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MODELS PREDICTING SATURATED AND UNDER-SATURATED VISCOSITY FOR SOME LIBYAN CRUDE OILS

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ABSTRACT

In this work the idea was to apply literature models to predict viscosity of crude oils. Fifteen different oil samples from Libyan reservoirs have been used. Experimental data collected from the Libyan Petroleum Institute database. Supplementary data were collected from published literature. Chew-Connally, Beggs-Robinson, Labedi, Kartoatmodjo and Schmidt, modified Kartoatmodjo, and Elsharkawy & Alikhan models have been investigated for saturated oil , while Beal , Vasquez and Beggs, Khan and Ali, Labedi ,Kartoatmodjo and Schmidt, and Elsharkawy & Alikhan have been used to undersaturated oil. The accuracy of models for investigated viscosity were applied to the acquired data set and a comprehensive error analysis was performed based on a comparison of the predicted value with the experimental value. The results obtained indicate, that modified Kartoatmodjo model is the best and accurate for saturated oil viscosity, while Beal's model is the best for undersaturated oils. The less AARE % was calculated 23.9% for saturated oil, and 21.9 % for undersaturated oil.

Key Words: Viscosity; model; sample; saturated oil; undersaturated oil.

1. OVERVIEW

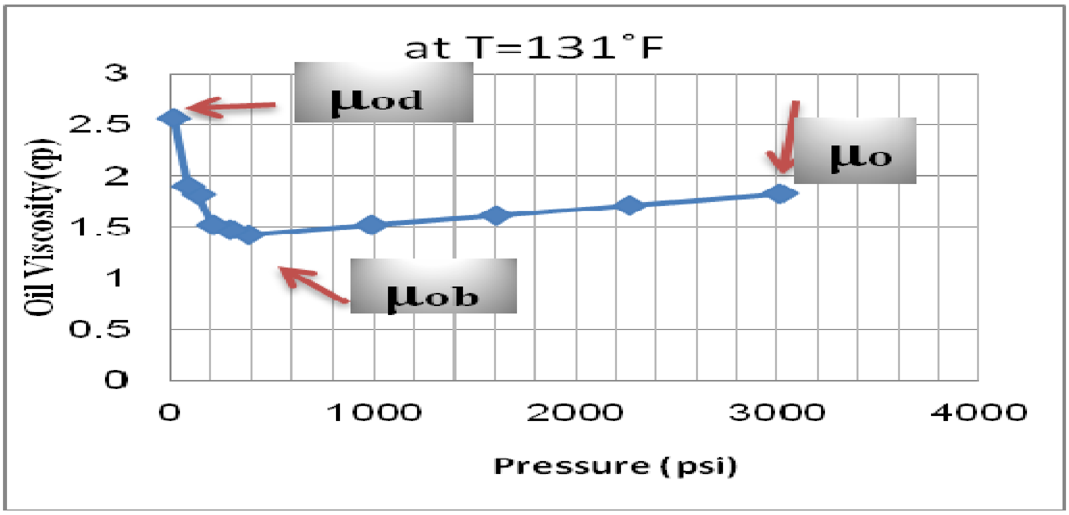
Viscosity is a strong function of the temperature, pressure, oil gravity, gas gravity, and gas solubility. Viscosity could be measured by two methods semi-theoretical which are derived from a theoretical framework, but involve parameters experimentally determined, or empirical, which include a wide variety of equations used throughout the industry. Empirical models can be classified to corrective, which is an experimental mixture data used for evaluation of model parameters, and predictive which is the properties of pure components are utilized.

The viscosity is usually reported in standard PVT analyses. If laboratory data are not available, engineers may refer to published correlations, which usually vary in complexity and accuracy depending upon the available data. The viscosity of hydrocarbon mixtures and petroleum reservoir fluids is commonly measured by either the rolling ball viscometer or the capillary tube viscometer. In the rolling ball viscometer, the time required by the steel ball to travel through the fluid is correlated to its density and viscosity. Other nonconventional methods include the laser light scattering and the piezoelectric quartz crystal techniques.

The objective of this study is to apply an accurate correlations to predict oil viscosity at various operating conditions. In the literature, several empirical correlations have been proposed for oil viscosity prediction (saturated, and undersaturated). Here, based on Libyan oil reservoirs data, accuracy of these correlations has been confirmed by comparing the obtained results of these correlations with experimental data for Libyan oil samples. Statistical analysis is the criteria adopted for the evaluation in this study.

2. MATERIAL AND METHODS

PVT experimental data of fifteen samples include bubble point (saturated) pressure Psi , API gravity and solution gas-oil ratio Scf/STB at reservoir temperature Fº. A typical viscosity plot as a function of pressure is shown in Figure 1 (sample No 6). It can be seen from Figure 1 that, the oil viscosity decreases with pressure reduction in single phase (undersaturated condition). This reduction continues to bubble point. As the pressure decreased below the bubble point pressure causes gas release. Therefore the oil viscosity has been increased. It can be concluded that the minimum value of the viscosity is at bubble point pressure.



Statistical experimental data are shown in table 1. At pressures above bubble point pressure, oil is at single-phase state, while its solution gas–oil is constant and it seems that pressure will be the most effective in oil viscosity.

Table 1. Statistical experimental data of sample oils

Sample	T F°	Y API°	Pb psi	Rs scf/stb	P psi	μob exp	μo exp
1	170	48.7	1655	930	5015	0.4933	0.5767
2	184	36.51	3302	1382	4509	0.2888	0.4583
3	174.4	47.8	1560	800	5015	0.4342	0.5033
4	161	38.94	1400	521	5000	0.696	0.828
5	200	43.25	287	119	3015	0.7615	0.8761
6	131	37.5	375	173	3015	1.4304	1.8247
7	250	38.86	5935	1738	7015	0.5541	0.5931
8	270	30.41	3002	649	5206	0.662	0.739
9	167	42.183	340	138	3015	0.734	0.933
10	176	46.62	2445	1762	5000	0.29	0.44
11	210	35.7	495	90	3015	1.07	1.426
12	262.4	38.49	3130	864	5515	0.388	0.516
13	262	41.14	1525	536	5015	0.5362	0.6354
14	257.8	37.03	2805	1215.7	5615	0.4107	0.4711
15	285	42.08	3240	904	4515	0.408	0.45

3. CORRELATIONS LITERATURE

Six correlations were used to predict the viscosity of saturated oil, including: Chew-Connally [1], Beggs-Robinson[2], Labedi [3], Kartoatmodjo and Schmidt [4], modified Kartoatmodjo [4], and Elsharkawy & Alikhan [5] correlations, the accuracy of each correlation of predicted saturated oil viscosity was checked with experimental data table2 reveals average relative error (ARE%), and absolute average relative error (AARE%) for saturated oil viscosity.

Table 2 ARE% and AARE% for saturated oil viscosity

Model	ARE(%)	AARE(%)
The modified Kartoatmodjo	6.51867	23.9795
Elsharkawy & Alikhan	20.2973	24.0984
Chew & Connally	13.4312	25.2184
Beggs & Robinson	24.4467	27.0632
Kartoatmodjo & Schmidt	24.3451	32.7524
Labedi	19.8468	35.901

The contradiction may be clarified by referring to figure 2, which compares the scatter diagram relationship between the measured and the predicted viscosity.

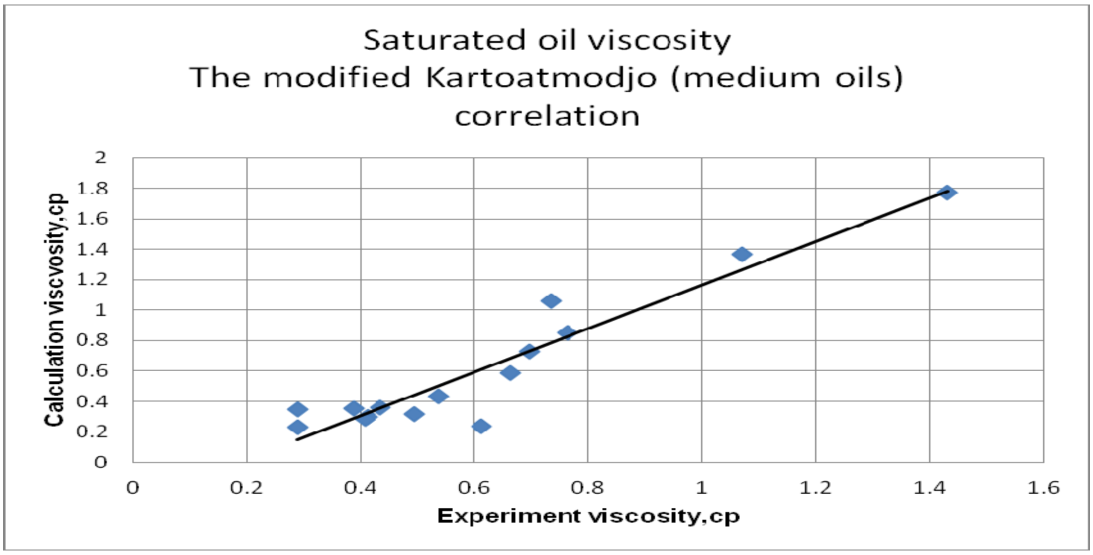


Figure 2 Accuracy of modified Kartomodjo correlation

The accuracy and ability of modified Kartoatmodjo correlation for calculating oil viscosity was checked with experimental data, and the %ARE , AARE% obtained, 6.51867%and 23.9795% respectively.

Six correlations were used to predict viscosity of undersaturated oil, these correlations are: Beal , Vasquez and Beggs, Khan and Ali, Labedi , Kartoatmodjo and Schmidt, and Elsharkawy and Alikhan. The accuracy of each correlation for undersaturated oil viscosity predicted was checked with experimental data table 3 reveals average relative error (ARE), absolute average relative Error (AARE) for undersaturated oil viscosity correlations respectively.

Table 3 ARE% and AARE% for undersaturated oil viscosity

Model	ARE(%)	AARE(%)
Beal´s	11.5994	21.9456
Khan & Ali	3.48919	22.6405
Labedi	11.2513	22.6869
Elsharkawy & Alikhan	8.4213	24.5423
Kartoatmojo & Schmidt	19.3142	25.4266
Vasques &Beggs	-14.188	36.8857

The accuracy and ability of Beal's correlation for calculating oil viscosity was checked with experimental data, and the %ARE , AARE% obtained, 11.5994% and 21.9456% respectively.

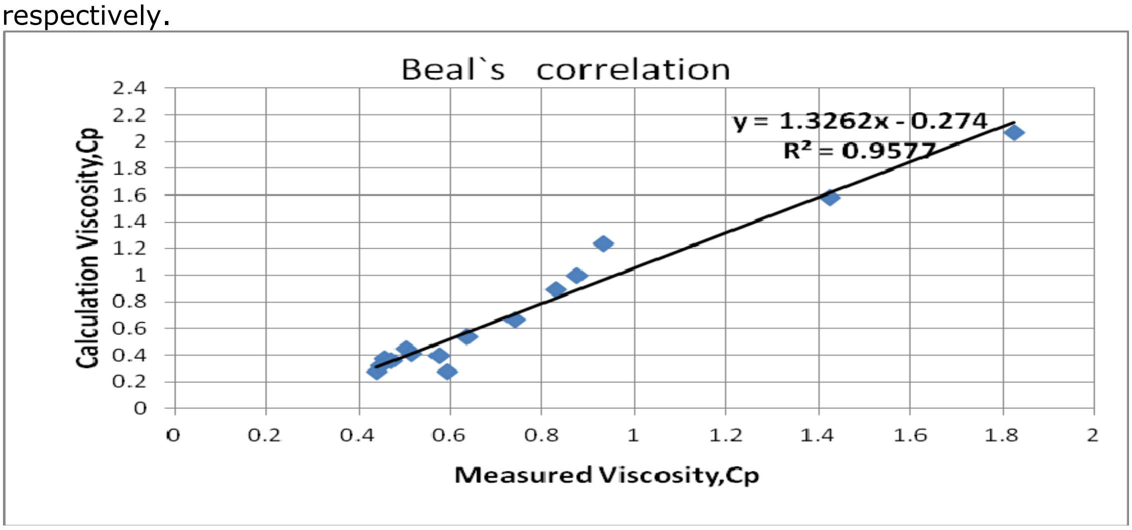


Figure 3. accuracy of Beal's correlation

4. Conclusion

Several empirical models for estimating the viscosity of crude oils (saturated and undersaturated) have been evaluated using viscosity data of crude oils from the selected Libyan oil reservoirs. Good agreements between the predicted and experimental values have been observed. It can be concluded from results that, the modified Kartoatmodjo, and Elsharkawy & Alikhan correlations are the best and accurate for saturated oil viscosities, while Beal's, and Khan & Ali correlations are preferred to get accurate results for undersaturated oils. The less AARE% was calculated 23.9% for saturated oil, and 21.9 % for undersaturated oil.

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