New tuning method to improve heavy oil viscosity prediction with friction theory

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The present work involves improving the viscosity prediction of heavy oils using "Friction Theory", developed by Quiñones-Cisneros et al. [1,2]. The tuning method (will be referred as *Old Tuning*) used by Quiñones-Cisneros et al. [1,2] results in increasing deviation with increasing viscosity of heavy oils, particularly for viscosity below the saturation pressure. The authors developed a new tuning method (will be referred as *New Tuning*), which predicted the viscosity of heavy oils with a greater accuracy for all pressure conditions.

Heavy oil viscosity prediction has always been a challenge in the oil and gas industry. There are correlations and semi-theoretical methods of viscosity prediction but led to large deviations leaving scope for further research work. Friction Theory of viscosity is of recent development and has been used to model different kinds of oils: light, medium, and heavy.

Friction Theory viscosity prediction works well for very light fluids and may not require tuning. But as viscosity level increases, deviation starts and tuning with one experimental viscosity data is required to contain the error for light and medium oil in lower region. However, it is observed that deviation in viscosity prediction progressively becomes higher for pressure below saturation pressure and becomes unmanageable for heavy oil.

Quiñones-Cisneros et al. [1,2] used two experimental viscosity data above saturation pressure to tune two parameters (*critical viscosity tuning parameter*, K_c, and *compressibility correction parameter*, K_z) involved in the friction theory model for heavy oils. It is observed that the tuning method predicts the viscosity for pressure above saturation pressure with good accuracy (Table 1) but the deviation progressively becomes very high with increasing viscosity for pressure below saturation pressure (Fig. 1).

The new tuning method optimizes the value of two parameters (K_c and *exponential mixing term* ε in the mixing rule) using two experimental data, one of data at (10 to 15) bars above the saturation pressure and the other data below the saturation pressure in the range of (6 to 10) bars. The authors have made ε, a function of Z-factor calculated from a cubic equation of state.

Viscosity prediction with the two tuning methods has been compared in Fig. 1. It is seen that for viscosity above saturation pressure, the two tuning methods performances are almost the same. However, in the case of pressure below the saturation pressure, whereas the old tuning methods under predicts the experimental data, the deviation is very high (around 25%). The new tuning method predicts the viscosity with greater accuracy. The analysis is presented in Table 1.

The new tuning method's performance and consistency were checked with other sets of data [3]. The analysis (Table 2) shows that accuracy is not only consistent, it is also better. Thus, with the new tuning method, the authors predicted experimental viscosity data below the saturation pressure successfully for first time.

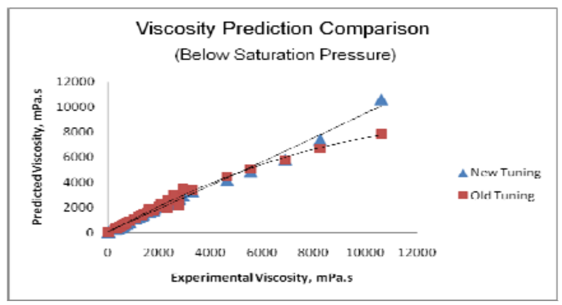

Fig. 1. Comparison of performances for the two tuning methods.

Table 1: Analysis of viscosity prediction for oils 2-8 [1,2]

Pressure	% AAD – *Old Tuning*	% AAD- *New Tuning*
Above Saturation	1.34	2.52
Below Saturation	11.95	4.19
Over all*	7.5	3.49

*Total no. of data =81. 47 below saturation point

Table 2: Analysis of viscosity prediction for oils 5,6,7 (3)

Pressure	% AAD-*New Tuning*
Above Saturation	1.25
Below Saturation	2.30
Over all#	1.70

#Total no. of data = 67. 29 below saturation pressure

References

[1] Quiñones-Cisneros, S. E., Andersen S. I., Creek, J. (2005) Energy and Fuel, 19,1314 -1318
[2] Quiñones-Cisneros, S. E., Zéberg-Mikkelsen, C. K., Baylaucq, A., Boned, C., (2004) International Journal of Thermophysics,25 (5), 1353-1366.
[3] Lindeloff, N., Pedersen K.S., Ronningsen H.P., and Milter J., (2004) Journal of Canadian Petroleum Technology, 43(9), 47-53.