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Simulation of the Viscosity of Different Nigerian Crude Oil

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Abstract

The main objective of this paper is to propose a suitable, simple procedure to predict viscosity of Nigerian crude oil. The data correlated were for light, medium and heavy crude oil samples collected from different sites in Nigeria, with densities ranging from 0.813-0.849 g/mol for light samples 0.886- 0.886 g/mol for medium samples, 0.925-.935 g/mol for heavy samples at 15°C respectively. The Puttangunta et al model for the viscosity's of conventional light crude oil was used for this study. The predicted viscosity's obtained were in good agreement with the experimental values. The average absolute deviation obtained is within the range of 1-17%. This shows that the Puttagunta et al model is the most suitable for predicting effect of temperature on kinematic viscosity.

Keywords

Crude oil, Viscosity, Puttaguntal model, Simulation

Introduction

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. The variation of viscosity with temperature is important, frequently, it is necessary to evaluate a crude oil with respect to viscosity, especially if the crude is to be worked up for lubrication oil. Also the viscosity of petroleum oils is of importance in studying the energy loses during production. Any engineering activities including piping and pipeline construction require the knowledge of the viscosity of the crude oil to enhance transportation. Viscosity plays an important role in reservoir simulations as well as in determining the structure of liquids. Several models for the viscosity of pure components and mixtures are available in literature, summarized recently in [1]. Good reviews are [2] and [3]. However, petroleum fluids were covered only by [1]. Petroleum fluids are complex fluids, normally of undefined composition that require a characterization procedure to obtain relevant properties. Therefore this paper intends to predict or simulate the viscosity of Nigerian crude oil using the available models.

Experiment

The crude oil samples, used for this experimental work, were obtained from oil wells or storage tank of the following companies: Shell, Agip and Elf. Both Qua Iboe and Brass light crude oil type were collected from storage tank. The following apparatus were used in the determination of viscosity of the crude oil, this include thermometer, 300 size, cannon-fenske type viscometer etc. The standard determination of kinematic viscosity generally employs a glass u-tube viscometer with a capillary tube build into one leg. The length-diameter ratio is such that end effects are negligible and the precision is, therefore higher. 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 below to give a direct measure of the kinematic viscosity in centistokes:

$$V = Ct + B/t \text{ [cSt]},$$

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

A certain amount of each crude oil sample was poured into a beaker then transferred to the viscometer. The viscometer have been cleansed with a non toxic solvent and dried.

The viscometer, containing the crude, is 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 is used to close the other limp to avoid the flow of the crude due to air. The finger is removed to allow his flow of crude down the capillary at that point, the time at which the crude flow down is taken and recorded. This process is repeated for the various crude oils and at different temperature. The viscosity then is obtained by multiplying the constant of the viscometer by the time obtained.

Simulation of Viscosity of Nigerian Crude Oil

The overall objective of this work is not to develop a new model, but to test the existing models. Attention was given to Punttagunta et al. equation given as:

$$\log \eta = \frac{b}{\left[1 + \frac{T - 37.78}{310.93}\right]^{s}} + C, \quad (1)$$

where η = viscosity (cSt), T = Temperature (°C). Other parameters are constants to be determined.

Linearising eq. (1) gives:

$$\log(\log \mu - c) = \log b - s \log\left(1 + \frac{T - 37.78}{310.93}\right) \quad (2)$$

Comparing equation 2 with the general straight line equation:

$$Y = Mx + C, \quad (3)$$

where Y = log(logμ-c), C = log b, M = -s, X = log(1+(T-37.78)/310.93).

Therefore the constants can be evaluated using linear regression analysis.

Determination of the Constants c, b and s

The viscosity-temperature curve was used to determine the constant c. the other coefficient was obtained using regression analysis.

Results

The comparative viscosity-temperature variation of the experimental results and the simulated (from Puttangunta & all) of pure Nigerian crude oil are presented in Tables 1 and 2.

Table 1. Qua Iboe Light-Enang B, Brass Light-Mbede 26 Tb, and Bonny Light-Terminal

	Qua Iboe Light-Enang B			Brass Light-Mbede 26 Tb			Bonny Light-Terminal		
Temp.	Viscosity [cSt]		Error	Viscosity [cSt]		Error	Viscosity [cSt]		Error
[°C]	Exp	Pred	[%]	Exp	Pred	[%]	Exp	Pred	[%]
15	9.05	9.1237	-0.8139	5.88	4.93277	16.1094	16.7	20.8178	-24.657
20	7.63	7.7506	-1.5805	4.63	4.19856	9.31836	14.8	15.7204	-6.2191
25	6.25	6.6493	-6.3893	3.38	3.61333	-6.9033	11.6	12.1342	-4.6047
30	5.63	5.7567	-2.2506	3	3.14132	-4.7107	8.75	9.55399	-9.1885
35	5.07	5.0261	0.8659	2.75	2.75646	-0.2349	8	7.65953	4.25588
40	4.55	4.4226	2.7998	2.63	2.43949	7.24373	7.38	6.24246	15.4138
45	4	3.9199	2.003	2.38	2.17601	8.57101	6.6	5.16433	21.7526
50	3.75	3.4978	6.7261	1.15	1.95508	-70.007	5.8	4.3312	25.3241
55	3.47	3.1407	9.4899	1.88	1.76836	5.9383	3.8	3.67816	3.20632
60	3.05	2.8366	6.9977	1.75	1.60937	8.036	3.2	3.1595	1.26563
65	2.5	2.5759	-3.034	1.63	1.47305	9.62883	2.35	2.74258	-16.706
70	2	2.351	-17.548	1.45	1.35543	6.52207	1.95	2.4037	-23.267
	%AAD = 5.0416			%AAD = 12.7686			%AAD = 12.9883		

Table 2. Bonny Medium Terminal and Bonny Light - Cawthon Channel 1

	Bonny Medium Terminal			Bonny Light - Cawthon Channel 1		
Temp.	Viscosity [cSt]		Error	Viscosity [cSt]		Error
[°C]	Exp	Pred	[%]	Exp	Pred	[%]
15	9.05	26.5	10.2217	8.88	8.8058	0.83559
20	7.63	17.7	-12.893	8	8.00522	-0.0653
25	6.25	16.3	-3.9318	7.25	7.30702	-0.7865
30	5.63	15	3.4098	6.72	6.69525	0.3683
35	5.07	12.8	2.40289	6.08	6.15683	-1.2637
40	4.55	10.6	-2.3908	5.7	5.68098	0.33368
45	4	9.3	-2.1134	5.25	5.25876	-0.1669
50	3.75	8.25	-1.389	4.9	4.88271	0.35286
55	3.47	8.13	8.81402	4.73	4.54659	3.87759
60	3.05	7.05	6.25915	4.3	4.24513	1.27605
65	2.5	6.25	5.2224	3.95	3.97388	-0.6046
70	2	4.55	-17.291	3.55	3.72907	-5.0442
	%AAD = 6.3616			%AAD = 1.2479		

Discussions

Puttaguntal model is a one parameter viscosity in which temperature correlation was developed from the simplest expression for the change in viscosity with temperature which give the slope as the viscosity. Since, for a given crude oil, the slope change rapidly with temperature for different crude oil fraction from the same natural source, it is evident generally that as temperature increases the viscosity of each oil decreases appearing to reach an asymptotic limit.

The results obtained are shown in the table of result. In order to verify the correctness of the Puttaguntal et al model, the percentage error was calculated for each of the viscosity and compared with experimental values. The average absolute deviation (AAD) is the mean of the sum of the deviation or error percentage obtained in a set of data. The overall average deviation for the entire data is 7.5%. The average absolute deviation for the qua-Iboe, utua-Enang B was found to be 5.04% while the AAD for brass light - Mbede 20TB is 12.76%. The AAD for Brass light-shade 26TB, Bonny light-terminal, Bonny medium terminal and Bonny light-cawthon channel are 12.76%, 12.988%, 6.36% and 25% respectively.

The result showed that the correlation can predict as good as experimental measurement particularly for lower viscosity crude oil fraction.

Conclusion

A simple and generalized correlation has been presented for predicting the kinematic viscosity of light crude petroleum. The predictions were based on a single viscosity measurement, at 37.78°C and one atmosphere pressure, which does not require any physical parameter. The overall average absolute deviation for the entire pure crude data for the Puttagunta et al model equation was found to be 7.5%. Puttagunta et al equations were found to be the most suitable for the prediction of viscosity, since it can predict as good as experimental measurement particularly for lower viscosity crude oil fractions.

References

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