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Anti Paraffin Agent Stimulation to Increase Injection Rate in NP-082 Injection Well, Lirik Field Pertamina EP

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Abstract. Water management is crucial in the oil production planning and development. Supported with adequate production facilities, injection well is required to reinject produced water from production well after appropriate treatment in surface. Without adequate injection well, number of wells and ability of wells to inject produced water, oil production can be a separate problem. The ability of an injection well to inject produced water is important to note, proven with its sufficient injection rate in particular wellhead pressure. Unfortunately, some injection wells may have any borehole problems that reduce its ability to inject produced water. Paraffin may occurs, and block the flow of injected water in that well. This paper aims to deliver an effective solution on how injection rate can increase in the parffinic injection well using anti-paraffin agent stimulation. In Lirik Field, anti paraffin agent stimulation is applied in NP-082 injection well. 958 barrels water per day (bwpd) is the initial injection rate with 150 psi of wellhead pressure of this well before stimulation. Due to its conversion from production well into injection well historically, oil slug is estimated to occur in perforation zone of this well. Moreover, paraffinic oil is produced in North Pulai structure. Anti paraffin agent injection is then applied to dissolve the paraffin in the perforation area. Anti paraffin agent, an additive, is able to break the paraffin contaminant in wellbore. Operational procedure is applied, injection pressure may not exceed the fracturing pressure on this well. Pre-treatment IRT is applied to compare with IRT after treatment. Increasing IRT before and after the treatment indicates its success. Post-job IRT is applied with various wellhead pressure and rate. Before treatment, injection rate varies from 0.5 – 0.75 bpm at 290 to 350 psi of wellhead pressure. With similar wellhead pressure, injection rate increases up to 1.75 bpm. Even in maximum pressure of 500 psi, injection rate could reachs 3.5 bpm. It indicates the stimulation in NP-082 well succeed to increase injection rate. This well is now operated at 280 psi of wellhead pressure with 1500 – 1600 bwpd of injection rate. Anti paraffin agent stimulation becomes effective way with paraffinic problem in injection well.

Keyword: anti paraffin agent, injection, paraffin, stimulation

1 Introduction

Lirik is an active production field in Riau Province under Production Sharing Contract (PSC) between Pertamina EP and SKK Migas. Located in Indragiri Hulu and Pelalawan regency of its production and injection wells, Lirik Field has been operated since 1936, along before Indonesian independence day. The terminal facility is located in Buatan, Siak, to lift crude oil into Refinery Unit (RU) II Sei Pakning using barges. With total of 422 km^2 working area, Lirik Field produces 1684 bopd currently with ±141,000 bwpd produced water. North Pulai, South Pulai, Ukui, Andan, Lirik, Sago, and Molek are active structures that contibute oil production in Lirik Field, in Japura Block. With total of 113 active production wells and 52 injection wells, Lirik Field has its own operational challenge. Electrice Submersible Pump (ESP) is used dominantly as artificial lift in Lirik production wells, about 75% of total well, while 25% using Sucker Rod Pump (SRP).

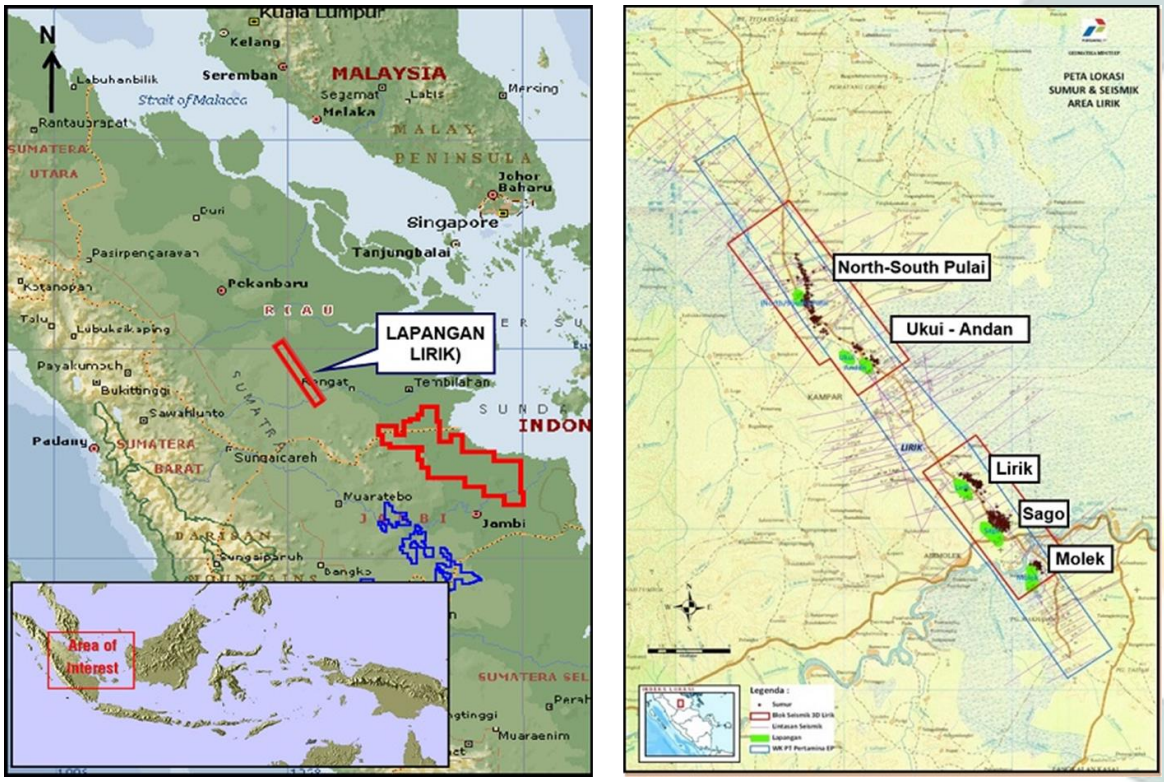

Figure 1. Lirik Field Working Area

As mature field with 50% Recovery Factor and 98% water cut averagely, Lirik Field has its own special challenge in water management, in that produced water with crude oil from reservoir is reinjected into reservoir. Surface and subsurface reliability is a must to inject produced water optimally. Surface reliability relates to production facilities, such as water tank and injection pump in gathering station. Subsurface reliability relates to injection wells, particularly their capacities with sufficient number of wells and well ability in injecting produced water in sufficient amount. Optimization program in Lirik

Field aims to increase oil production, but the increasing of water production becomes its own issue. Moreover, optimization is oftentimes hampered with injection capacity, both surface and subsurface.

Ropening of some suspended wells into injection wells in Lirik Field becomes another way to increase injection capacity. The reopened wells varies from originally as injection wells to conversion wells (convert production wells become injection well). Unfortunately, some reopened wells don't result significant amount of injection capacity. NP-082 is a reopened well as injection well and contributes 958 bwpd of injection rate after reopening with 150 psi of wellhead pressure. The initial injection index is 2.6 bwpd/psi as seen in Table 1.

Table 1. NP-082 Initial Injectivity Index

Well name	NP-082	-
Structure	North Pulai	-
Top perforation	1793	ft
Bottom perforation	1835	ft
Middle perforation	1814	ft
Wellhead pressure, Pwh	150	psi
Reservoir pressure, Pr	562	psi
Bottomhole pressure, Pwf	937	psi
Injection rate, q	958	bwpd
Injectivity index	2.6	bwpd/psi

After reopening, stimulation is applied in NP-082 well. Anti-paraffin agent is injected to dissolve paraffinic acumulation in borehole as NP-082 well is historically operated as production well. Laboratory study using water test analysis and imbibition test is applied to calculate Scale Index (SI) in North Pulai structure and to examine anti-paraffin agent performance to crude oil sample respectively.

2 Methodology

2.1 Well Profile

NP-082 is an injection well in North Pulai structure in Lirik Field that is injected with anti paraffin agent to increase water injection rate. There are some general informations of this NP-082 well:

- reopened as injection well since February 14, 2020
- previously as production well and suspended since February 2014
- injected in MLS layer with 3 interval: 1793 – 1803 ft, 1809 – 1817 ft, and 1829 – 1835 ft
- injection system is connected in Gathering Station VII in Lirik Field.

As seen in Figure 2, 7" cup packer is used in NP-082 to insulate injection zone with surface due to its shallow depth. 2-7/8" tubing is used to injected produced water to all intervals in MLS layer. As conversion well from production to injection, the tendency of paraffin accumulation in NP-082 borehole quite significant. It relates to crude oil characteristic in North Pulai structure, which is HPPO (high pour point oil). Commonly, paraffin deposit is formed in production or injection line, flowline, and perforation

zone. It caused by some factors, such as flowrate, temperature difference, and coiling rate (Bott and Gudmundsonn, 1977). In laminar flow, paraffin accumulation increases with flowrate.

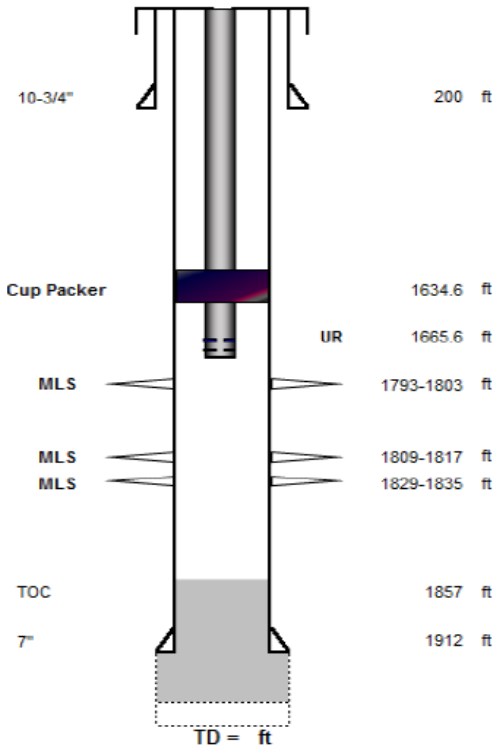

Figure 2. NP-082 Well Profile

Paraffin accumulation can also formed in low flowrate due to long residence time in an area with decreasing temperature (cooling rate) and causes temperature difference between *cloud point* and temperature in a particular area (Rif'ati, 2016).

2.2 Anti Paraffin Agent

Anti paraffin agent is a mixture of chemical wash stimulation from following compound:

- KCL (Pottasium Chloride)
- PA-EH1 (Non-Emulsifying Surfactant)
- PA-MU1 (Mutual Solvent)
- HPS-105 (Multi Functional Surfactant)
- PA-SI (Scale Inhibitor)
- PA-CH23 (Clay Stabilizer)

Mixing process of those compounds is directly operated in well location before injection. Pumping is operated with particular rate by considering injection pressure not more than fracture pressure or casing integrity in well. Pre-treatment injectivity rate (IRT) is also operated to be compared with post-injection rate test in order to evaluate anti paraffin agent injection into NP-082 well.

2.3 Laboratory Study

In order to evaluate injection water characteristic and anti paraffin agent solubility, laboratory study is implemented, both are Water Test Analysis and Imbibition Test.

2.3.1. Water Test Analysis

This test aims to determine Scale Index (SI) of formation water that is produced in North Pulai structure. It is crucial to evaluate the tendency to form scale in bottomhole. Formation water sample is taken in injection manifold in North Pulau structure. From water test analysis, using Stiff Method and Skillman Method, there is a tendency to form $CaCO_3$ in bottomhole, while $CaSO_4$ has no tendency to form.

Stiff Method : SI $CaCO_3$ is 1.9424 (SI>0), $CaCO_3$ scale has a tendency to form

Skillman Method : solubility calculation (S) SO_4^{2-} is 34.6172 meq/l with actual concentration (S') of SO_4^{2-} is 0.7083 meq/l (S>S'), $CaSO_4$ scale has no tendency to form.

Figure 3. Formation Water Sample in North Pulai Structure

2.3.1. Imbibition Test

The Imbibition test is implemented to examine anti paraffin agent. PA-HPS105 is tested in laboratory as the dominant compound to form anti paraffin agent. Test is applied to crude oil sample from North Pulai structure. These are the general characteristics of crude oil in North Pulai:

Color	:	dark black
Specific gravity (SG) @25^{o}C	:	0.8692 gr/cc
^{o}API	:	31.32
Pour point	:	42^{o}C
Viscosity	:	19.48 cP @50^{o}C; 15.63 cP @55^{o}C; 12.05 cP @60^{o}C

Anti paraffin agent PA-HPS105 is soluble and able to overcome paraffin by recovering it with crude oil characteristic as it is in North Pulai structure. Increasing concentration of PA-HPS105 increases crude oil recovery, indicates PA-HPS105 as main compound of anti paraffin agent is effective to dissolve paraffin accumulation in bottomhole as seen in Table 2 and Figure 4.

Table 2. PA-HPS105 Tendency to Recover Crude Oil Sample

PA-HPS105 Concentration	Crude Oil Recovery
0%	42.68%
5%	76.20%
10%	78.69%
15%	80.26%

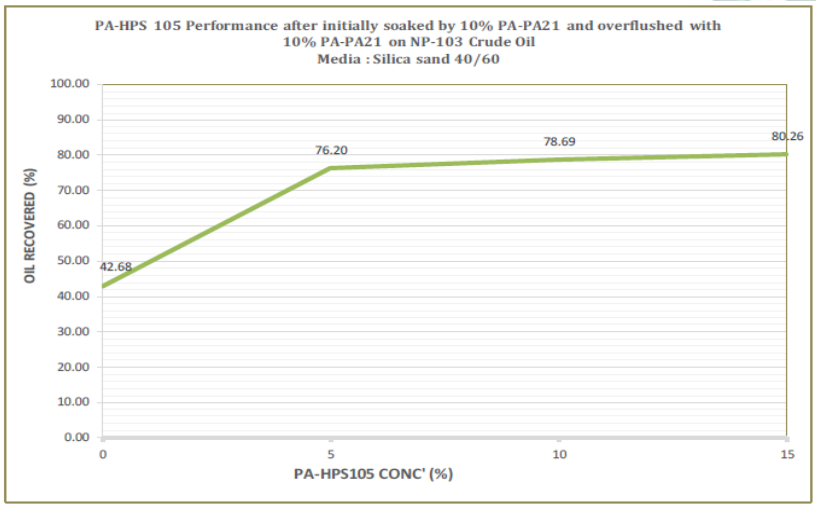

Figure 4. PA-HPS105 Tendency to Recover Crude Oil Sample

From Table 2 and Figure 4, injection of anti paraffin agent has tendency to recover crude oil sample with increasing concentration. With 0% concentration of PA-HPS105 or no anti paraffin agent is injected, the recovery of crude oil is only 42.68%. Increased concentration of PA-HPS105 to 5% increases crude oil

recovery to 76.2%, and continously increases to 78.69% and 80.26% recovery with 10% and 15% respectively. Based in this laboratory result, anti paraffin agent is then applied operationally in NP-082 well to overcome paraffin problem. Hypothetically, it will dissolve paraffin in bottomhole that block water injection, and produced water will then injected more efficiently with increased rate and decreased pressure.

2.4 Operational Procedure

To inject anti paraffin agent into NP-082 well, there are some main procedures: IRT pre-job, mixing, anti paraffin agent injection, IRT post-job. All treatments are executed without using rig (rigless). It is due to easiness of this operation and concequently more effective to operate.

2.4.1. IRT Pre-Job

IRT or injection rate test is implemented using injection unit to get initial injection rate in particular pressure. It indicates initial well capability to inject water into reservoir which is then compared with IRT after stimulation (post-job). There area the result of IRT Pre-Job with various injection pressure:

Table 3. IRT Pra-Job of NP-082

Injection Pressure	Injection Rate
290 psi	0.50 bpm
350 psi	0.75 bpm
405 psi	1.00 bpm
445 psi	1.25 bpm
460 psi	1.50 bpm
490 psi	1.75 bpm
505 psi	2.00 bpm
510 psi	2.25 bpm
515 psi	2.50 bpm

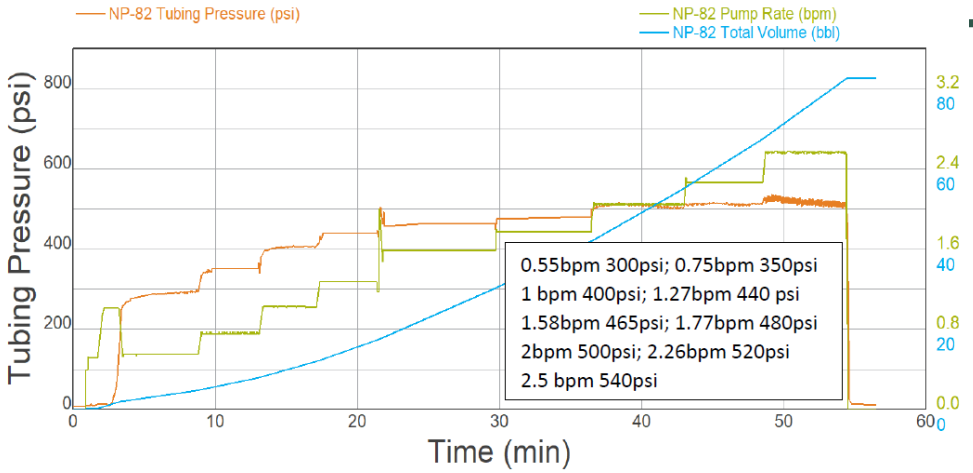

Figure 5. IRT Pra-Job of NP-082

2.4.2. Mixing

Some compounds or additives are mixed to produce anti paraffin agent directly before injection process near NP-082 well. The mixture 37 bbls or 1,568 gallons with various concentration and volume as seen in Table 4.

Table 4. Anti Paraffin Agent Mixture

Additive		Concentration		PER JOB			
FRESH WATER		713.00	GPT	1118	Gal	26.6	BBL
5% KCL	POTASSIUM CHLORIDE	417.00	PPTG	660	Lbs	6.0	SCKS
PA-EH1	Non Emulsifying Surfactant	10.00	GPT	16	Gal	0.3	DRMS
PA-MU1	MUTUAL SOLVENT	10.00	GPT	16	Gal	0.3	DRMS
PA-PA21	PARRAFIN SOLVENT	100.00	GPT	165	Gal	3.0	DRMS
PA-CH23	CLAY STABILIZER	30.00	GPT	55	Gal	1.0	DRMS
HPS105	MULTI FUNCTIONAL SURFACTANT	50.00	GPT	78	Gal	1.4	DRMS
PA-SI	SCALE INHIBITOR	50.00	GPT	78	Gal	1.4	DRMS

2.4.3. Anti Paraffin Agent Injection, Displacement, and Soaking

After anti paraffin agent compounds are mixed, injection is executed hand in hand, started with anti paraffin agent injection and followed with displacement fluid injection. Total of 37 bbls anti paraffin agent and 15 bbls displacement fluid are injected into NP-082 well. Annulus pressure is monitored 300 psi maximum due to its fracture gradient pressure, which is 0.6 psi/ft. Injection process is executed in 2

bpm injection rate constantly. After anti paraffin agent and displacement injection, well is soaked for 3 hours before executing post-job injection rate test (IRT).

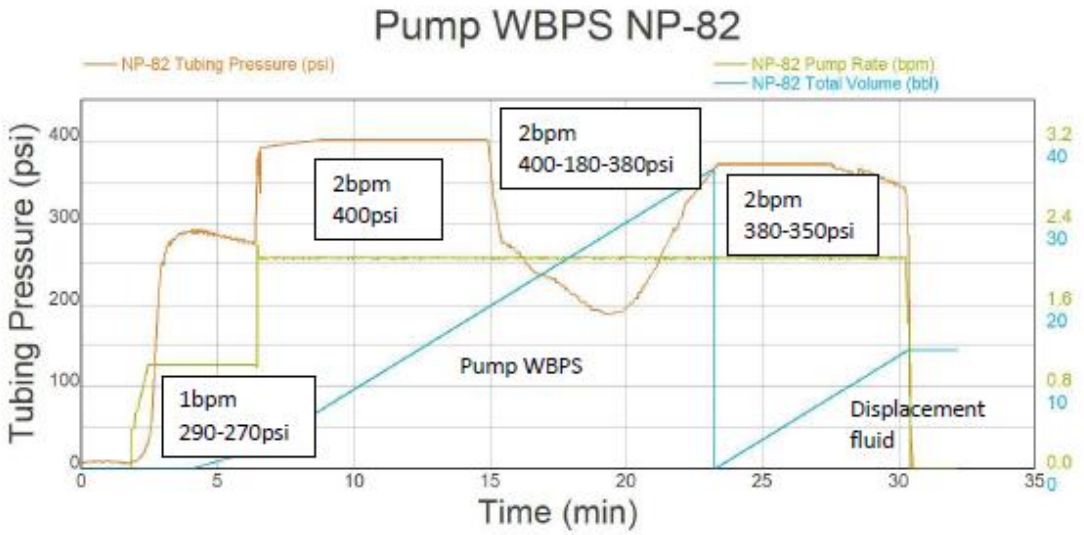

Figure 6. Injection Monitoring of Anti Paraffin Agent in NP-082

2.4.4. IRT Post-Job

IRT post-job is implemented after well is soaked for 3 hours to be compared with initial IRT before anti paraffin agent injection as seen in Table 5 and Figure 7.

Table 5. IRT Post-Job of NP-082

Injection Pressure	Injection Rate
15 psi	0.50 bpm
120 psi	1.00 bpm
320 psi	1.75 bpm
360 psi	2.00 bpm
420 psi	2.50 bpm
450 psi	2.75 bpm
460 psi	3.00 bpm
500 psi	3.50 bpm

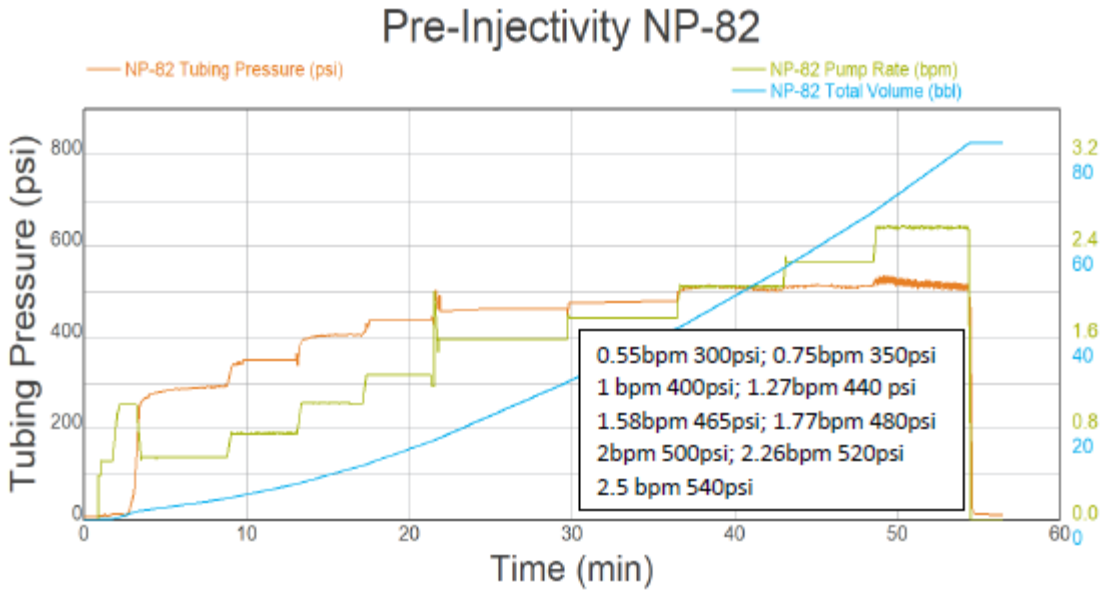

Figure 7. IRT Post-Job of NP-082

3 Result and Discussion

Based on injectivity rate test (IRT) before and after anti paraffin agent injection, step rate diagnostic before and after stimulation in NP-082 is created to evaluate the succees of anti paraffin agent injection. Higher injection rate with same pressure indicates the success of it. From Table 3 and Table 5, it can be generally seen the increase of injection rate in NP-082 well after anti paraffin agent is injected. Surface pressure as the representative of injection pressure is figured to get particular injection rate before after treatment as seen in Figure 8 and Figure 9.

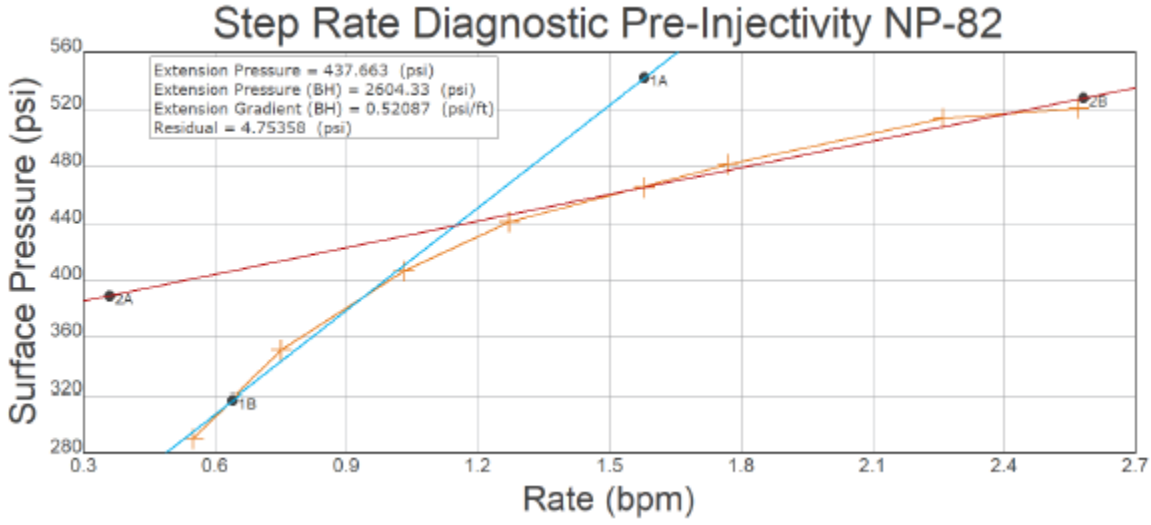

Figure 8. Step Rate Diagnostic in NP-082 Before Treatment

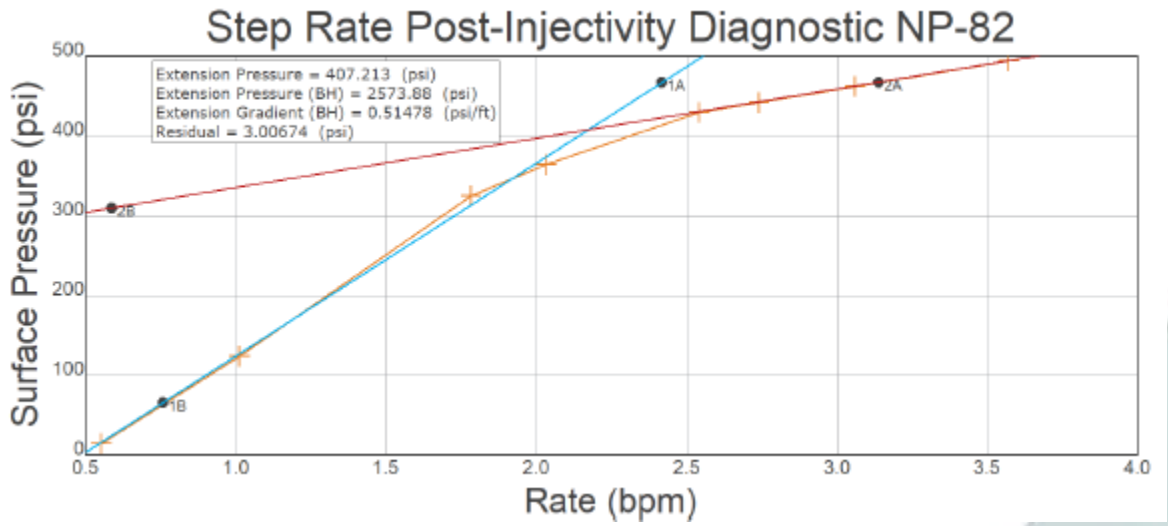

Figure 8. Step Rate Diagnostic in NP-082 After Treatment

Based on Figure 7 and Figure 8, lower pressure aftre treatment is need to get same injection rate compared with initial condition before treatment. As an example to inject 1 bpm of water into well, initially NP-082 well needs 405 psi of pressure higher than injection pressure after treatment, which is only 120 psi. Therefore, injection rate in NP-082 well can be increased after treatment. Operational injection rate and pressure is monitored to validate the success of anti paraffin agent, compared with initial condition as seen in Table 6.

Table 6. IRT Post-Job of NP-082

Parameters	Before Stimulation	After Stimulation
Wellhead Pressure, Pwh	150 psi	270 psi
Bottomhole Pressure, Pwf	937 psi	1057 psi
Reservoir Pressure, Pr	562 psi	562 psi
Injection Rate, q	958 bwpd	1539 bwpd
Injectivity Index	2.6 bwpd/psi	3.1 bwpd/psi

From Table 6 the success of anti paraffin agent can be seen, especially from the increasing of injection rate and injectivity index in NP-082 well. Operationally, injection rate average increases from 958 bwpd to 1539 bwpd or increases 581 bwpd. Injectivity index as the parameter to indicate well ability in injection water into reservoir also increases from 2.6 bwpd/psi to 3.1 bwpd/psi or increases 0.5 bwpd/psi. The additional well capacity of NP-082 to inject produced water into reservoir contributes oil production increases in North Pulai Structure Lirik Field.

4 Conclusion

Anti paraffin agent injection is a stimulation to overcome low injection rate. Implemented in NP-082 injection well, it contributes to increase injection capacity in North Pulai Structure. Total volume of 37 bbls anti paraffin agent and 15 bbls displacement fluid injection is executed without rig (rigless). The stimulation increases Injectivity Rate Test (IRT) after treatment. Consequently, it increases injection rate in NP-082 from 958 bwpd to 1539 bwpd, together with increased injectivity index from 2.6 bwpd/psi to 3.1 bwpd/psi. It concludes the injection of anti paraffin agent is able to dissolve paraffin accumulation in bottomhole and increase injection rate in NP-082 well, Lirik Field.

References

[1] Amperianto, A., Sofa, A., and Priyandono. 2007. Upaya Peningkatan produksi Minyak di Sumur Produksi Parafinik Unit Bisnis EP Lirik – Riau Menggunakan Inovasi Solvent dan Surfactant.

[2] Bercker, J.R. 1993. Crude Oils, Waxes, Emultions, and Asphaltenes. Penwell Books: Oklahoma, USA.

[3] Bott, T.R. and Gudmundsson, J.S. 1977. Deposition of Paraffin Wax from Kerosene in Cooled Heat Exchanger Tubes. The Canadian Journal of Chemical Engineering 55(4): 381 - 385, August 1977. DOI:10.1002/cjce.5450550403.

[4] Lake, L.W. 2007. Petroleum Engineering Handbook. Society of Petroleum Engineers: Texas, USA.

[5] Rif'ati, E.F. 2016. Alternatif Strategi Penanggulangan Masalah Waxy Parafin pada Tubing Sumur yang Memproduksikan Minyak Parafinik. Forum Teknologi Pusdiklat Migas Vol.06 No.01.