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Invitation Letter

31. 07. 2020

To : Universitas Islam Riau

Attention : Dr. Eng. Muslim Abdurrahman.
(Associate Professor in Petroleum Engineering Department)

Dear Prof. Muslim;

We, Golden Engineering Co., Ltd. ("Golden"), are 1 (one) of the engineering company in Korea. Our business areas are; engineering of geotechnical, underground, and oil&gas service. We are doing a Korean government-sponsored R&D which elaborated under below.

We, Golden, invite you as an Indonesian partner for year 3 and year 4.
This is an honor to work and research together with you.

Title	Development of Paraffin Inhibition and Removal Technology for Oil Field Production System				
No.	20182510102400				
Duration	01-05-2018 ~ 30-10-2021				
Consortium (3 organizations & 1 assistant)	- Golden Engineering Co., Ltd. - UNICOH Specialty Chemicals Co., Ltd. - Korea Institute of Geoscience and mineral resources (KIGAM). - Hanyang University as an assistant 3rd party.				
Budget (KRW 1,000)	Year 1 (2018)	Year 2 (2019)	Year 3 (2020)	Year 4 (2021)	Total
	1,127,001	914,793	1,319,553	189,255	3,550,602

Kindest Regards

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Grant Number 20182510102400
Golden Engineering Co., Ltd.
South Korean

Laboratory Test Paraffin Inhibitor

PUSAT STUDI PENGEMBANGAN DAN PENINGKATAN PRODUKSI MINYAK BUMI (PSP3MB)

SEPTEMBER 2021

Schedule	**Laboratory**
August – September 2021	Analisa Fluida Reservoir

Team Member

No		Institution	Major
1	Dr. Eng. Muslim, MT	Universitas Islam Riau	Team Leader
2	Annur Suhadi ST, MSc	Universitas Islam Riau	Senior Researcher
3	Ramdhani Asywal ST	Universitas Riau	Junior Researcher
4	Rifal Fauzi ST	Universitas Islam Riau	Junior Researcher
5	Reki Antoni ST	Universitas Islam Riau	Junior Researcher

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CHAPTER I INTRODUCTION

1.1 Background

The wax paraffin component in crude oil is one of the problems that can interfere with the activities of the oil and gas industry (Zhu et al., 2008). Components wax paraffin in hydrocarbons exist in gas, liquid and solid phases depending on pressure and temperature, when wax paraffin freezes, it will form crystals. (Thota & Onyeanuna, 2016). If the wax paraffin component in crude oil freezes and forms crystals, it creates problems during the production process including reservoirs, wellbore, tubing, flow lines and surface facilities causing billions of dollars in loss per year for the oil industry. (Zhu et al., 2008). Deposition that occurs can cause partial blockages during the production and transportation processes, thereby endangering production in the oil industry (Wang et al., 2003). The severity of the wax deposition problem depends on the type of oil and the molecular composition of the wax molecules (Thota & Onyeanuna, 2016).

There are several methods that can be used to solve the problem wax, they are: chemical method, hot water method, magnetic field method, water dispersible wax inhibitor method, and microbial method (Abdurrahman et al., 2018). This research was using a chemical method. The chemical method has proven to be the most effective method of mitigating wax deposition in the petroleum system because it deals with the root causes of formation (Fadairo et al., 2019).

Understanding the mechanism of formation of paraffin/wax deposits is also very important to overcome paraffin/wax problems in production pipelines and in production wells. furthermore, understanding this mechanism of a particular crude oil will be very helpful in determining what chemical inhibitor is most effective at preventing paraffin/wax deposits in the pipelines carrying that oil. Initial testing of oil containing paraffin/wax is very important to determine the content of paraffin/wax contained in the oil and at what temperature at which paraffin/wax begins to form. laboratory testing was carried out to test oils containing paraffin/wax after adding paraffin inhibitors to see the effectiveness of paraffin inhibitors to overcome operational problem and sweep reduction due to paraffin/wax deposition

1.2 Research Purposes

1. Investigating the effect of chemical inhibitor on paraffin deposit
2. Investigating the effect of chemical inhibitor on pour point temperature
3. Investigating the effect of chemical inhibitor on viscosity of crude oil

CHAPTER II LITERATURE REVIEW

2.1 Field Overview of Langgak Field

2.1.1 Location

Figure 2. 1 Map of Indonesia

Figure 2. 2 Location of Langgak Field

This field is located in Kampar District, Rokan Hulu, Riau. This field has area of 79.65 km^2 and can be reached 135 km from Pekanbaru. The detail of the field location can be seen at the picture as follows.

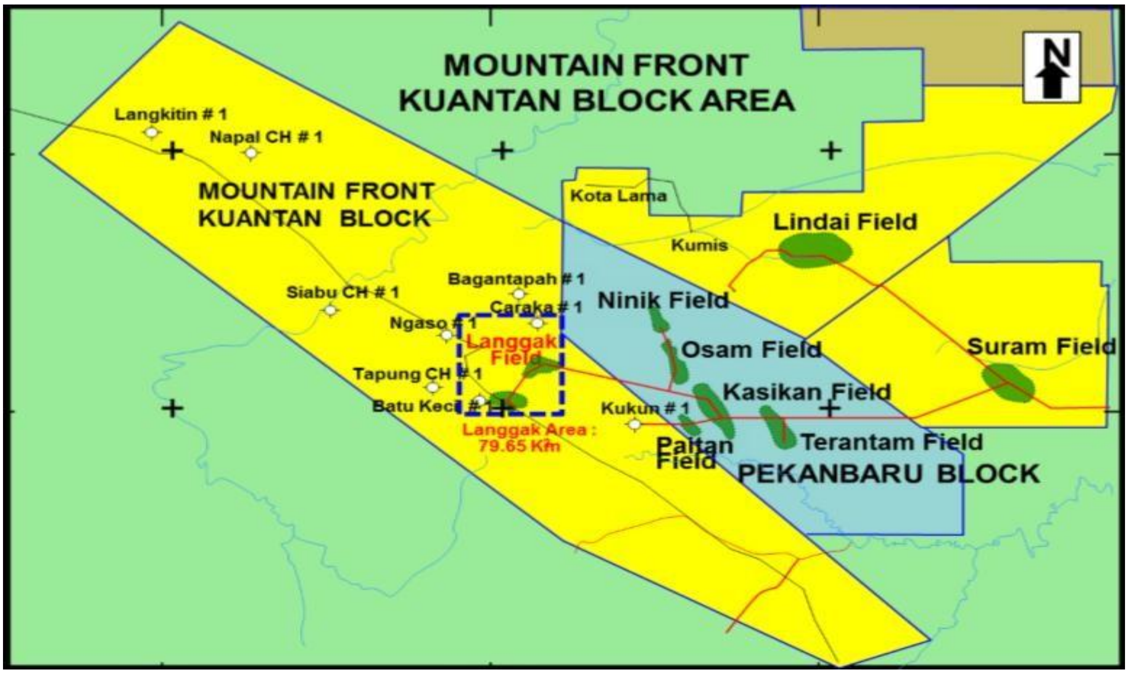


Figure 2. 3 Field Langgak

2.1.2 Field History

Langgak Field was discovered in 1975 and developed by PT. Chevron Pasific Indonesia (PT. CPI) more than 40 years until April 2010. There are 33 wells including 6 PA wells that have already been drilled. Afterward, PT SPRL took the opportunity to replace CPI as oil company operator of this field to the present. During four years operation, there were 5 infill wells that have already been drilled. Now, there are 27 active wells which are 26 production wells, and a water-well.

Langgak field had been drilled since 1979. It has 51.94 MMBO with current recovery factor of 27.2%. Until December 2017 current cumulative production was 14.1 MMBO with estimate primary recovery was 33.7% and remaining reserve was 3.40 MMBO. This EOR method can improve the recovery up to 2025% (10-12 MMBO additional reserve) in return.

2.1.3 Reservoir Overview

Table 2. 1 Crude Oil Properties

Properties	Value
Well	NA
Formation	Sihapas Group
Density	0.856 gr/ml
˚API	31.9
Pour Point	105 ˚F (40.5 C)
Cloud Point	100.4 ˚F (38 ˚C)
Cold Point	95 ˚F (35 ˚C)
Wax Content	27 % w/w

Table 2. 2 Formation Water Analysis

Sample	Parameter	Concentration (Value)
Formation Water	Salinity	100 ppm
	Salinity	0.01 %
	SG (Specific Gravity)	1.002
	pH	7.44
	Conductivity	241 µs/cm
	ORP (Oxidation Reduction Potential)	215 mV
	TDS (Total Dissolved Solid)	121 ppm
	Viscosity	0.52 cP
	Density	1.003 gr/ml

Table 2. 3 Formation Water Analysis

Sample	Element	Concentration (ppm)
Formation water	Ca^{+2}	3.5367
	Fe^{+2}	-0.07696
	K^{+1}	2.2826
	Mg^{+2}	0.6145
	Mn^{+2}	-0.19196
	CO_3^{-2}	< 1
	Cl^{-}	13.2
	SO_4^{-2}	4.0
	Salinity (NaCl)	100.0

The salinity is 100 ppm, which was very low, was caused by the upper (deltaic) marine system of reservoir of Bekasap formation (i.e. Sihapas group)

Table 2. 4 Rock Properties

Parameter	Value
Porosity	26 %
Permeability	500 mD

Table 2. 5 Basic Reservoir Data

Parameter	Value
Depth (Average)	1100 – 1300 ft
Pressure	530 psi
Temperature	136 ˚F
Drive Mechanism	Water Drive

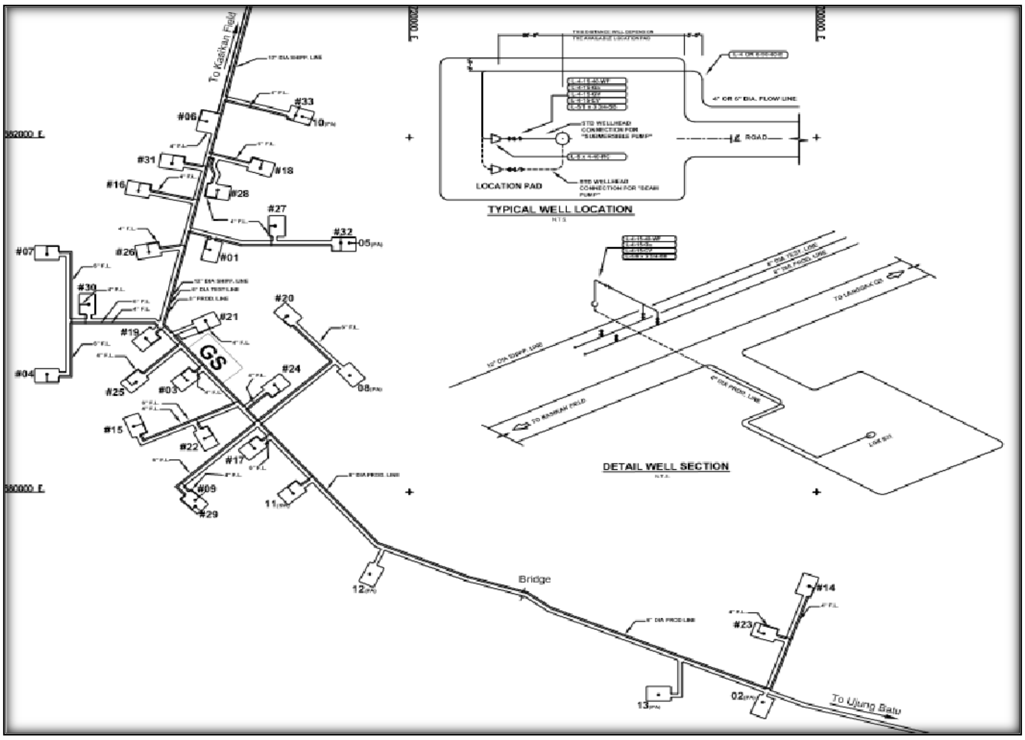


Figure 2. 4 Map of Langgak Field

In Langgak Field there are 33 wells with 27 active wells (8 *ESP*, 15 SRP, 3 PCP, and 1 Shipping Well) and 6 well plug and abandoned.

Table 2. 6 Artificial Lift Types in Langgak Field

Wells	Pump Type	Status
A#1	Sucker Rod Pump	Production
A#2	Plug and Abandonment	Suspended
A#3	Sucker Rod Pump	Production
A#4	Sucker Rod Pump	Production
A#5	Plug and Abandonment	Suspended
A#6	Sucker Rod Pump	Production
A#7	Electrical Submersible Pump	Production
A#8	Plug and Abandonment	Suspended
A#9	Electrical Submersible Pump	Production
A#10	Plug and Abandonment	Suspended
A#11	Shipping Well (HPS)	(W) Production
A#12	Plug and Abandonment	Suspended

A#13	Plug and Abandonment	Suspended
A#14	Sucker Rod Pump	Production
A#15	Sucker Rod Pump	Production
A#16	Sucker Rod Pump	Production
A#17	Progressive Cavity Pump	Production
A#18	Electrical Submersible Pump	Production
A#19	Sucker Rod Pump	Production
A#20	Electrical Submersible Pump	Production
A#21	Electrical Submersible Pump	Production
A#22	Sucker Rod Pump	Production
A#23	Electrical Submersible Pump	Production
A#24	Sucker Rod Pump	Production
A#25	Electrical Submersible Pump	Production
A#26	Sucker Rod Pump	Production
A#27	Sucker Rod Pump	Production
A#28	Sucker Rod Pump	Production
A#29	Electrical Submersible Pump	Production
A#30	Progressive Cavity Pump	Production
A#31	Sucker Rod Pump	Shut Down
A#32	Sucker Rod Pump	Production
A#33	Progressive Cavity Pump	Production

CHAPTER III RESEARCH METHODOLOGY

3.1 Equipments and Materials

The equipments and materials used in this study are as follows:

1. Water bath
2. Beaker
3. Micropipette 100 – 1,000 µL
4. Micropipette 10 – 100 µL
5. Measuring cup
6. Redwood viscometer
7. Pycnometer
8. Reaction Tube
9. Filter Paper whatman grade 42 (pore size 2.5 µm)
10. Funnel glass
11. Erlenmeyer
12. Thermometer
13. Analytical Balance
14. Crude oil PT SPR Langgak
15. Paraffin Inhibitor Golden Engineering Co., Ltd.

Analytical balance


Water bath


Funnel glass

Beaker

Thermometer

Erlenmeyer

Spatula

Filter Paper

Pycnometer

Micropipette 10 – 100 µL

Reaction tube

Micropipette 100 – 1000 µL

Viscometer Redwood

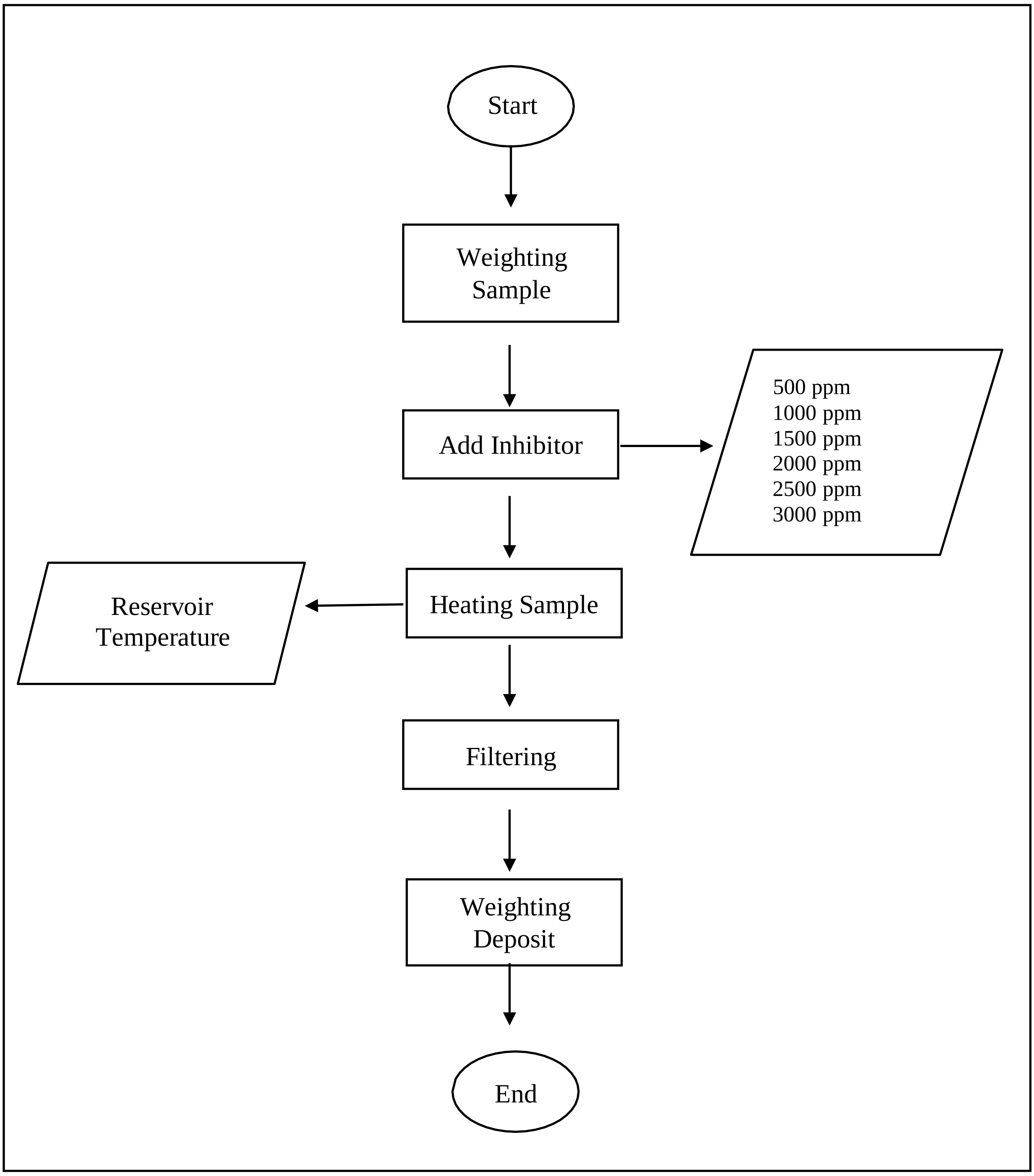
3.2 Procedures

3.2.1 The Study of the Effect of Paraffin Inhibitor on Reduction of Paraffin Deposit

Laboratory tests were carried out to test the oil containing paraffin wax after adding the inhibitor, with the following procedure

1. Calculating the density of crude oil with a pycnometer
2. Use the density equation to calculate the amount of mass to be weighed
3. Weigh the sample of waxy crude oil 8.5 gram, which is the calculation of the density of crude oil (0.85 gr/ml) with the volume of oil used in the pour point test (10 ml)
4. Add inhibitor according to the specified concentration (0.05 ; 0.1 ; 0.15 ; 0.2 ; 0.25 and 0.3) % w/v
5. Heat in a water bath for 1 hour at reservoir temperature (58 ˚C)
6. Filter the solution with filter paper at reservoir temperature
7. Dry at room temperature and weight the filter paper and insoluble deposits.
8. Calculate the paraffin wax deposit using the following equation

Paraffin Deposit = Initial sample weight – Weight of deposit on filter paper



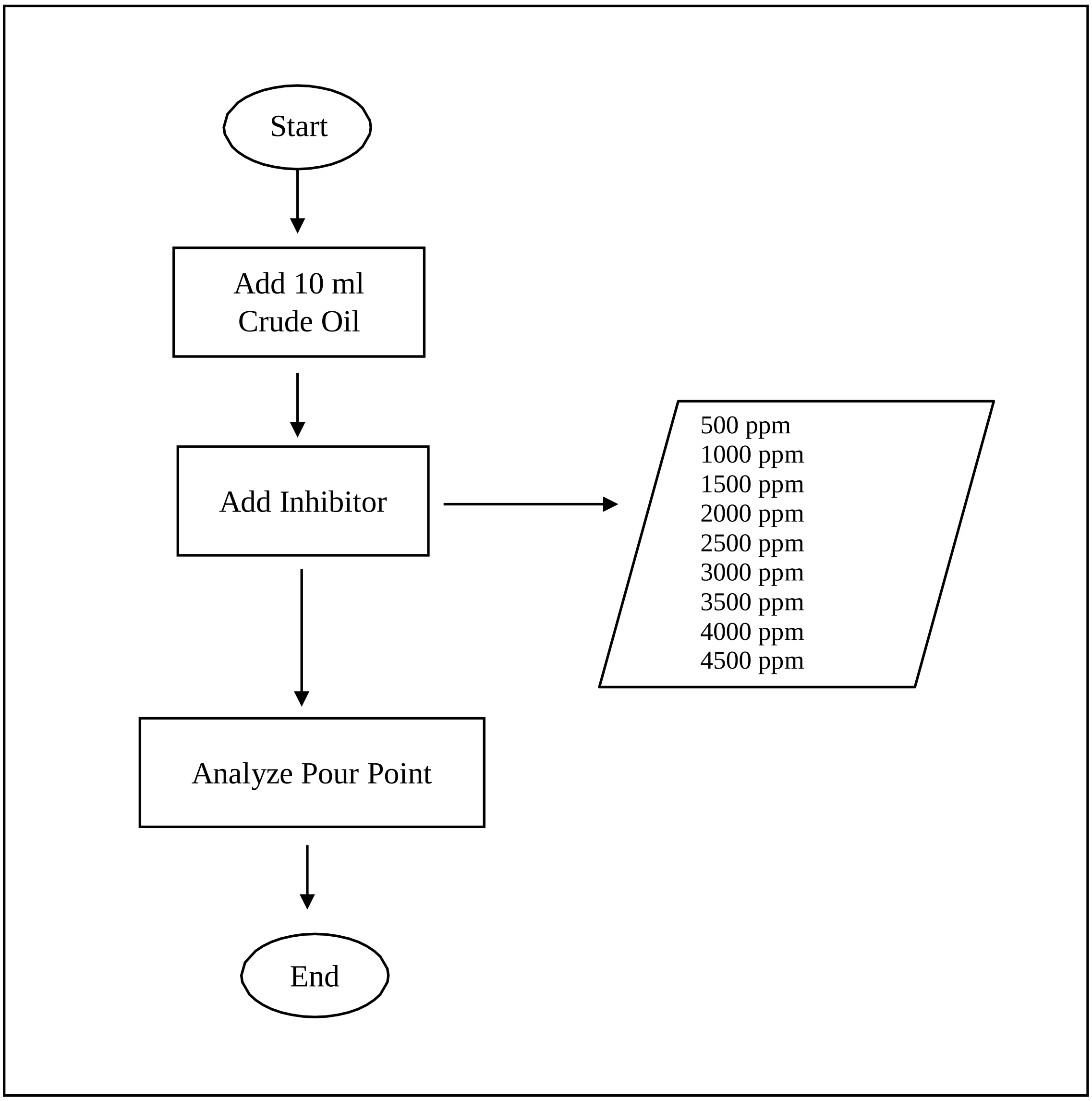
Flow Chart of Paraffin/Wax Deposit Testing

3.2.2 The Study of the Effect of Paraffin Inhibitor on Pour Point Reduction

Laboratory tests were carried out to test the oil containing paraffin after adding the inhibitor by pouring point testing. In this test, two tests were carried out, namely the pour point test before adding the inhibitor (blank) and after adding the inhibitor. Laboratory tests were carried out to test the oil containing paraffin after adding the inhibitor, with the following procedure:

1. Pour the sample into the tube as much as 10 cc, and attach the thermometer to the tube
2. Insert the tube into the water bath and heat it according to the test temperature, and observe the temperature on the thermometer
3. Remove the tube from the water bath and observe the temperature change when all the samples can be poured.

Repeat steps 1 to 3 with the addition of inhibitor before being heated in a water bath at a concentration of (0.05% ; 0.1% ; 0.15% ; 0.2% ; 0.25%; 0.3% ; 0.35%; 0.4% and 0.45%) v/v. The expected data is a decrease in pour point of 10 ˚C when an inhibitor is added at a certain concentration. The observational data on the effect of adding inhibitors on decreasing the pour point can be seen in Table 2 below.



Flow Chart of Pour Point Testing

3.2.3 The Study of the Effect of Paraffin Inhibitor on Reduction of Viscosity of Crude Oil

Laboratory tests were carried out to test the oil containing paraffin after adding the inhibitor, with the following procedure:

1. Pour the sample into the measuring cup as much as 50 ml
2. Make sure the iron ball in the tube is right in the hole where the sample flows
3. Insert the sample into the tube
4. Setting the desired temperature to heat the sample
5. Lift the iron ball on the tube after the temperature reaches the desired limit
6. Then record the sample flow time until the last drop
7. Perform steps 1 to 6 for the next sample with the addition of inhibitor at concentrations (0.05% ; 0.1% ; 0.15% ; 0.2% ; 0.25% and 3%) v/v
8. Fluid viscosity can be calculated using the formula:

Equation of Kinematic Viscosity

Viscosity Scale	**Time**	**Kinematic Viscosity (cm^2/s)**
Redwood	43 < t < 100	0.00269t – 1.79/t
	t > 100	0,00247t – 0.50/t

Equation of Dynamic Viscosity

$$\mu_{din} = \rho \times \mu_{kin}$$

CHAPTER IV RESULT AND DISCUSSION

4.1 Paraffin/Wax Deposit

Crude Oil used in this study was taken from PT. SPR Langgak. The results of the paraffin weight deposit test can be seen in the following table 4.1:

Table 4. 1 The Effect of Paraffin Inhibitor on Weight Paraffin Deposit

Sample		**Weight Paraffin Deposit**					
	Blank (0 % w/v)	0.05 % (w/v)	0.1 % (w/v)	0.15 % (w/v)	0.2 % (w/v)	0.25 % (w/v)	0.3 % (w/v)
Crude Oil	8.5 gr	7.76 gr	7.75 gr	7.74 gr	7.73 gr	7.72 gr	7.71 gr

Table 4.1 shows that the increase the volume of paraffin inhibitors reduced paraffin deposits. The graph of the effect of paraffin inhibitor dosage on deposit paraffin shows in Figure 4.1

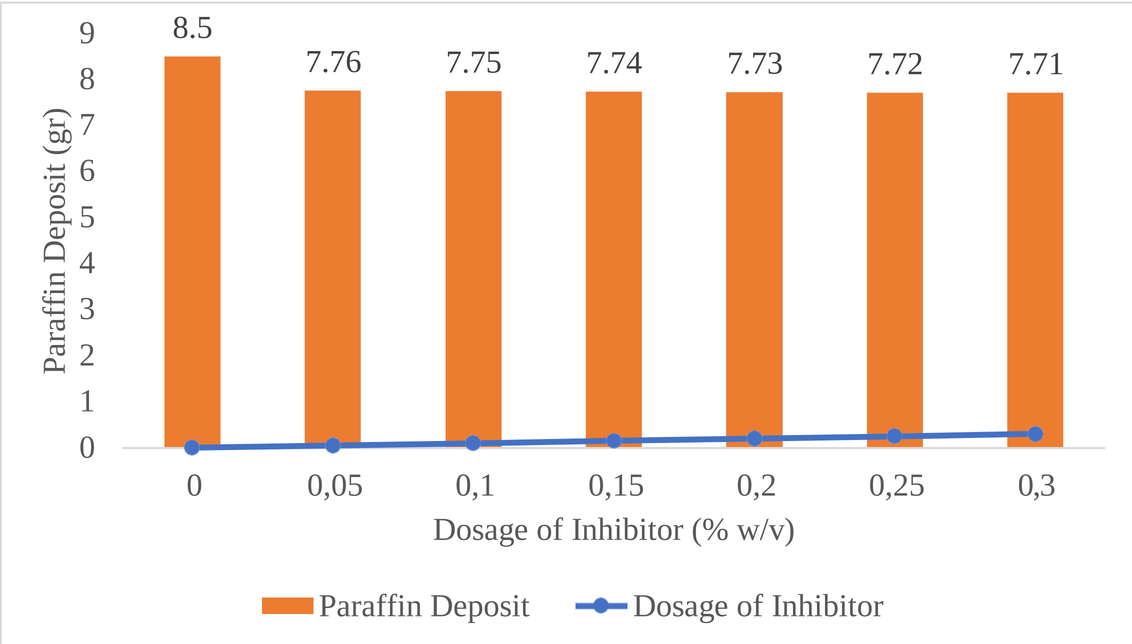


Figure 4. 1 The effect of paraffin inhibitor dosages on deposit paraffin reduction

Figure 4.1 shows that the reduction of paraffin deposit, which indicates the inhibiting of paraffin/wax deposition, was linear as the increase of paraffin inhibitor

4.2 Effect of Paraffin Inhibitor on Pour Point Temperature

Crude oil used in this research was taken from PT. SPR Langgak. The results of the pour point blank comparison test with the pour point after the paraffin inhibitor is dissolved can be seen in table 4.2 below:

Table 4. 2 The Effect of Paraffin Inhibitor on Pour Point

Sample	Pour Point									
	Blank (0 % v/v)	0.05 % (v/v)	0.1 % (v/v)	0.15 % (v/v)	0.2 % (v/v)	0.25 % (v/v)	0.3 % (v/v)	0.35 % (v/v)	0.4 % (v/v)	0.45 % (v/v)
Crude Oil	40 ˚C	38 ˚C	37 ˚C	36 ˚C	35 ˚C	34 ˚C	33 ˚C	32˚C	31 ˚C	31 ˚C

Pour point is the point at which a fluid can flow at the lowest temperature (Kasmungin, 2017). Table 4.2 is a pour point test carried out on crude oil before it is mixed with paraffin inhibitor (crude oil blank) and crude oil after being mixed with paraffin inhibitor to see a decrease in pour point. The graph of the decrease in the pour point value after being mixed with paraffin inhibitors can be seen in Figure 4.2 below:

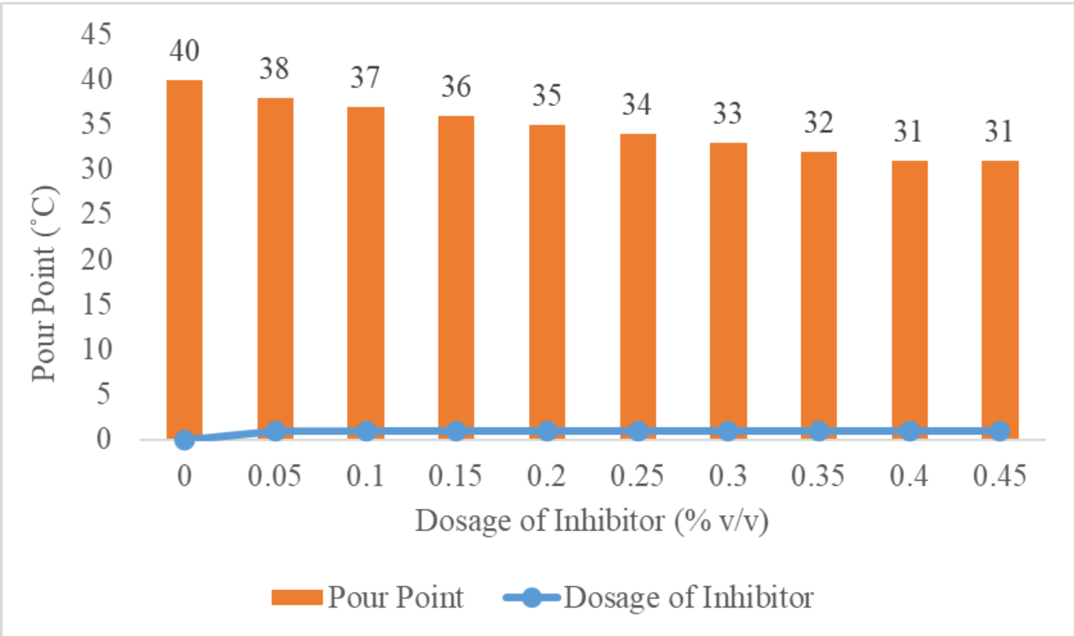


Figure 4. 2 The effect of paraffin inhibitor dosages on pour point reduction

Judging from the table and figure above, it can be seen that there was a change in the value of the pour point test before adding paraffin inhibitors and increasing the volume of paraffin inhibitors. Changes in the pour point temperature of crude oil can indicate the effect of paraffin inhibitors on crude oil containing paraffin wax where at the initial pour point temperature of crude oil is 40˚C, which means that under these conditions the oil can flow for the first time (Kasmungin, 2017). With the addition of a paraffin inhibitor of 500 ppm, it can reduce the pour point temperature from 40 C to 38 C. Then the addition of paraffin inhibitor was increased to 1000 ppm, 1500 ppm, 2000 ppm, 2500 ppm and 3000 ppm resulting in a decrease in temperature point of only 1˚C. The decrease in pour point is not too significant because the volume of paraffin inhibitor used is very small, but if the volume of paraffin inhibitor is increased, the use of paraffin inhibitor is not economical due to higher operating costs.

4.3 Effect of Paraffin Inhibitor on Viscosity of Crude Oil

Crude oil used in this research was taken from PT. SPR Langgak. Viscosity can be divided into two, namely kinematic viscosity and dynamic viscosity. Kinematic viscosity is a measure of how difficult a fluid is to flow which is influenced by gravity and density while dynamic viscosity is a measure of how difficult a fluid is to flow which is influenced by external force. (Kasmungin, 2017).

4.3.1 The Effect of Paraffin Inhibitor on Viscosity at Temperature 58 ˚C, 53 ˚C and 48 ˚C

The viscosity test with the addition of paraffin inhibitor to see the effect on viscosity can be seen in the following Table 4.3

Table 4. 3 The Effect of Paraffin Inhibitor on Viscosity

Temperature	**Viscosity by Concentration of Paraffin Inhibitor**						
	Blank (0 % v/v)	**0.05 % (v/v)**	**0.1 % (v/v)**	**0.15 % (v/v)**	**0.2 % (v/v)**	**0.25 % (v/v)**	**0.3 % (v/v)**
58 ˚C	59.27 cP	57.79 cP	56.11 cP	55.48 cP	53.79 cP	52.74 cP	52.53 cP
53 ˚C	82.08 cP	80.10 cP	79.40 cP	77.84 cP	72.22 cP	70.93 cP	65.90 cP
48 ˚C	118.60 cP	115.69	113.29	110.67	105.74	101.86	100.26

Table 4.3 shows the effect of adding paraffin inhibitor on crude oil viscosity. The addition of paraffin inhibitors of 500 ppm, 1,500 ppm, 2,000 ppm, 2,500 ppm, and 3,000 ppm at temperatures of 58 °C (temperature reservoir) 53 °C and 48 °C showed a decrease in crude oil viscosity. The test results at each temperature and concentration of paraffin inhibitor can also be seen in Figures 4.3 – 4.5 below.

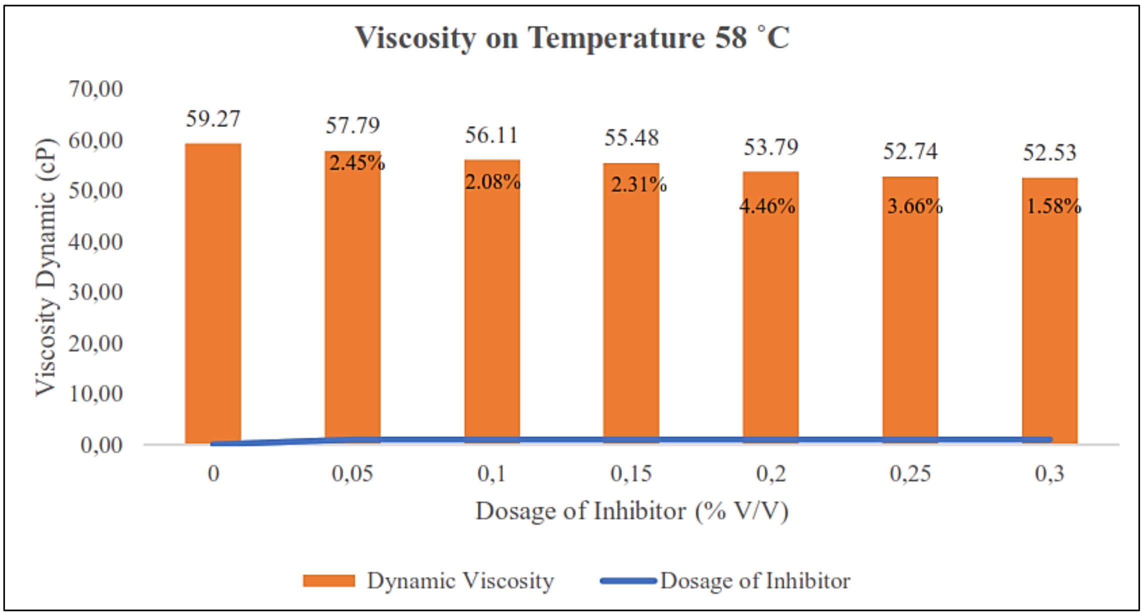


Figure 4. 3 The effect of paraffin inhibitor dosages on dynamic viscosity reduction over a range temperature 58 ˚C

Figure 4.3 shows that the reduction of viscosity was linear as the increase of paraffin inhibitor. The addition of each dosage of the inhibitor can reduce the viscosity of crude oil. The addition of the inhibitor dose of 500 ppm was able to reduce the viscosity value of crude oil by 2.45%, from 59.27 cP to 57.79 cP. The addition of a maximum inhibitor dose of 3000 ppm was able to reduce the viscosity value of crude oil by 15.46%, from 59.27 cP to 52.53 cP. This shows that the effectiveness of the inhibitor increases with the increase in the inhibitor dose given to crude oil.

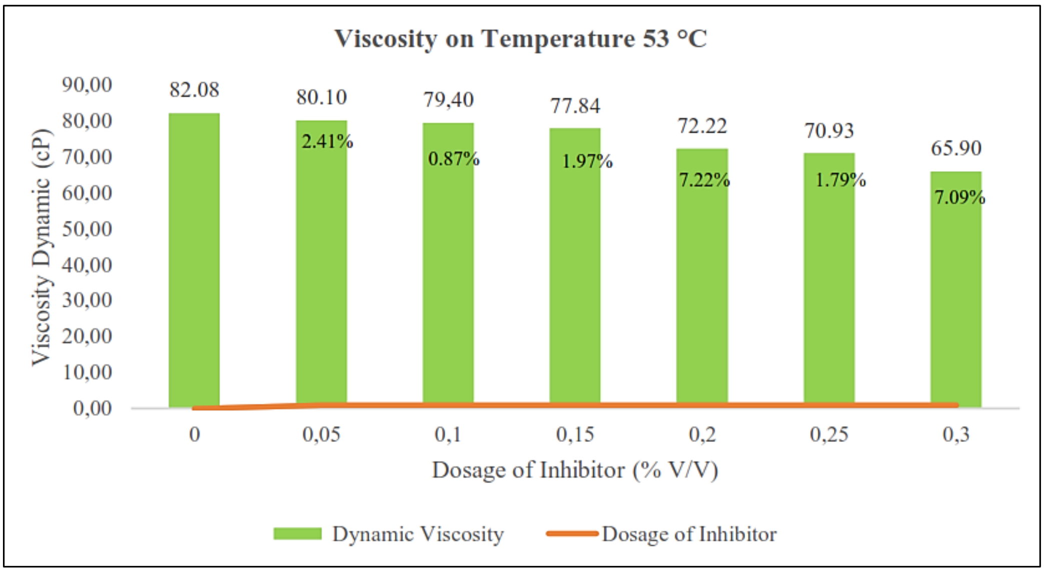


Figure 4. 4 The effect of paraffin inhibitor dosages on dynamic viscosity reduction over a range temperature 53 ˚C

Figure 4.4 shows that the reduction of viscosity was linear as the increase of paraffin inhibitor. The addition of each dose of inhibitor can reduce the viscosity of crude oil. The addition of the inhibitor dose of 500 ppm was able to reduce the viscosity value of crude oil by 2.41%, from 82.08 cP to 80.10 cP. The addition of a maximum inhibitor dose of 3000 ppm was able to reduce the viscosity value of crude oil by 19.71%, from 82.08 cP to 65.90 cP. This shows that the effectiveness of the inhibitor increases with the increase in the inhibitor dose given to crude oil

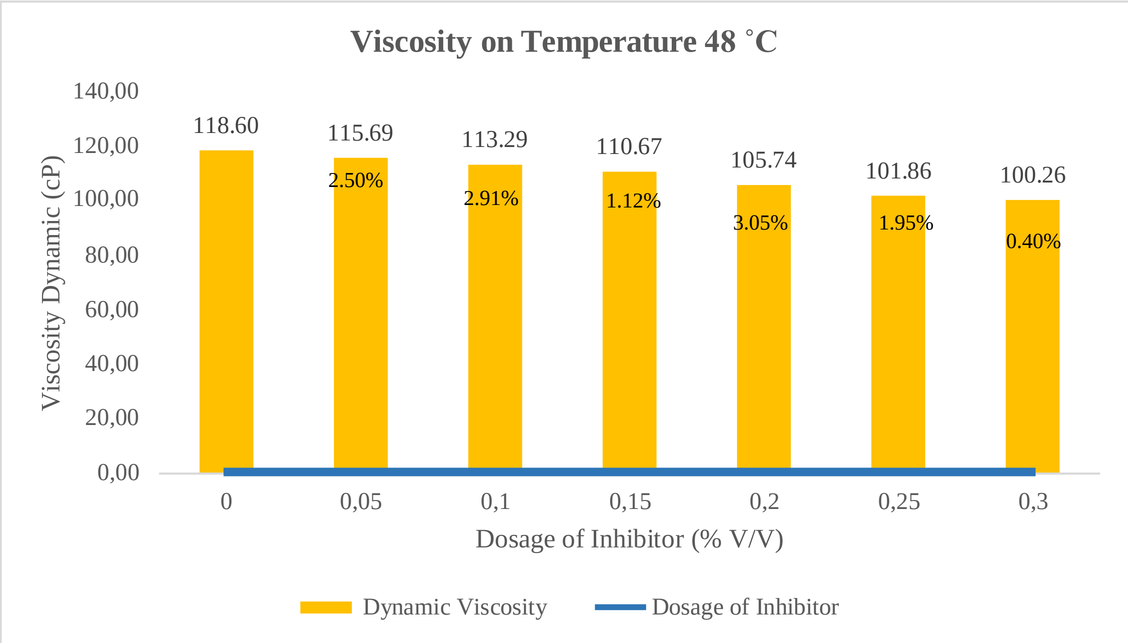


Figure 4. 5 The effect of paraffin inhibitor dosages on dynamic viscosity reduction over a range temperature 48 ˚C

Figure 4.5 shows that the reduction of viscosity was linear as the increase of paraffin inhibitor. The addition of each dose of inhibitor can reduce the viscosity of crude oil. The addition of the inhibitor dose of 500 ppm was able to reduce the viscosity value of crude oil by 2.50%, from 118.60 cP to 115.69 cP. With the addition of a maximum inhibitor dose of 3000 ppm, it can reduce the viscosity value of crude oil by 11.37%, from 118.60 cP to 100.26 cP. This shows that the effectiveness of the inhibitor increases with the increase in the inhibitor dose given to crude oil.

The strength of waxy crude oil can be determined through yield stress tests using viscometer. At cold and/or deepwater subsea injection through umbilicals, flexible risers, and capillaries, the instability in the polymer solution resulting in flexible risers failure. Better inhibitor solubility, even at reduced temperature and high pressure representing phenomena of oil flowing in flexible risers of deep water project, can be achieved using combination of weak to moderate solvent (i.e. benzene, toluene, xylene, ethyl benzene, propyl benzene, or trymethyl benzene) and strong solvent including cyclopentane, cyclohexane, carbon disulfide, decalin, and mixtures thereof.

Dodecyl Benzene Sulfonate Acid sometimes was added to paraffin inhibitor for detergency purpose, so that the wax either C16 – 25 or C25 – C50 was less sticky onto piping inside. In addition the polarity on headgroup will stabilize asphaltene, through either solubilizing or dispersing asphaltene. DBBSA is also known as Asphaltene Dispersant. Too high DBBSA concentration will decrease the performance of paraffin inhibitor due its interaction with asphaltenes. Nonyl phenol ethoxylated resin can be added to the polimer solution instead of DBBSA. The paraffin inhibitor can be predicted by method of Dissipative Particle Dynamic (DPD)/(COSMOSAC) Conductor-like Screening Model–Segment Activity Coefficient

Dosage of paraffin inhibitor which is used in pipeline is calculated based on the calculation in the following:

Gallon per Day= (ppm paraffin inh x BOPD x 42)/1000000

$$= \frac{(4500 \times 500 \times 42)}{1000000}$$

= 94.5 Gallon per Day = 425.25 Liter per Day

Noted:

4500 = Dosage of paraffin inhibitor (ppm)

500 = Barrel Oil Per Day (BOPD) of SPR Langgak

Production of crude oil in Langgak Field is 500 BOPD. Paraffin inhibitor is to inhibit the wax appearance and decreased pour point temperature. Paraffin inhibitor at 4500 ppm, which decreased the pour point of crude oil from 40 ˚C to 31 ˚C. The recommended paraffin inhibitor dosage is 4500 ppm, so that production of Langgak field 500 BOPD, the paraffin inhibitor shall be injected is 95.5 gallons per day or 425.25 litres per day.

CHAPTER V CONCLUSION

1. Increasing the dosage of paraffin inhibitor reduced the weight of paraffin deposit.
2. The increase of dosage of paraffin inhibitor decreased 1°C for every 500 ppm incremental dosage of 500 - 4,500 ppm.
3. The maximum dosage of paraffin inhibitor was 4,500 ppm, which was able to reduce pour point of 40 °C to 31 °C.
4. Higher dosage of paraffin inhibitor slightly decreased viscosity of crude oil.
5. Acceptable paraffin inhibitor is when it can reduce pour point of crude oil of 10 °C at lower dosage of paraffin inhibitor.
6. The recommended paraffin inhibitor dosage is 4500 ppm, so that production of Langgak field 500 BOPD, the paraffin inhibitor shall be injected is 95.5 gallons per day or 425.25 liters per day.

REFERENCES

ASTM D88 – 94, “Standart Test Method for Saybolt Viscosity”.

ASTM D – 97, “ Standart Test Method of Pour Point of Petroleum Products”.

Abdurrahman, M., Ferizal, F. H., Husna, U. Z., & Pangaribuan, L. (2018). Possibility of wax control techniques in Indonesian oil fields. *AIP Conference Proceedings*, *1941*(March). https://doi.org/10.1063/1.5028059

Fadairo, A., Ogunkunle, T., Lana, O., Oladepo, A., & Babajide, L. (2019). The use of bio-diesel based additive as rheology improver and pour point depressant of Nigerian waxy crude. *Petroleum Science and Technology*, *37*(15), 1747–1754. https://doi.org/10.1080/10916466.2018.1522340

Kasmungin, S. (2017). *Studi Pemilihan Pour Point Depressant Untuk Penanggulangan*. 211–217.

Thota, S. T., & Onyeanuna, C. C. (2016). *Mitigation of wax in oil pipelines 1*. *4*(4), 39–47.

Wang, K. S., Wu, C. H., Creek, J. L., Shuler, P. J., & Tang, Y. (2003). Evaluation of effects of selected wax inhibitors on paraffin deposition. *Petroleum Science and Technology*, *21*(3–4), 369–379. https://doi.org/10.1081/LFT-120018526

Zhu, T., Walker, J. a, Liang, J., & Laboratory, P. D. (2008). *Evaluation of Wax Deposition and Its Control During Production of Alaska North Slope Oils* (Issue December).

ATTACHMENTS

A. Documentations of Research Procedural

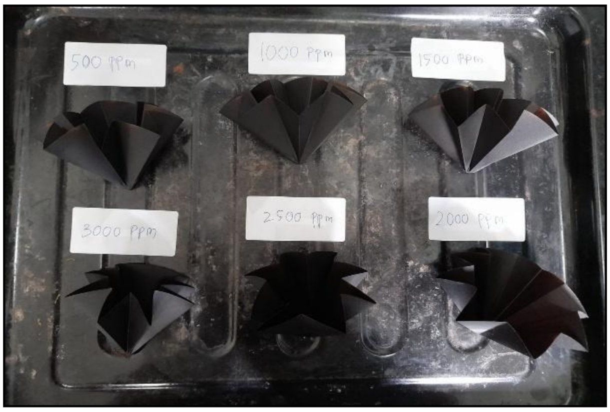
1. Measurement of Wax Deposit

Weighting Sample

Adding Inhibitor

Heating at Reservoar Temperature (58°C)

Filtering at Reservoar Temperature (58°C)



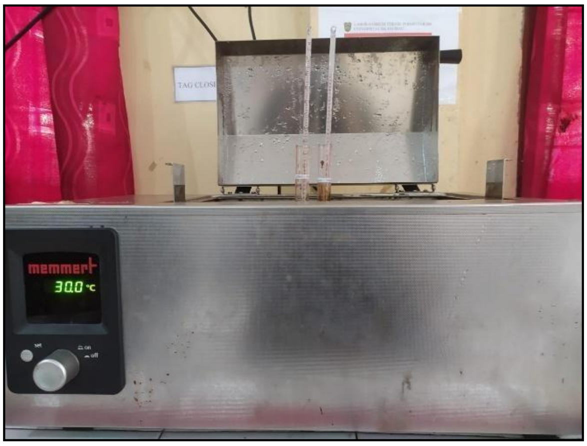
Sample After Filtering

Weighting Deposit

2. Measurement of Pour Point

Sample crude oil 10 cc

Adding Inhibitor



Heating sample in waterbath

Analyze Pour Point

Pour point read

3. Measurement of Viscosity

Sample crude oil 50 ml

Adding Inhibitor

Heating sample in waterbath

Insert the sample into the tools

Calculate fluid flow time

B. Documentations of Research Result

Blank Sample of Crude Oil

Pour Point 40 °C

After adding 4500 ppm inhibitor

Pour Point 31 °C

C. Documentations of Langgak Field

Sampling Point at Langgak Field

Well Head

Gathering Station Langgak Field

Pumping Unit

Progressive Cavity Pump (PCP) at Langgak Field

Chemical Reverse Demulsifier at Langgak Field

Gas Boot

Wash Tank

Shipping Tank

Shipping Pump

Meter Reading

Flare Stack

Storage Tank

Pit

Skimming Tank