GE-International Journal of Engineering Research
Vol. 5, Issue 3, March 2017 **Impact Factor- 5.613**
ISSN(O): 2321-1717, ISSN(P): 2394-420X

Website: www.aarf.asia Email : editor@aarf.asia , editoraarf@gmail.com

EFFECTS OF TEMPERATURE ON NIGERIAN WAXY CRUDE OIL

Igwilo K.C[1]. , Anawe P. A.L[2]. , Orodu O.D[3]., Okechukwu L T[4].., Okolie T.A[5].

[1,2,3,4] Covenant University, Ota, Ogun State, Nigeria. 4 Federal University of Technology, Owerri, Imo State, Nigeria.

ABSTRACT

This technical paper evaluates the effects of temperature on Nigerian waxy crude oil. The laboratory measurements were carried out on wax appearance temperature, using the precipitation method. The transient state measurement, the degree of viscosity reduction and the yield stress of the given crude oil were also determined. It is noted that the crude oil sample has no transient behavior since the shear stress shows time independent behavior. It can be observed that the yield stress which was required to start the flow decreased as the temperature increases. The results of the study shows that the percent wax deposited decreased as temperature increases. Also the percent Degree of Viscosity Reduction increased from 20^{O}C to 60^{O}C. Also, the Nigerian waxy crude oil has no transient behavior and the yield stress decreased as the temperature increases.

Key words: Temperature, Nigerian waxy crude oil, Transient state, Yield stress, Degree of viscosity reduction.

INTRODUCTION

The severity of paraffin deposition depends predominantly on the composition (wax content) of the crude oil, the cloud-and pour-points, the rate of evolution of gas, well depth, formation temperature, the ambient and operating temperatures, pressure drop, previous shear history, pipe roughness and production practices. Cloud-point is the temperature at which a haze forms in clear oil which is being cooled. For a crude oil, it is the temperature at which paraffin particles begin to precipitate out of solution. Generally, depending on the flow regime, wax deposition begins to occur on any surface referred to as cold spot whose temperature is below this critical cloud-point and that of the bulk oil. The pour-point is defined as the temperature below which the oil ceases to flow (pour). The pour-point is usually 10°F-20°F lower than the cloud-point. In the case of asphaltene deposition, the severity depends mainly on the composition of the crude oil, operating pressure and temperature and the enhanced oil recovery methods. It is known in both cases that the severity of the problem increases with the age of the oil field. Thus the term waxy crude is used to embrace both kinds of organic deposition. Of the two kinds of deposition, paraffin deposition is the most widespread and more easily handled while asphaltene deposition is much more difficult to treat because of the complex depositional relationship between the crude oil composition, pressure and temperature.

Wax is a commonly occurring component of crude oil. It is generally characterized as consisting of large n-paraffins that are solid at room temperature when isolated. Yet, they are soluble in the crude oil mixture at elevated temperatures. Waxy crude oils are crude oils with relatively high amount of wax suspended in them (1). It is found that n-paraffin dissolved in organic solvents display a sharp transition in gel strength at the pour point, whereas by addition of isoparaffins, the buildup in gel strength as a function of temperature is much more gradual, because increasing isoparaffin fraction facilitates the formation of amorphous wax solids (2).

At high temperatures, waxes are in the molten state, and crude oils normally behave like Newtonian fluids (3). If waxy crude is allowed to cool to the temperatures below the Wax Appearance Temperature (WAT), wax will precipitate, agglomerate and entrap the liquid oil into its structure, and the crude will become a two-phase dispersion with wax solid particles dispersed in the liquid hydrocarbons. Precipitation of wax significantly increases crude viscosity and will gradually change the flow properties of the crude from Newtonian to non-Newtonian behavior. The crude begins to show non-Newtonian flow behavior at a temperature called the abnormal point which is generally a few degree Celsius below the WAT. Further cooling of the crude enhances the gel formation.

MATERIALS AND METHODS

A crude oil sample from the Niger-Delta basin is collected. The characteristics of the crude oil sample are presented in Table1. Initially, the crude oil is homogenized by shaking it for an hour to ensure that the crude oil's physical properties are the same anywhere the sample is taken for the measurements. The measurements are taken at room temperature.

Table 1: Characteristics of the Crude Oil Sample.

SAMPLE	A
SPECIFIC GRAVITY	0.91
API	23.99
POUR POINT	- $19^{O}C$
CLOUD POINT	- $13^{O}C$
TYPE	INTERMEDIATE CRUDE

Laboratory measurements were carried out on wax appearance temperature, followed by the transient test was also conducted in order to know the behavior of the crude oil sample with respect to time.

We also carried out a study to know the % Degree of Viscosity Reduction, that is, the degree of viscosity reduction (%DVR) was introduced and calculated using the equation below and the result shown in table 4.

$$DVR\% = (\eta_r - \eta_c) * 100 / \eta_r$$

Where η_r is the reference viscosity at $50s^{-1}$ shear rate and 20°C, and η_c is the corresponding viscosity at $50s^{-1}$ shear rate and corresponding temperature. Yield stress was also determined at different temperatures as shown in table 5.

RESULTS AND DISCUSSION

Four tables of data results which include wax appearance temperature, % degree of viscosity reduction, transient measurements and yield stress were then generated and their results then discussed.

Table 2: Wax precipitated at different temperatures

Temperature (°C)	Weight of residue (g)	Weight of precipitate (g)	Wax precipitated (%)
-10	1.29	0.83	45.60
0	0.96	0.50	27.47
10	0.79	0.33	18.13
20	0.72	0.26	14.29
30	0.65	0.19	10.44
40	0.57	0.11	6.04
50	0.52	0.06	3.30
60	0.46	0.00	0.00

Table 3: DVR % of crude oil versus temperature

Temperature, °C	DVR %
20	0
30	61
50	78
60	81

Table 4: Transient Measurements at Constant 600 rpm

25°C		45°C		65°C	
τ, Pa	t, s	τ, Pa	t, s	τ, Pa	t, s
53.7	30	20.5	30	9.20	30
53.7	60	20.5	60	9.20	60
53.7	100	20.5	100	9.20	100
53.7	140	20.5	140	9.20	140
53.7	170	20.5	170	9.20	170
53.4	200	20.5	200	9.20	200
53.4	230	19.9	230	9.20	230
53.4	270	19.9	270	9.20	270
53.4	300	19.9	300	8.70	300

Table 5: Yield Stress of the Crude Oil Sample at different temperatures

Yield Stress, Pa	Temperature °C
2.04	20
0.67	30
0.62	50
0.47	60

From tables 2 to 5 above, they following discussions were made. % Wax precipitated decreased as temperature increases.

Also, the % Degree of Viscosity Reduction (% DVR) over the temperature range of 20°C to 60°C occur. A significant increase in %DVR from 0 to 81 was noticed as the temperature increases from 20°C to 60°C. This can be attributed to strong effect of temperature on the viscosity of heavy components of the crude. The second reason is due to the effect of high temperature on the chemical structure of heavy components in the crude oil phase, and hence reducing the oil viscosity.

It is noted that the crude oil sample has no transient behavior since the shear stress shows time independent behavior. It can be observed that the yield stress which is required to start the flow decreased as the temperature increases.

CONCLUSIONS

- Wax precipitates out of the waxy crude oil at temperatures below its wax appearance temperature (WAT). And as the temperature decreases below the wax appearance temperature, the amount of wax precipitated increases.
- The yield stress required to start the flow of the crude oil sample decreased with increase in temperature.
- The crude oil sample did not show any transient behavior, hence there is no time dependent.

REFERENCES

1. Wardhaugh L.T., Boger D.V. and Tonner S.P. (1988): Rheology of Waxy Crude Oils, SPE 17625.
2. Vistin R.F.G., et al. (2005): Rheological Behavior and Structural Interpretation of Waxy Crude Oil Gels.
3. Shadi Hasan (2007): Rheology of Heavy Crude Oil and Viscosity Reduction for Pipeline Transportation.