. The acid deployment mechanism depended on each well's completion scheme:

1) If the ESP was completed on a standard production tubing-ESP string, the acid was deployed by bullheading mechanism. The acid is injected through coiled tubing and out through a Sliding-Sleeve Door (SSD) located above the ESP. So, the intact 15% HCl makes a physical contact with the inner surfaces of casing, outer surfaces of ESP housing, elastomer, cable, pump stages, etc, before eventually reacting with the formation. Figure 1 shows a summarized list of advantages and disadvantages of using bullheading mechanism from both the completion and acid job performance standpoints.

2) If the ESP was completed with a Y-tool, the acid was deployed using "spot-acid" mechanism, in which coiled tubing was run all the way to the target interval (such as sand face) instead of just above the ESP. Thus, the ESP components were not exposed to such strong-acid environment. Figure 2 shows a summarized list of advantages and disadvantages of using spot-acid mechanism from both the completion and acid job performance standpoints.

EFFECT ON ESP COMPONENTS INTEGRITY

15%-HCl solution is corrosive that it could dissolve ESP metal components somewhere along the fluid production conduit. By the time this evaluation was finished, the number of readily-available relevant reliable papers on the effect of acid job on ESP components integrity was limited. Spagnolo discussed in the paper that bullheading 15% HCl through CT just above the pump to dissolve the carbonate deposits plugged between the pump stages turned out to be successful in cleaning up the pump and allowing the ESP back online [1]. Since the purpose of the acid job was merely to dissolve carbonates inside the pump instead of near wellbore-perforation area, the soaking period was 1 hour only. It turned out that the ESP showed no sign of corrosion because the ESP runlife was maintained after the acid job.

Another field case from Bakar showed that bullheading 15% HCl into sandstone formation caused an increase in decline rate from 17% to 40% post-stimulation and corrosion on the ESP [2]. Such acid job failure should be expected because mud acid (HCl followed by HF) should be used for such clastics (sandstone). In regards to both papers, our own field case (PHE ONWJ) seemed to follow the same conclusion drawn by Spagnolo. Using either bullheading or spot-acid mechanism, our acid job mechanism, which injects the acid while the ESP remains downhole, does not adversely affect the ESP runlife.

In order to confirm the field observation, we carried out an in-house laboratory analysis. To see any sign of corrosion, we soaked the same type of our ESP cable, elastomer, housing, impeller, and shaft into 15% HCl solution for 8, 16, and 24 hours. We measured the corrosion loss rate (in the unit of lb/ft^2). The lab result showed that even after soaking those ESP elements for up to 24 hours, the only component that exceeded the acceptable limit on corrosion loss (e.g. 0.05 lb/ft^2) was the ESP housing (Figure 3). Since our actual soaking period is less than 6 hours, based on the field observation and laboratory analysis, it is valid to state that our current practice of acid job deployment does not damage our ESP. At least, this is our most current conclusion, because we never really know if the corrosion occurs until the “acidized ESP” is pulled out of hole.

ACID JOB PERFORMANCE ANALYSIS

Since the ESP keeps running for months and even years after the stimulation, we proceed to evaluate how successful our acid job has been in the attempt to improve the well deliverability. To answer this question, we consider conducting a thorough data analysis between two parameters: productivity index (PI) and production rate. We decided to analyze the acid job success level using PI instead of production rate because production rate is a function of the choke size, back pressure, operating pump frequency, pump maximum design capability, all of which most likely change time after time; thus, PI is a more objective parameter. The simple formula to calculate PI is:

$$P.I. = \frac{q}{P_e - P_{wf}}$$

Production rate (q) is obtained from well test data; flowing bottom-hole pressure (Pwf) is from sensor data that is available on all of our ESPs; for the average reservoir pressure (Pe), since we do not want to shut-in the well, we will not execute Pressure Build-Up (PBU) test; instead, we use Material Balance approach to estimate Pe value. Given two pairs of available data of cumulative fluid production volume with the corresponding reservoir pressure at each time, we linearly extrapolate these two points to the point of cumulative fluid production volume at which time we execute the acid jobs (Figure 4). Having collected all three points, we can now calculate PI for any given time. We have made sure that PI is calculated from production rate and flowing bottom-hole pressure data taken on the same date. If well test and sensor data did not fall on exactly the same date, we took a closer look to make sure the data fell within the expected value. If this resulted in a PI value which did not make sense, we eliminate this point. In fact, we have also eliminated some data which do not make sense due to sensor failure (e.g. due to tuning or electricity leakage) although the well test and sensor data fell into exactly the same date.

After calculating PI from all available well test and sensor data, we discover that each and every well acidized in Field-Y shows an increase in PI. Since PI is a multiplier, we represent the PI increment in terms of a percentage rather than an arithmetic addition. The important finding is that PI increment averages at 200% of the latest PI value just before the acid job. This means that the PI value just after the job is, on average, three times the PI value just before the job.

From the ESP completion standpoint, two wells with the first and second highest PI increment were completed on a standard production tubing-ESP string, with no Y-tool. This is interesting because it was initially thought that bullheading mechanism was not effective because we could not control the amount of acid to the specific targets. Also, such a mechanism exposed the ESP components to the strong acid which might cause corrosion. However, since the number of wells acidized was small, a firm conclusion on the effect of ESP completion (whether standard or Y-tool ESP string) on the acid job success rate could not be drawn. As more wells in Field-Y are acidized, a firmer conclusion on the effect of ESP completion type on the acid job success level will be more accurately drawn. It is also important to note that we are not analyzing the effect of both mechanisms on the oil gain, especially in horizontal wells.

Meanwhile, it is noted that one particular well (Well-1) shows a PI increment of 1400%, and we exclude this well data from our calculation to obtain the field-wide average of PI increment. This is mainly because when we look at the PI value of all the acidized wells, Well-1 PI value is such an outlier: while all remaining well's PI value falls below 5 bfpd/psi, Well-1 PI value goes well above 10 bfpd/psi.

ANALYSIS OF PERIODIC ACID JOB TIMING

Since the acid job program is proven to successfully increase PI in Field-Y, the next question is when to re-acidize these wells again. In other words, we were creating some approaches which could help us analyze if the field actually required a periodic acid job and after how long the following acid job should commence after the previous one. Thus, we came up with two approaches:

1) Using PI cutoff from "PI average before acid"

In this approach, we take the average of all available PI values before acid. Then, we take a trendline out of the declining PI after acid. Since there is currently no theoretical study on PI decline, whether to use linear or something else, we simply create linear and exponential trendlines. By extrapolating the trendline of PI decline, at some point in time, the trendline will intersect with the PI cutoff value (Figure 5). This intersection point represents the time by which we should re-acidize the corresponding well.

2) Using PI cutoff from "25% PI increment"

Similar to the first approach, this particular method involves taking both linear and exponential trendlines of the declining PI values after acid. However, the PI cutoff in this approach is slightly higher, because the cutoff value is calculated by adding the latest PI value before acid plus 25% of the total PI increase (Figure 6). By extrapolating the PI decline trendlines, we must obtain at least an intersection point again with the PI cutoff.

Recalling that we take both linear and exponential trendlines from each well's PI decline after the acid job, each well will show two intersection points: the lower value being the intersection with the linear trendline, while the upper being the exponential. Figure 7 summarizes the findings. The numbers presented in the second and third column represents the number in months that the following acid job should commence. Of the acidized wells which have adequate and reliable PI data, one well shows an outlying number of months again (Well-1); so, we exclude this well when taking the average of months. It turned out that this is the same exact well which PI value is unusually higher than all remaining wells.

Since we would like to know this "number" for all wells throughout the field in general, even for other wells which are yet to be acidized, we take an average of the lower and upper limit for each approach. We obtain a conclusion that based on the currently available data, such a typical ESP well in Field-Y should be acidized every 10 to 16 months. This number is particularly useful for us to be able to have a more guided idea about when the next acid job should commence.

CONCLUSION

PHE ONWJ current practices of acid job show no adverse effect on ESP components integrity to date. In fact, acid jobs are proven to be successful in Field-Y, with an average PI increment of 200% of the PI value just before the acid job. As far as the ESP completion is concerned, there is really no clear correlation between the use of Y-tool and the acid job success level, in terms of PI. Lastly, a rule of thumb for periodic acid jobs in Field-Y is obtained using currently available data, and the analysis suggests that ESP wells in Field-Y should be acidized every 10 to 16 months.

[1] S. Spagnolo, S. Pilone, L, Mauri, and G. Diciaula, Eni spa, 2014. Stimulation Through ESP: An Innovative Solution to Improve Production. IPTC-18014-MS presented at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia, 10 – 12 December 2014.

[2] H. B. Bakar, I. C. XianLung, M. Z. B. M Nadzri, M. A. B. M Zaini , J. B. Jaafar, Petronas, M. Hirman, Setegap Ventures Petroleum, H. A. Nasr-El-Din, SPE, Texas A&M University, C. A. de Wol, SPE, AkzoNobel, 2013. SPE 166335 presented at the Annual SPE Conference and Exhibition held in New Orleans, Louisiana, USA, 30 September – 2 October 2013.

Figure 1 – Bullheading Advantages and Disadvantages

Advantages

- **Completion:**
  - ✓Standard ESP string (no Y-tool expense)
  - ✓Simple BHA (less tendency for fishing job, more accurately applied by the field crew, less installation and material costs)
  - ✓No special constraint on the production tubing-casing annulus size
- **Acid job:**
  - ✓Minimized downtime because of higher injection rate (2-3 bpm) compared to Spot-Acid through CT (1-1.5 bpm)

Disadvantages

- **Completion:**
  - ✓Not allowing well intervention to sand face
- **Acid job:**
  - ✓Non-selective target
  - ✓Uneven treatment across long interval (possibly only high perm paths or fracks)
  - ✓Exposing the non-targeted tubular and ESP components to possible corrosion

Figure 2 – Spot-Acid Advantages and Disadvantages

Advantages

- **Completion:**
  - ✓Allowing well intervention to sand face
- **Acid job:**
  - ✓Selective target (more controlled/ more amount of injected acid on target spot)
  - ✓Minimizing the risk of exposing upper tubular and ESP components to corrosion

Disadvantages

- **Completion:**
  - ✓Y-tool investment cost
  - ✓Y-tool limited tubing-casing annulus clearance (may limit ESP size or ESP placement inside the casing/ liner
- **Acid job:)**
  - ✓Longer downtime which leads to more loss of production

Figure 3 – Laboratory Analysis for ESP Corrosion Loss in 15%-HCl Solution

ESP Component	Corrosion Loss (lb/ft^2)		
	8 hr	16 hr	24 hr
Cable	.0018	.004627	.0125
Elastomer	0	0	0
Housing	.0240	.0253	.177
Impeller	.0136	.0154	.0486
Shaft	.0012	.00217	.0122

Figure 4 – Estimating Current Pr Using Material Balance

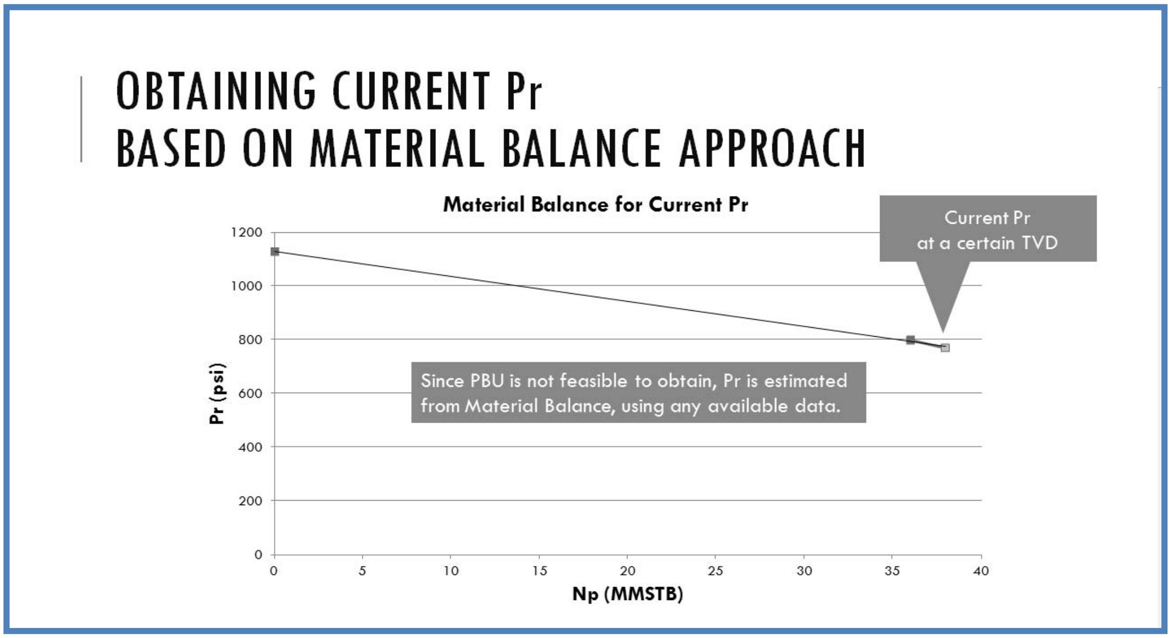

Figure 5 – PI Cutoff From "PI Average Before Acid"

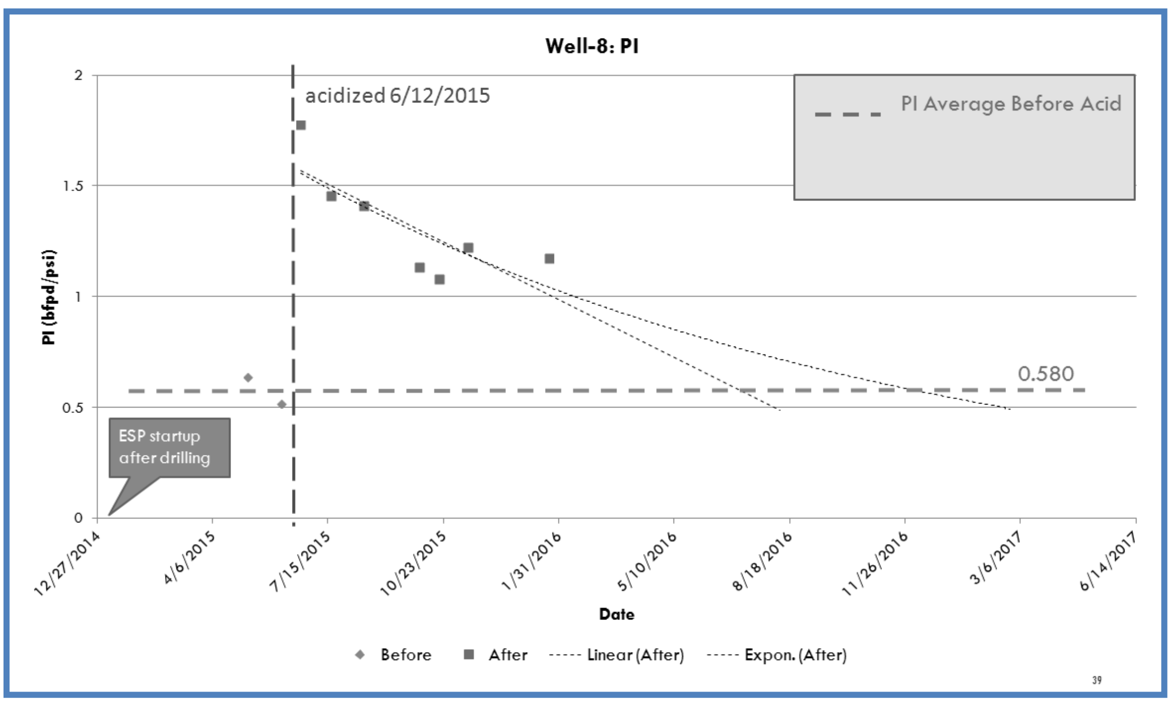

Figure 6 – PI Cutoff From “25% PI Increment”

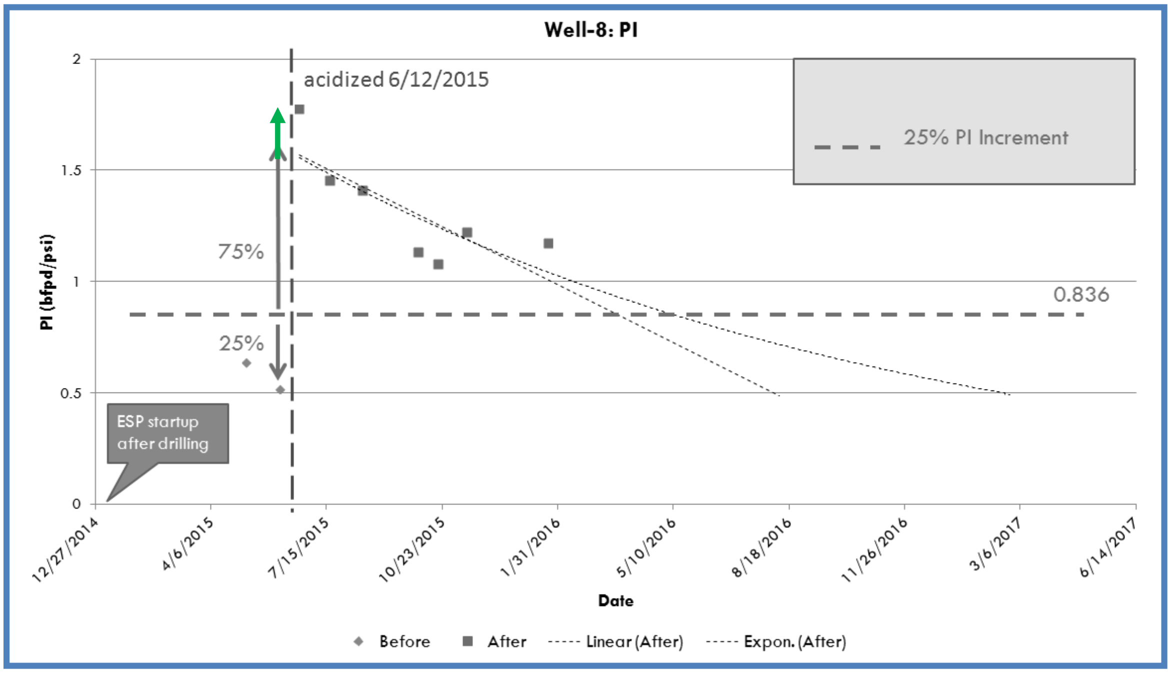

Figure 7 – Conclusion Table for Period Acid Job in Field-Y

PER-WELL PERIODIC ACID JOB (MONTHS)

Well	Using PI Cutoff: 1st Approach (PI before acid)	Using PI Cutoff: 2nd Approach (25% PI Increment)
Well-1	92	74
Well-3	9	8
Well-5	9 – 12	7 – 9
Well-7	20 – 24	16 – 17
Well-8	13 – 18	9 – 11
Average (months), ***excluding Well-1***	12.75 - 15.75	10 - 11.25

*No PI data for Well-2 and Well-6 due to sensor failure
**No PI data for Well-4 due to not enough to show PI decline due to ESP failure
***If Well-1 is included, the average is 28.6-31 and 22.8-23.8 months using the 1st and 2nd approach respectively