A NUMERICAL SIMULATION TO INTERPRET VISCOSITY VARIATIONS OF OILS FROM THE RECÔNCAVO BASIN, BRAZIL

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Viscosity is one of the main physical properties controlling fluid flow in oil-bearing reservoirs (KANTI et al., 1989). The values of viscosities of oils from the Recôncavo Basin, Brazil, show large variations even though all oils were generated from similar lacustrine source rocks of Early Cretaceous age. These oils are paraffinic (percentages of saturates between 48 to 84%), with low contents in resins and asphaltenes (7 to 34%), and API gravities ranging from 17 to 40^0. A set of crude oils from several fields of the basin was studied including samples with higher values of viscosity. These different values of dead-oil viscosities (5.6 to 92.0 cP) can be related to the chemical composition of the oils.

To verify how differences in the global chemical composition of oils can be related to the differences in dynamic viscosity, a mixture law must be used to determine the role of the viscosities of its chemical classes in the overall petroleum viscosity. The mixture law chosen was proposed by GRUNBERG & NISSAN (1949) and modified by WERNER (1996). It allows one to calculate the dynamic viscosity of a mixture represented by the gas (C_1-C_5), light oil (C_6-C_{20}), heavy oil (C_{20+}) and asphaltenes fractions, all at 373.15K and 350bar.

The gas phase (C_1-C_5) was not taken into account in the mixture law because only dead-oil viscosities have been used in this study. The percentages of the C_6-C_{20} and C_{20+} fractions of the oils were obtained by integration of areas in whole-oil gas chromatography traces. Viscosities of the light oil fraction (C_6-C_{20}) were considered constant for all the oils (0.0646mPa.s) because the relatively restricted number and similar distribution of compounds in this fraction can be shown to cause only slight variations of viscosities in comparable distillation cuts. Likewise, a constant viscosity was attributed to the asphaltenes fraction ($8{,}5\mathrm{x}10^6$mPa.s), which is present in very low amounts in these paraffinic oils (<2%). The calculations of the viscosities of the C_{20+} fraction were done in three steps:

1) Extrapolation of the total oil dynamic viscosities at 48.8^0C to 373.15K and 350bar, using the formula of KANTI et al. modified by WERNER (1996):

$$\ln \frac{\eta(P,T)}{\eta(P_0,T_0)} = \alpha \left(\frac{1}{T} - \frac{1}{T_0} \right) + E \ln \left(\frac{D+P}{D+P_0} \right)$$

where: P_0 is the initial pressure and P the final pressure (bar); T_0 is the initial temperature and T the final temperature (K); η is the dynamic viscosity (mPa.s); α is the parameter that determine the variation of viscosity in function of temperature; D and E are parameters that determine the variation of viscosity in function of pressure.

2) Estimation of the percentage of asphaltenes that are necessary to the mixture law equation, through an exponential equation obtained from generic oils.

3) Estimation of the viscosity of the C_{20+} fraction using the mixture law of GRUNBERG & NISSAN modified by WERNER (1996):

$\ln \eta_m = w_2 \ln \eta_2 + w_3 \ln \eta_3 + w_4 \ln \eta_4 + w_2 w_3 \lambda_{23} + w_2 w_4 \lambda_{24} + w_3 w_4 \lambda_{34} + w_2 w_3 w_4 \lambda_{234}$,

where: η_m is the mixture of four fractions viscosity; η_1, η_2, η_3 and η_4, are viscosities associated with the four fractions; the λ_{ij} values are the binary components, the λ_{ijk} are ternary components and the λ_{ijk} values are quaternary components.

w_1, w_2, w_3, and w_4 are the mass percentage of the fractions.

Total dead-oil viscosity could be simulated by considering it as the interaction of viscosities of three oil fractions (light oil, heavy oil and asphaltenes) through the numerical simulation. The viscosity mixture law has been successfully used to model dead-oil viscosity. The viscosity of the C_{20+} fraction plays a major role in the overall oil viscosity and increases with the increase of the total dynamic oil viscosity. The percentage of asphaltenes fraction apparently does not have a considerable effect on the large discrepancies in total oil viscosities in paraffinic oils such as those from the Recôncavo Basin.

The C_{20+} viscosity is related with the oil maturation and the abundance of normal paraffins abundance. There is a tendency to increase the product $(nC_{15}/nC_{27})*(DiahopaneH_{30}/Hopane_{30})$, which represents the interaction between a maturation parameter and the abundance of heavy paraffins, with the decrease of dynamic viscosity values. The oils with lowest viscosities present higher maturation and abundance of light paraffins than the oils with the highest viscosities.

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