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Comparative Study of the Effect of Temperature on the Viscosity of Niger Delta Crude Oils.

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Abstract: This research work compared the effect of temperature on the viscosity of Niger Delta oils. The investigation was carried out on five crude oil samples obtained from different reservoirs in the Niger Delta region. Experimental method was used to determine the effect of temperature on the viscosity of these crude oil samples under gravity flow in a capillary tube viscometer inserted in a thermostatically controlled water bath at temperatures below and above room temperature from 100C to 900C. The results show the variation of their kinematics and dynamics viscosities with temperature. It shows that NOAC crude oil had the highest API value of 36.392, while Umuechem 7L had the least API value of 20.095. The results show that the viscosity of Niger Delta crude oils reduces with an increase in temperature in all capillary or pipeline system. Pipes with larger diameter should be designed for locations in the Niger Delta to ease flow in pipeline transportation.

Key Words: Viscosity, temperature, Niger Delta, crude oil, viscometer

Introduction

Crude oil is a form of unprocessed oil that comes out of the ground, composed primarily of hydrocarbons which are carbons and hydrogen and also contains trace quantities of oxygen, nitrogen and heavy metals in some cases (Olutoye, 2005). According to Abdulkareem and Kovo (2006), crude oil is one of the most important constituents of the reservoir fluids. Therefore, a better understanding of the nature and properties of the crude petroleum is important in the viscosity of crude petroleum and its applications.

An important physical property of petroleum necessary in the studying flow characteristics is viscosity which is a measure of the crude oil resistance to flow or penetration (Little and Kennedy, 1968). According to Sattarin et al (2007), the viscosity of crude oil varies depending on its origin, type and the nature of its chemical composition, particularly the polar components, for which intermolecular interactions can occur. Crude oil viscosity increases with decrease in API gravity and also increases with decrease in temperature (Standing, 1957).

The Niger Delta region consists of 606 oil field enriched with various kind of crude oil, 353 are onshore and 251 are offshore (Ahmed, 1992). The study of viscosity of crude oil in Niger delta can be determined by the use of viscometer at different temperature though there are other methods that can be used to determine the viscosity of a particular sample of crude oil (Olutoye, 2005).

The evaluation of viscosity of dead oil is an important step in the design of various operations in oilfield and refineries. Therefore, viscosity of crude oil, which is pressure and temperature dependent, must be evaluated for both reservoir engineering and operation design (Sattarin et al., 2007).

There are various method of predicting oil viscosities among the early works found ,the most popular method presently used are those of (Beal 1946) for dead oil viscosity; Chew and Conally (1959) for life of saturated oil. Beal (1946) correlated dead oil viscosity as a function of API gravity and temperature. Chew and Conally (1959) presented a correlation for the effect s of dissolved gas on the viscosity. The variation of viscosity with temperature is important, frequently, it is necessary to evaluate a crude oil with respect to viscosity. Viscosity plays an important role in reservoir simulations as well as in determining the structures of liquids. This paper presents a comparative study of the effect of temperature on the viscosity of Niger Delta crude oils.

Materials and Method

The crude oil sample were collected from oil wells within the Niger Delta area. The following apparatus were used in the determination of viscosity of the samples, this are thermometer, cylinder, beaker, thermostatically controlled water bath, stop watch, 300 size capillary viscometer. The viscosity of the samples were determined at temperature below and above room temperature (30^0C); from 10^0C to 90^0C. The standard determination of kinematic viscosity generally employs a glass u – tube viscometer with a capillary tube build into one leg (Abdulkareem and Kovo, 2006). The instrument is suspended vertically in a thermostatically controlled water bath, and the time measured for a given measured time period is inserted into equation (1) to give a direct measure of the kinematic viscosity.

$$V = Ct + {}^{B}/_{t} \tag{1}$$

Where C is the instrument calibration constant, B is the instrument type constant depending on the capillary diameter, t is efflux time in seconds.

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The viscometer was cleansed with a non-toxic solvent and dried. A certain amount of each crude oil sample was poured into a beaker, then transferred to the viscometer. The viscometer was inserted into the water bath at the required temperature. The pump was used to raise the level of the crude to the starting mark on the left hand limp of the viscometer; another finger was used to close the other limp to avoid the flow of the crude due to air. The finger was removed to allow the flow of crude down the capillary at that point, the time at which the crude flow down was taken and recorded. This process was repeated for the various crude oils and at different temperature.

Results and Discussion

Table 1 shows the densities and API gravity of the crude oil samples. The densities of the samples were obtained using the density bottle at room temperature (37^0C). According to Standing (1957), the API gravity of the dead crude oil can be assumed to remain near constant at the temperatures studied. Density of crude oil as a function of pressure and temperature can be expressed by this relationship

$$\rho = \rho_{sc} + \Delta\rho_p - \Delta\rho_T \quad (2)$$

Where ρ is crude oil density at P (pressure) and T (temperature), ρ_{sc} is crude oil density at standard condition, $\Delta\rho_p$ is density correction for compressibility of oils and $\Delta\rho_T$ is density correction for thermal expansion of oils.

According to Taraneh et al (2008), viscosity is influenced by the effect of temperature reduction that causes increase in viscosity at a particular shear rate. Abdulkareem and Kovo (2006) discovered that for a given oil, the viscosity with temperature slope change rapidly with temperature for different crude oil fraction from the same natural source. It is evident generally that that as temperature increases the viscosity of each oil decreases appearing to reach an asymptotic limit. According to Kumar et al (2014), viscosity is influenced by two parameters: the effect of temperature reduction that causes increase in viscosity at a particular shear rate.

Table 2 shows variation of experimental kinematics viscosity values of different crude oil samples with temperature, while Table 3 shows variation of experimental dynamic viscosity values of different crude oil samples with temperature. NAOC has the lowest kinematic and dynamic viscosities at the different temperatures followed by Ubit, Umuechem 12L, Usari and Umuechem 7L, with the highest viscosity, which implies that the higher the temperature, the lower the viscosity.

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Table 1 shows that NAOC crude oil is the lightest, while Umuechem 7L oil is the heaviest from density values. The higher the temperature, the lower the viscosity, thus the higher the API gravity value which stands as an indicator to the worth of the crude oil. High API gravity value means that the crude is light and can be easily transported in pipelines. The results indicate that NAOC has the highest API gravity value, while Umuechem 7L has the lowest API gravity value.

Table 4 shows variation of predicted kinematics viscosity values of different crude oil samples with temperature, while Table 5 shows variation of predicted dynamic viscosity values of different crude oil samples with temperature. The result also show that the predicted kinematic and dynamic viscosity values reduces with an increase in temperature.

Table 1: Densities and API gravity values of the crude oil samples

Crude oil samples	**Umuechem 7L**	**Umuechem 12L**	**NAOC**	**Ubit**	**Usari**
Density (g/cm^3)	**0.933**	**0.863**	**0.843**	**0.852**	**0.904**
API gravity	**20.095**	**25.095**	**36.392**	**34.482**	**32.463**

Table 2: Experimental kinematics viscosity of the different crude oil samples

Temperature (^0C)	**Crude oil samples and viscosity values**				
	Umuechem 7L	**Umuechem 12L**	**NAOC**	**Ubit**	**Usari**
10	155.503	43.835	7.675	12.745	78.148
20	90.250	9.080	4.980	6.065	26.313
30	84.038	8.605	4.380	5.375	24.483

ISSN 2229-5518

40	45.175	6.735	3.660	4.100	18.448
50	38.202	5.898	3.465	3.705	15.593
60	29.695	5.078	3.263	3.165	12.745
70	22.578	4.490	3.120	2.858	11.040
80	17.445	3.813	2.648	2.675	9.095
90	14.125	3.685	2.350	2.385	8.535

Table 3: Experimental dynamic viscosity of the different crude oil samples

Temperature (^{0}C)	**Crude oil samples and viscosity values**				
	Umuechem 7L	**Umuechem 12L**	**NAOC**	**Ubit**	**Usari**
10	145.146	42.145	6.469	10.864	70.614
20	84.274	7.860	4.197	5.170	23.776
30	78.441	7.126	3.692	4.382	22.122
40	42.166	5.812	3.085	3.158	16.669
50	35.698	5.090	2.920	2.698	14.089
60	27.717	4.382	2.750	2.436	11.516
70	21.074	3.875	2.630	2.280	9.976
80	16.283	3.290	2.213	2.280	8.218
90	13.184	3.180	1.981	2.030	7.712

Table 4: Predicted kinematics viscosity of the different crude oil samples

Temperature (^{0}C)	**Crude oil samples and viscosity values**				
	Umuechem 7L	**Umuechem 12L**	**NAOC**	**Ubit**	**Usari**
10	3.318	5.315	5.885	5.642	4.124
20	3.214	5.149	5.701	5.466	3.995
30	3.120	4.999	5.535	5.306	3.879
40	3.035	4.862	5.530	5.161	3.772
50	2.957	4.734	5.245	5.029	3.675
60	2.886	4.623	5.118	4.907	3.587
70	2.816	4.517	5.002	4.795	3.505
80	2.759	4.429	4.894	4.692	3.429
90	2.703	4.330	4.795	4.597	3.359

Table 5: Predicted dynamic viscosity of the different crude oil samples

Temperature (^0C)	Crude oil samples and viscosity values				
	Umuechem 7L	Umuechem 12L	NAOC	Ubit	Usari
10	3.097	4.587	4.960	4.810	3.726
20	2.999	4.444	4.805	4.660	3.610
30	2.912	4.314	4.665	4.523	3.505
40	2.833	4.196	4.534	4.400	3.408
50	2.760	4.085	4.420	4.287	3.321
60	2.694	3.989	4.313	4.183	3.241
70	2.631	3.898	4.216	4.088	3.167
80	2.575	3.822	4.125	3.999	3.098
90	2.522	3.737	4.041	3.919	3.035

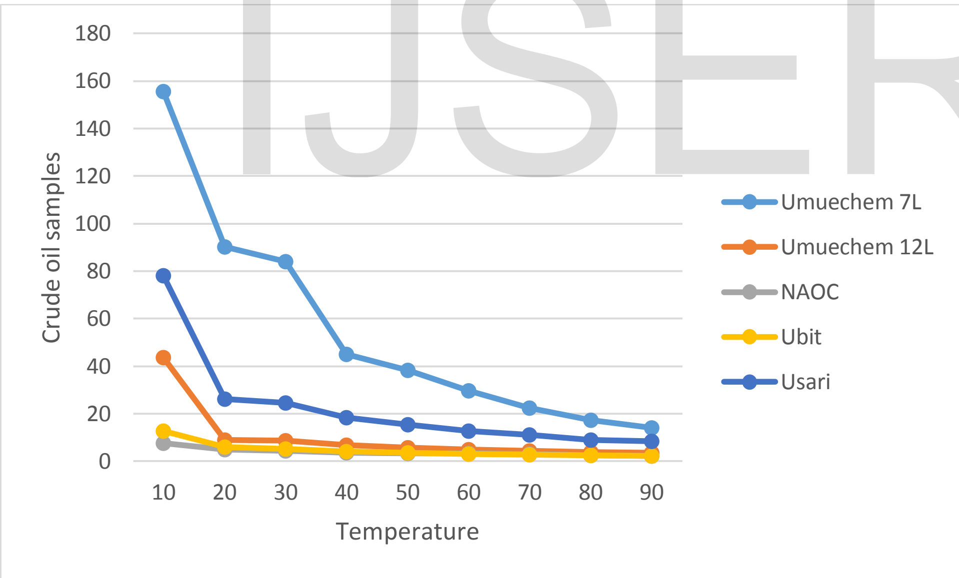

Figure 1: Graph of experimental kinematic viscosity against temperature

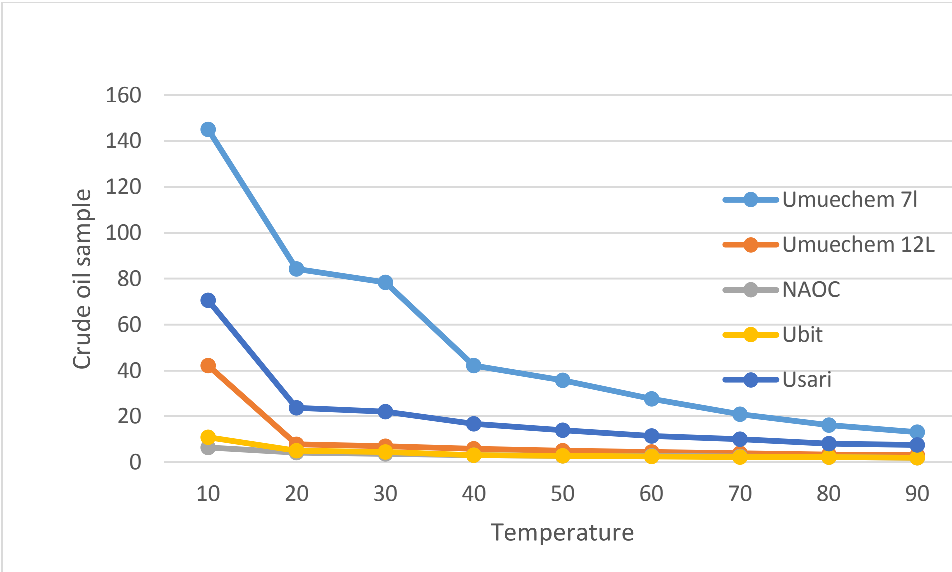

Figure 2: Graph of experimental dynamic viscosity against temperature

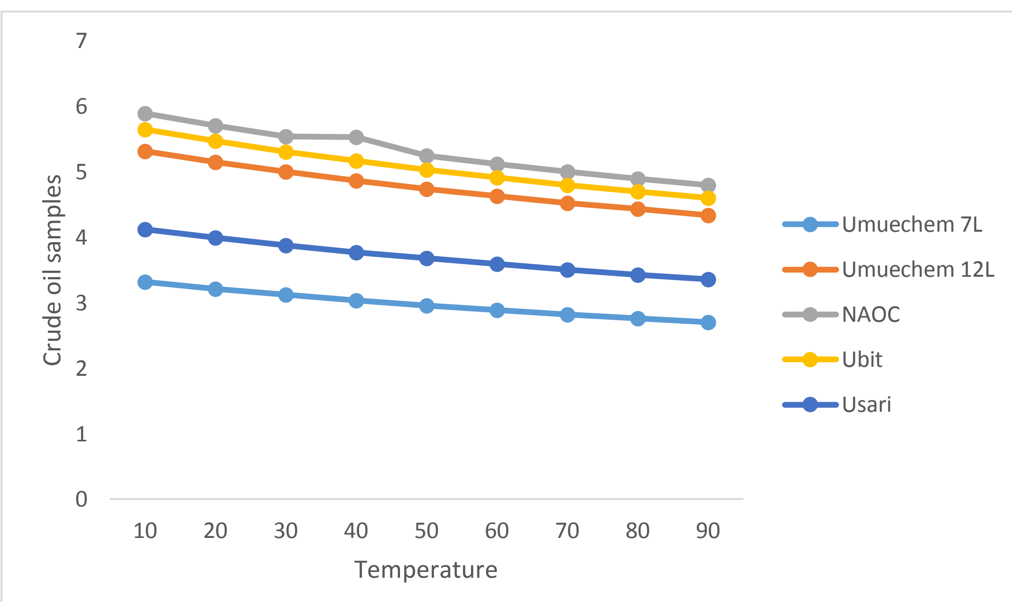

Figure 3: Graph of predicted kinematic viscosity against temperature

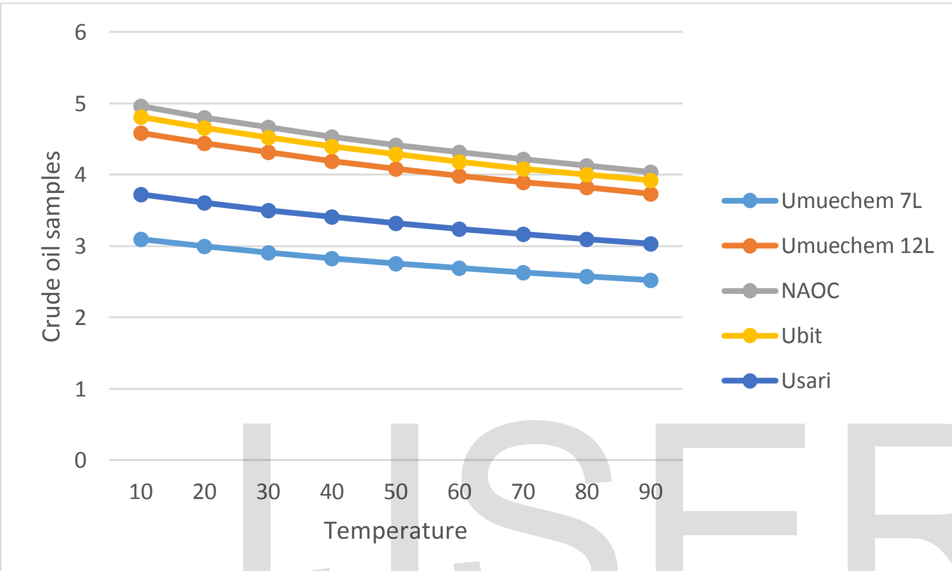

Figure 4: Graph of predicted dynamic viscosity against temperature

Conclusion and Recommendation

This paper concludes that the viscosity of Niger Delta crude oils reduces with an increase in temperature in all capillary or pipeline system. The temperature varies along the length of the pipe from maximum at the well head and re-heating station to temperature approaching the ambient condition. This is particularly important in the capillary viscometer where radial temperature gradients, bends and constriction affects composite effect. High viscosity of crude oil affect the measurement techniques, the interpretation of data and in aspects of design and operation of oil pipeline. Pipes with larger diameter should be designed for locations in the Niger Delta to ease flow in pipeline transportation. Since crude oil with high viscosities causes pipeline pressure drop and decrease in flow rate, flow improver additives should be added to these crude to reduce their viscosities, to enhance flow in pipelines.

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