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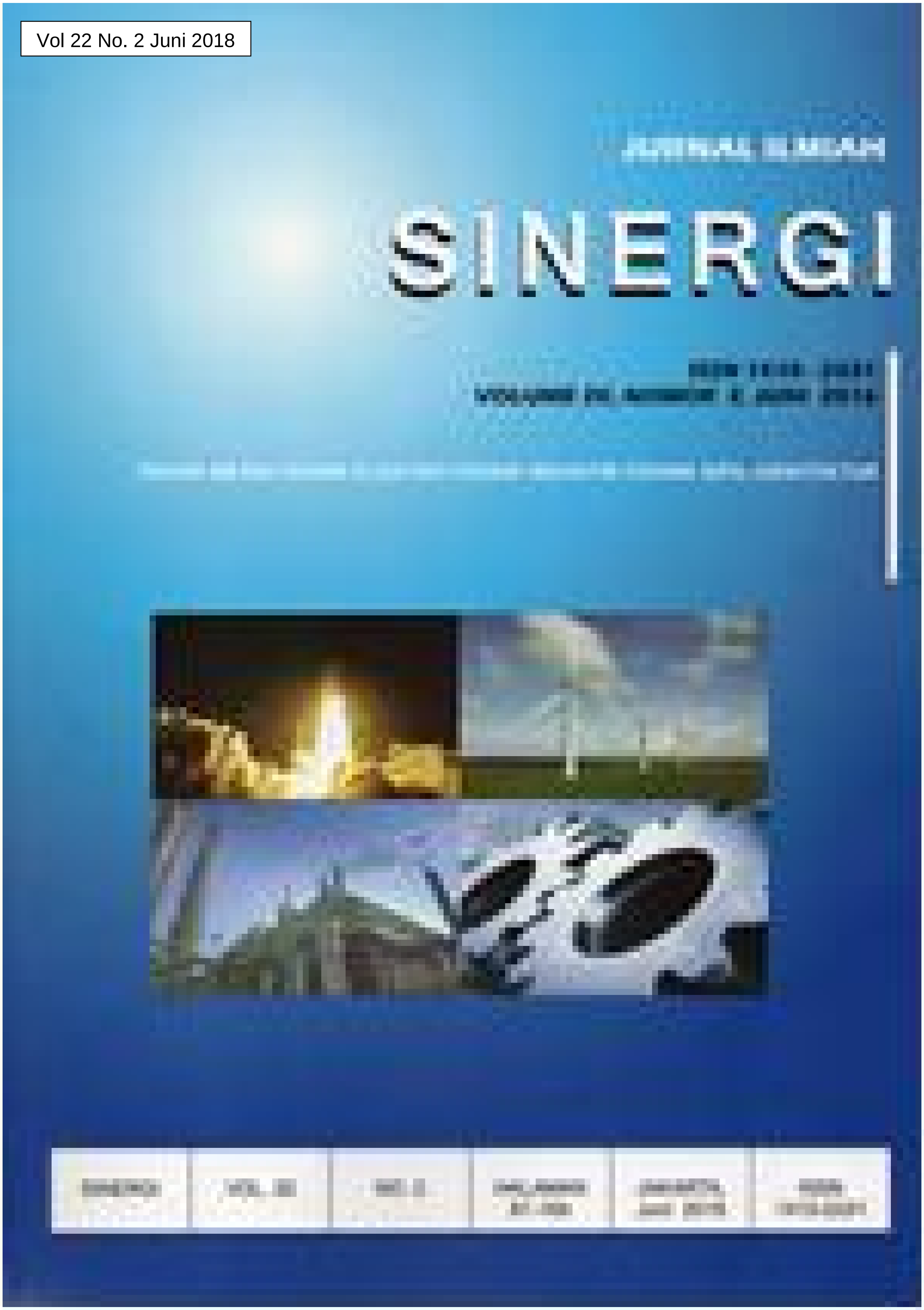

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PARAFFIN PROBLEM TREATING ALONG THE FLOWLINE (STUDY CASE: FROM WELLHEAD “X” TO THE SEPARATOR”

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Abstract – Paraffin deposition becomes a problem in crude oil transportation system in surface production facilities, especially in oil field flowline. The cause is big pressure drop which can inhibit the fluid flow rate. Paraffin problem occurence is effected by certain factor, such as crude oil characteristics, flowing pressure and oil temperature drop below the oil pour point. From the parameter mentioned before, the potention of experiencing paraffin deposition in the flowline from the wellhead to the separator need to be analyzed. From the physical properties analysis, paraffin deposition occur when temperature is decreased below the oil pour point (43 ^{O}C). In this case, the wellhead temperature is 65 ^{O}C. Paraffin problem countermeasures is being done by installing insulation along the flowline to resolve the fluid heat loss. If the previous countermeasure method could not resolve the problem, sand heater is needed to be installed to heat up the fluid inside the flowline in certain point of distance.
Keywords: Insulator, Oil Pour Point, Paraffin Deposition, Sand Heater

INTRODUCTION

One of problem that often experienced in producing oil is paraffin problem. Oil characteristics analysis, temperature and pressure drop can cause paraffin problem **(Camahan, F. Norman, 1989)**. If the fluids temperature and pressure decreased below the pour point, it will caused the paraffin deposition.Paraffin problem potential analysis will be done along the flowline in the oil field that have paraffin problem potential. Oil density, oil ^{o}API, and oil pour point need to be analysed along the flowline in the oil field that have paraffin problem potential**(Misra, Sanjay et.Al, 1995)**. Certain factors that effected the pressure drop along the flowline are pipe diameter, pipe length, pipe roughness, elevation and fluids properties like fluid density, and fluid viscosity **(Beggs and Shiu, 1976)**.

In this study case, two different production wells are analysed, which one of this two wells has parafinic oil. Two different types of oil are produced and unify in manifold, then it will streamed to the separator. Fluid properties that need to be evaluated from the wellhead to the manifold are fluid physical properties, pressure and temperature drop, and the countermeasures which will be done.

In this paper, paraffin occurence analysis based on the temperature loss that effected pressure loss along the flowline is done by calculating the fluid density and viscosity. It will prove that temperature loss related to pressure loss along the flowline. Then, the right steps to treat the paraffin problem based on temperature and pressure factor is obtained

METHODOLOGY

Paraffin is a production problem that caused by certain factors, to be spesific oil characteristics, fluid temperature below the pour point, so the fluid pressure will be decreased along with the flow rate.

The Effect of Temperature Drop

If the temperature drop below the pour point, paraffin will be deposited in the flowline. Pour point temperature is the lowest temperature which a liquid remains pourable (still behave as a fluid).Frezzing point is a temperature below the pour point, where the oil cannot be flew or with other word freeze. Oil temperature along the flowline can be calculated with Karge method:

$$\frac{T_0 - T_1}{T_2 - T_1} = e^z \quad \text{..........................} \quad (1)$$

Where,

$$z = \frac{2{,}54x®xKxDxL}{QxCpx10^5} \quad \text{...............} \quad (2)$$

To = oil initial temperature, ºC

T_1 = ambient temperature, ºC
T_2 = pour point temperature, ºC
K =coefficient heat fluids separation from pipes, Kcal/m^2/hour/ ºC
D = pipe outside diameter, m
L =pipe length, m
Q =flowing amount, m^3/jam

The Effect of Pressure Drop

Fluid inside the pipe will flow if the pressure drop is less than the initial pressure. Oil is a non newtonian fluid, which explains that oil will flowing if the pressure is beyond a certain pressure limit. It is different with newtonian fluid where newtonian fluid will flowing if it got pressure. The time the oil beyond the pour point, it can be said that it still got pressure to flow.

Pressure loss inside the pipe can be determined by determining the fluid density first. The fluid density is needed to calculate fluid Specific Gravity (SG), then the fluid specific gravity will be used to calculate the fluid viscosity. Viscosity is effected by the amount of pressure drop and temperature drop. In other words, temperature drop is related to pressure drop. The calculation steps are described by the following equation:

1. Determining the mix density by converting field unit to british unit (lb/ft3)

$$^{\circ}mix = \left[\left(\frac{Qoil}{Qmix}\right) xSGoilx^{\circ}w60^{O}F\right] + \left[\left(\frac{Qoil}{Qmix}\right) xSGwx^{\circ}w60^{O}F\right] \text{ .... (3)}$$

SG_{mix}=ρ_{mix}/ρ_{water} .... (4)

2. Determining the mix viscosity by converting field unit (centistoke) to british unit (lb/ft-sec).

µ *oil* = SGmix x Kinematic Viscosity........(5)

3. Determining velocity in british unit (ft/sec).

$$V = \frac{Q}{0{,}25x®x(ID/12)^2} \text{ .... (6)}$$

4. Determining the Reynold Number.

$$Re = \frac{^{\circ}xVxd}{«} \text{ .... (7)}$$

Where :
Re = Reynold number
ρ = fluid density, ppg
V = velocity, ft/sec
D = pipe inside diameter, inch
µ = fluid viscosity, lb-sec/ft

Reynold Number (NRe) can determine the type of fluid flow, where:
a. Laminer flow, Nre < 2000
b. Transition flow, 2000 < Nre < 4000
c. Turbulen flow, Nre > 4000

5. Determining the friction factor (f).

$$f = \frac{64}{Re} \text{ ....(8)}$$

6. Determining the pressure differential with Darcy-Weissbach method.

$$\Delta P = \frac{^{\circ}xfxLxV^2}{144xDx2g} \text{ ....(9)}$$

Where :
ΔP = pressure differential, psia
ρ = fluid density, ppg
L = pipe length, ft
D = pipe inside diameter, ft
f = friction factor
G = gravity constanta

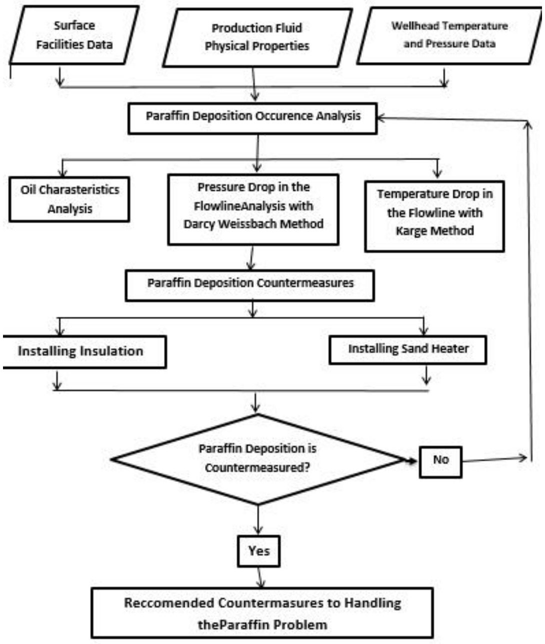

Figure 1. Analysis and Countermeasures Paraffin Problem Flowchart

This research is done by doing certain steps like describe in figure 1. First: collecting needed datas, namely surface facilities data, production fluid physical properties, temperature and pressure data. Surface facilities datas are pipe length from the wellhead to the manifold, pipe diameter from the wellhead to the manifold, pipe diameter from the manifold to the separator, and pipe conductivity. Production fluid physical properties datas are Qo, Qw, oil specific gravity, and oil pour point. Pressure and temperature datas are wellhead pressure and temperature, and ambient temperature.

After collecting datas needed, temperature loss along the flowline is analysed. Analyse the temperature loss by calculating the temperature drop with the pour point amount is 43 ^{O}C. If the temperature is dropped below the pour point, then paraffin problem is experinced. After that, pressure loss analysis is done by calculating the pressure drop. If the pressure drop is greater than the initial pressure, it can indicate that there is no flow and paraffin problem is occured.

From the analysis mentioned before, if the paraffin problem is experienced, countermeasures is needed. The first countermeasure is by installing calcium silicate insulation with 10mm thickness and covered by allumunium along the flowline from the paraffinic oil well's wellhead (Well JB-2) to the manifold. Second countermeasure is by installing sand heater along the flowline from 960m after the wellhead where the fluid's temperature in that point is 48 ^{O}C. The temperature where the sand heater is installed is designed by giving 5 ^{O}C safety factor beyond the pour point. After the two countermeasures is installed, the next step is analysing the most suitable paraffin problem countermeasures from the wellhead to the manifold and separator in field JB.

RESULT AND DISCUSSION

In this study case, two production well models analysis is done, there are Well JB-1 and JB-2. Where JB-1 has oil type that doesnt have paraffin problem potential, and in the other hand, Well JB-2 has paraffin problem potential. This two different types of oil unify in the manifold and streamed to the separator. So, paraffin problem countermeasures is needed, and in this study case, heating method is procured. After the countermeasures is installed, paraffin deposition wont be experienced is hoped.

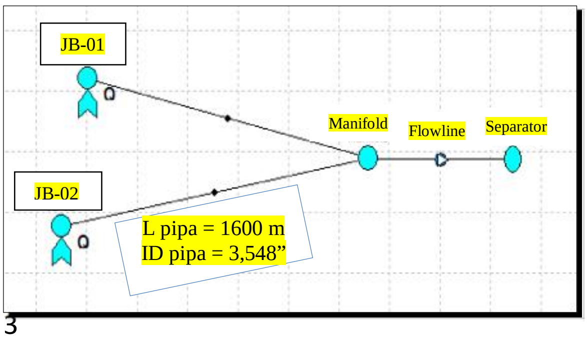

Figure 2. Flowline Scheme until Separator

Figure 2.explained about the analysis that will be conducted on two production wells in JB field, namely JB-01 and JB-02 wells. Where, JB-1 well has a type of oil that does not have the potential paraffin. Meanwhile, the JB-2 well has a paraffinic oil type.

Surface Facilities Data

Surface facilities data will be explained in Table 1 as follows :

Table 1. Surface Facilities Data

Well	Manifold Unit		Separator Unit	
	Pipe Length (m)	ID Pipe	Pipe Length (m)	ID Pipe
Well JB-01	1125	3,548"	600	6,065"
Well JB-02	1600	3,548"	600	6,065"

Table 1 explains the surface data facilities available in t JB field for JB-01 well and JB-02 well. With the existing data of surface facilities, we can calculate the pressure and temperature drop with the physical properties data of the fluid production and the pressure and temperature data in the wellhead.

Physical Properties of Production Fluids Data

The production fluid data at JB-01 and JB-02 wells can be seen in Table 2. The tendency of paraffin precipitate in JB field production well is found in JB-02 well.

Table 2. Oil Physical Properties of Well JB-01

Well	Parameters	Units	Results
Well JB-01	Q oil	BOPD	70,36
	Q water	BWPD	15,00
	Qtotal	BFPD	85,36
	SG @60 ºF	-	0,85
	API @60 ºF	-	35,4
	Viscosiy Kinematic	cSt	20,80
	Pour Point	ºC	35
	BS & W	% vol	0,01

Table 3. OilPhysical Properties at Well JB-02

Well	Parameters	Units	Result
Well JB-02	Q oil	BOPD	54,37
	Q water	BWPD	13,00
	Qtotal	BFPD	67,37
	SG @60 ºF	-	0,8676
	API @60 ºF	-	31,6
	Viscosity Kinematic	cSt	84,90
	Pour Point	ºC	43
	BS & W	% vol	0,05

Table 2 and Table 3 explains the well fluid characterization data of JB-01 and JB-02 wells. In the physical properties data of the production fluid shows that JTB-02 well has a tendency of paraffin precipitate potential because it has higher pour point oil viscosity, and more sediment content than JTB-01 well. Thus, the possibility of paraffin potency occurring at JTB-02 well.

Pressure and Temperature Data

Pressure and temperature data of well JB-01 and JB-02 at wellhead as follows :

JB-01

Wellhead Pressure = 105 psia
Wellhead Temperature = 80 ºC

JB-02

Wellhead Pressure = 130 psia
Wellhead Temperature = 65 ºC

From the parameters above can be identified the tendency of parraffin in flowline according to pressure and temperature drop.

Calculation of Temperature Drop

The decreasing in flow temperature is a major factor that causes paraffin precipitate. If the oil flow temperature falls below the pour point, there will be paraffin precipitate, and to determine the tendency of paraffin precipitation, a profile of flowline decrease in the flowline is made. The equation used to determine the temperature loss by the Karge Method, is by Equations (1) and (2) as follows:

$$z = \frac{2{,}54x3{,}14x0{,}75x3{,}548xL}{0{,}4462x0{,}248x10^5}$$

= 0,00192 L

$$\frac{T_0 - T_1}{T_2 - T_1} = e^{0{,}00192\,L}$$

Finding the flow temperature over the distance is used at L various prices . Flow temperature calculations are performed at the total pipe length from wellhead to manifold, whereL_{total} = 1600 m

Table 4. Oil Temperature Analysis JB-02

Distance from well (m)	Temperature (ºC)	Description
0	65,00	*Wellhead*
400	44,22	
1000	31,82	
1400	28,72	
1600	27,86	*Manifold*

$$\frac{T_0 - T_1}{T_2 - T_1} = e^{0{,}00192\,x1600}$$

$$\frac{65 - 26}{T_2 - 26} = e^{0{,}00192x1600}$$

T_2 = 27,86 ºC

pemisahan panas fluida daripipa, Table 4. Temperature Decrease at Well JB-2

A certain temperature drop at spesific distance can be determined by calculations above, whereL_{total} = 1600 m and the temperature is = 27,86ºC with pour point temperature 43 ºC that can be found with:

$$\frac{T_0 - T_1}{T_2 - T_1} = e^{z}$$

$$\frac{65 - 26}{43 - 26} = e^{0{,}00192\,L}$$

Ln 2,29412 = 0,0019 L
L = 436, 51 meter

From the analysis of temperature lossnya in this case there is a decrease in flow temperature at well JB-2 that exceeds the temperature pour point limit. The distance calculation above is the distance at the temperature of pour point = 43 ºC, from the calculation can be analyzed that the paraffin precipitation will occur if the temperature drop cross the pour point temperature that can occur at a greater distance 436.51 m from the wellhead. Thus, it can be indicated that there is a tendency for paraffin problems from that distance. Furthermore, the analyzed will be continue with pressure loss.

The Calculation of Pressure

Changes in pressure or decreased flow pressure will cause a mild fraction to leave the oil, and leaving the oil with heavy fraction, this is whatcauses the tendency of paraffin precipitation in paraffin. Flow pattern can be known using Darcy-Weisbach method. Based on actual conditions at the moment, the parameters above can be calculated with the following steps:

a. Mixed density can be calculated with equation (3) :

ρ_{mixed} = [(54,37/67,37)x0,8676x62,4] + [(13/67,37)x1,0x62,4]

ρ_{mixed} = 55,7324 lb/ft^3

Mixed SD can be calculated with equation (4):

SG_{mixed} $=\rho_{mixed}/\rho_{water}$
=55,7324lb/ft^3/62,4 lb/ft^3
= 0,8931

b. Mixed viscosity can be calculated with equation (5) :

μ *oil* = 0,8676 x 87,9 Cst
= 76,2620 cp
= 0,05125 lb/ft-sec

μ *water* = 1,0 x 87,9 Cst
= 87,9 cp
= 87,9/1488 = 0,05907 lb/ft-sec

μ mixed = 0,8931x 87,9 Cst
= 78,5077 cp
= 0,05276 lb/ft-sec

c. *Velocity*, can be calculated with equation (6) :

$$V = \frac{Q(BFPD)x42(gal/bbl)x0{,}13368(cuft/gal)}{0{,}25x®x(3{,}548/12)^2 x86400(day/\sec)}$$

$$= \frac{67{,}37\,x42x0{,}13368}{0{,}25x3{,}14x(3{,}548/12)^2 x86400}$$

= 0,0638 ft/sec

d. *Reynold Number*, can be calculated (7) :

$$\text{Re} = \frac{55{,}7324\,x0{,}022307\;\;x(3{,}548/12)}{0{,}05276}$$

Re = 19,925

e. Flow Type

nRe < 2000 = laminer flow, nRe = 19,925 for well JB-2, so the flow type is laminer.

f. Determine the friction factor (f), can be calculated with equation (8) :

$$f = \frac{64}{19{,}925} = 3{,}212$$

g. Pressure drop for two phases from dari wellhead-manifold, with L = 5248 ft, can be calculated with equation (9) :

$$\Delta P/100 = \frac{55{,}7324\,x3{,}6213x5248x(0{,}0638)^2}{144x\left(3.548/12\right)x2x32{,}2}$$

ΔP = 1,3945 psia/100 ft

h. Pipe length wellhead-manifold = 9680 ft

Pressure Loss = 9680 ft * 1,3945 psia/100 ft
= 134,98 psia

Pressure at Manifold= Pwh – Pressure Loss
= 130 – 134,98 psia
= -4,98 psia

Based on the calculation using the equation (Beggs and Shiu, 1976) of flow pressure drop, the value of pressure loss is 134,98 psia while pressure at wellhead is 130 psia. From the calculation, it shows that the pressure loss in the pipes from the wellhead to the well manifold JB-2 is greater than the pressure in the JB-2 wellhead. Thus, it can be indicated from the analysis of temperature loss and also pressure loss (Camahan, F. Norman, 1989) on the pipeline of the JB-2 wellhead until the manifold occurs paraffin problem at that spesific distance. Furthermore, the act to overcome the paraffin problem is needed.

Treating Paraffin Problem

The main purpose of treating paraffin is to maintain heat in the flow of oil so it remains stable above its pour point temperature so that the oil does not freeze and the paraffin precipitate does not form along the flowline and the oil continues to flow to the collecting station by maintaining the heat loss and adding temperature certain points.

Treating the paraffin precipitation can be done with two methods :

1. Installation of insulation on the flowline of JB-02 wellhead to manifold with 10 mm calcium silicate with aluminum coating.
2. Installation of one sand heater at a distance of 960 m is greater than the JB-02 wellhead on the insulated flowline.

Treating with Insulation

The first step will be done by installing insulation calcium silicate type with thickness of 10 mm and coated by aluminum with conductivity of calcium silicate of 0.063

W/m/K in the pipe of the wellhead JB-02 to the manifold with the following scheme:

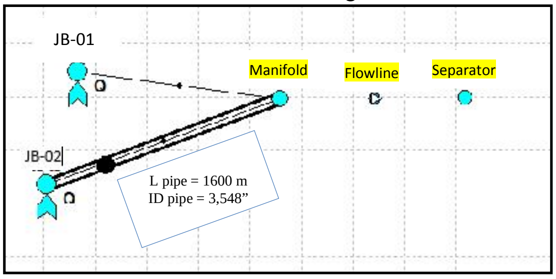

Figure 3.Flowline Scheme Using Insulation from Wellhead JB-2 to Manifold

Figure 3. explains the description of the first step of treating that being performed on the flowline of the wellhead JB-02. In the scheme is shown that the insulation at the flowline of the wellhead JB-02 due to paraffin analysis on the flowline of the wellhead JB-02 obtained the following results:

Table 5. Temperature Drop at Well JB-02

The Distance from Well (m)	Temperature (ºC)	Notes
0	65,00	*Wellhead*
320	58,27	
1280	44,24	
1404,77	43,00	
1600	41,06	*Manifold*

Table 5 shows a decrease in oil flow temperature after insulation. From the calculation, analyzed in the flow pipe of JB-02 wellhead with a length of 1600 m of pipe there is a decrease in temperature smaller than before the treating is being done, but still experiencing paraffin. Because the temperature in the manifold is below the temperature of the pour point of oil that is equal to 41.06 ºC, with oil pour point 43 ºC. The result of insulation control is obtained by decreasing the temperature that exceeds the pour point at 1404.77 m distance from the JB-02 wellhead. Thus, in this type of treating, it is said that **it has not succeeded** in overcoming the paraffin precipitate because the sediment still occurs at a distance of 1404.77 m. Therefore, a second countermeasure is required with insulation and sand heater.

Treating with Sand Heater

The second type of treatment is the installation of sand heater in the flowline at flow pipe with the distance 960 m that being insulated from the JB-02 wellhead where the temperature at the distance is 48 ºC is designed with a safety factor 5 ºC above the pour point with the following scheme :

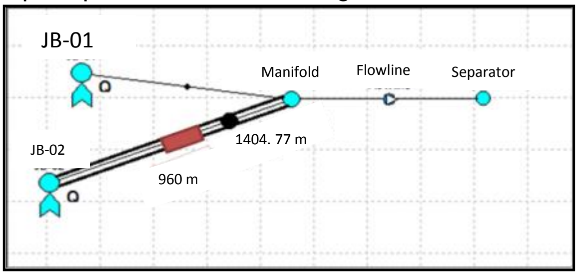

Figure 4. Scheme of Flowline Using Insulation and Sand Heater to Manifold

Figure 4.explain the description of the second countermeasures to be performed on the flowline of the JB-02 wellhead. In the scheme has been done the countermeasures by insulation installation on the flowline of the wellhead JB-02 and the installation of sand heater at a distance of 960 m from the wellhead. Where, paraffin precipitation occurs at a distance of 1404.77 m greater than JB-02 wellhead with pipe length from well head JB-02 to manifold along 1600 m when insulation is made in the first step and obtained the second result as follows:

Table 6. Temperature Drop at Well JB-02

The Distance from Well (m)	Temperature (ºC)	Notes
0	65,00	*Wellhead*
320	58,27	
640	52,69	
960	66,07	
1280	62,24	
1404,77	61	
1600	59,06	*Manifold*

Table 6 shows a decrease in oil flow temperature after insulation. From the calculation, it is analysed with a length of 1600 m pipes until the manifold there is a decrease in temperature that is smaller than before the treating is being done, and does not have paraffin precipitate. Because the temperature in the manifold is above the temperature of the oil pour point with 59.06 ºC, the temperature of the oil pour point of 43 ºC.

And the length of the pipe 100 m from the manifold to the separator also does not have paraffin precipitate, where the temperature in the separator is obtained at 57.39 ºC. The result of insulation and sand heater did not contained paraffin precipitation at the distance until separator. Thus, in this type of teating, is said to be successfully overcoming paraffin in JB-02 well flowing pipe.

CONCLUSION

1. Based on the temperature analysis of JB-02 well with pipe length 1600 m, the temperature drop is passed the pour point. The temperature of the end pipe is 27.86^{o}C with pour point 43^{o}C. This condition shows there is possibilities of paraffin happened.
2. After the temperature analysis has shown the possibilities in paraffin happened, the pressure analysis should be done. At JB-02 well, the pressure drop is greater than the initial pressure at the wellhead. The wellhead pressure value is 130 psia and pressure drop till the end of the pipe is 134.98 psia. This condition shows that there is no flow in the pipe because of paraffin deposition.
3. The first treatment to solve paraffin problem is by equipping calcium cilicate insulator type with thickness of 10 mm and coated aluminum. This treatment is not too effective because there is still happened paraffin deposition at 1404.77m from wellhead
4. The second treatment is applied with sand heater installation at the flowline with safety factor 5^{o}C above oil pour point at 960m. The safety factor is applied in order to avoid the pressure drop at night or rain. The second treatment can countermeasures the paraffin problemsuccesfully from wellhead till manifold. The temperature at manifold is 59.06^{o}C which is still greater than oil pour point = 43^{o}C.
5. The next analysis is to examine the paraffin problem from the manifold to the separator, there is a change of the fluid composition so the pour point becomes 35 ºC, but there is no paraffin precipitation because it has been **successfully** overcome by sand heater installation before the manifold, so the installation of insulation after manifold is needed to keep the temperature still above the pour point.

REFERENCES

Arnold, Ken P.E., Surface Production Operation : Design of Oil-Handling System and Facilities", Volume I Chapter 3 (p.55-65), Chapter 8 (p.226-255), Gulf Publishing Company, Houstoun, Texas, 1986.

Ahmed, Tarek H., Hydrocarbon Phase Behavior" Volume 7 (p.206-207), Gulf Publishing Company, Houstoun, Texas, 1989.

A.K. Soejoso,.Handling of Heavy JB Crude Oil Production (p.1-14), Reservoir Engineering Pertamina Unit III, Maret, 1974.

Carnahan, F. Norman, *Paraffin* Deposition in Petroleum Production, SPE JPT (Journal of Petroleum Technology), October, 1989.

Core Laboratories Inc, "Data-data JB-02". Mei, 2017.

C.E. Reistle, JR., *Paraffin* Production Problem, East Texas Engineering Association, Texas.

Hunt, Elton B. JR, Laboratory Study of *Paraffin* Deposition, Pan American Petroleum Corp, Tulsa, Okla, 1962.

Hammami, Ahmed. Raines, A. Michael, *Paraffin* Deposition from Crude Oils : Comparison of Laboratory Result to Field Data, San Antonio, Texas, 1997.

Beggs and Shiu, Johnny Kuo-Cheng,An Empirical Method of Predicting Pressure and Temperatures in Flowing Wells, Tulsa, 1976.

McCain, W. D., The Properties of Petroleum Fluids, Second Edition pages 237, PennWell Publishing Company Tulsa., Oklahoma, 1990.

Misra, Sanjay, dkk, *Paraffin* Problems in Crude Oil Production and Transportation : A Review, SPE Oil & Natural Gas Corp, 1995.