Crude oil formation pdf

Oil formation volume factor is defined as the volume of oil (and dissolved gas) at reservoir pressure and temperature required to produce one stock tank barrel of oil at the surface.From: PVT Property Correlations, 2018Tarek Ahmed Ph.D., P.E., in Equations of State and PVT Analysis, 2007The oil formation volume factor, Bo, is defined as the ratio of the volume of oil (plus the gas in solution) at the prevailing reservoir temperature and pressure to the volume of oil at standard conditions. Evidently, Bo always is greater than or equal to unity. The oil formation volume factor can be expressed mathematically as:whereBo = oil formation volume factor, bbl/STB(Vo)p, T = volume of oil under reservoir pressure, p, and temperature, i, bbl(Vo)sc = volume of oil is measured under standard conditions, STBA typical oil formation factor, as a function of pressure for an undersaturated crude oil (pi > pb), is shown in Figure 4-7. As the pressure is reduced below the initial reservoir pressure, pi, the oil volume increases due to the oil expansion. This behavior results in an increase in the oil formation volume factor and continues until the bubble-point pressure is reached. At pb, the oil reaches its maximum expansion and consequently attains a maximum value of Bob for the oil formation volume factor. As the pressure is reduced below pb, volume of the oil and Bo are decreased as the solution gas is liberated. When the pressure is reduced to atmospheric pressure and the temperature to 60°F, the value of Bo is equal to 1.FIGURE 4-7. Typical oil formation volume factor/pressure relationship.Most of the published empirical Bo correlations utilize the following generalized relationship:Six methods of predicting the oil formation volume factor are presented here: Standing's correlation, Vasquez and Beggs's correlation, Glaso's correlation, Marhoun's correlation, Petrosky and Farshad's correlation, and the material balance equation. It should be noted that all the correlations could be used for any pressure equal to or below the bubble-point pressure.Standing (1947) presented a graphical correlation for estimating the oil formation volume factor with the gas solubility, gas gravity, oil gravity, and reservoir temperature as the correlating parameters. This graphical correlation originated from examining a total of 105 experimental data points on 22 California hydrocarbon systems. An average error of 1.2% was reported for the correlation.Standing (1981) showed that the oil formation volume factor can be expressed more conveniently in a mathematical form by the following equation:(4-38)Bo=0.9759+0.00012[Rs(γgγo)0.5+1.25(T−460)]1.2whereT = temperature, °Rγo = specific gravity of the stock-tank oil, 60°/60°γg = specific gravity of the solution gasVasquez and Beggs (1980) developed a relationship for determining Bo as a function of Rs, γo, γg, and T. The proposed correlation was based on 6000 measurements of Bo at various pressures. Using the regression analysis technique, Vasquez and Beggs found the following equation to be the best form to reproduce the measured data:(4-39)Bo=1.0+C1Rs+(T−520)(APIγgs)[C2+C3Rs]whereR = gas solubility, scf/STBT = temperature, °Rγgs = gas specific gravity as defined by equation 4-25:γgs=γg[1+5.912(10−5)(API)(Tsep−460)log(psep114.7)]Values for the coefficients C1, C2, and C3 of equation (4-39) follow:COEFFICIENTAPI ≤ 30API > 30C14.677 × 10−44.670 × 10−4C21.751 × 10−51.100 × 10−5C3−1.811 × 10−81.337 × 10−9Vasquez and Beggs reported an average error of 4.7% for the proposed correlation.Glaso (1980) proposed the following expressions for calculating the oil formation volume factor:(4-40)Bo=1.0+10Awhere(4-41)A=−6.58511+2.91329log⁡Bob*−0.27683(log⁡Bob*)2Bob* is a "correlating number," defined by the following equation:(4-42)Bob*=Rs(γgγo)0.526+0.968(T−460)where T = temperature, °R and γo = specific gravity of the stock-tank oil, 60°/60°. These correlations were originated from studying PVT data on 45 oil samples. The average error of the correlation was reported at −0.43% with a standard deviation of 2.18%.Sutton and Farshad (1984) concluded that Glaso's correlation offers the best accuracy when compared with Standing's and Vasquez-Beggs's correlations. In general, Glaso's correlation underpredicts formation volume factor, Standing's expression tends to overpredict oil formation volume factors, while Vasquez-Beggs's correlation typically overpredicts the oil formation volume factor.Marhoun (1988) developed a correlation for determining the oil formation volume factor as a function of the gas solubility, stock-tank oil gravity, gas gravity, and temperature. The empirical equation was developed by use of the nonlinear multiple regression analysis on 160 experimental data points. The experimental data were obtained from 69 Middle Eastern oil reserves. The author proposed the following expression:(4-43)Bo=0.497069+0.862963×10−3T+0.182594×10−2F+0.318099×10−5F2with the correlating parameter F as defined by the following equation:F=Rsaγgbγocwhere T is the system temperature in °R and the coefficients a, b, and c have the following values:a=0.742390b=0.323294c=−1.202040Petrosky and Farshad (1993) proposed a new expression for estimating Bo. The proposed relationship is similar to the equation developed by Standing; however, the equation introduces three additional fitting parameters to increase the accuracy of the correlation.The authors used a nonlinear regression model to match experimental crude oil from the Gulf of Mexico hydrocarbon system. Their correlation has the following form:(4-45)Bo=1.0113+7.2046(10−5)A with the term A is given by:A=[Rs0.3738(γg0.2914γo0.6265)+0.24626(T−460)0.5371]3.0936where T = temperature, °R, and γo = specific gravity of the stock-tank oil, 60°/60°.From the definition of Bo as expressed mathematically by equation (4-37),The oil volume under p and T can be replaced with total weight of the hydrocarbon system divided by the density at the prevailing pressure and temperature:where the total weight of the hydrocarbon system is equal to the sum of the stock-tank oil plus the weight of the solution gas:Given the gas solubility, Rs, per barrel of the stock-tank oil and the specific gravity of the solution gas, the weight of Rs scf of the gas is calculated as:where mg = weight of solution gas, lb of solution gas/STB.The weight of one barrel of the stock-tank oil is calculated from its specific gravity by the following relationship:Substituting for mo and mg,Bo=(5.615)(62.4)γo+Rs379.4(28.96)γg5.615ρooriBo=62.4γo+0.0136Rsγgρowhere ρo = density of the oil at the specified pressure and temperature, lb/ft3.The error in calculating Bo by using equation (4-46) depends on the accuracy of only the input variables (Rs, γg, and γo) and the method of calculating ρo.The table below shows experimental PVT data on six crude oil systems. Results are based on two-stage surface separation. Calculate the oil formation volume factor at the bubble-point pressure by using the preceding six different correlations. Compare the results with the experimental values and calculate the absolute average error.OilTpbRsBoρcoγ at p > pbpsepTsepAPIγg1250223775751.52838.1322.14 × 10−6 at 4300 psig1508040.70.743268915060471.10.8512220.62670781.47440.9518.75 × 10−6 at 5000 psig1009640.40.89337526929011.25870.6418.1612.57.3722.69 × 10−6 at 4700 psig10010046.20.815442726180.9431.03960.6621.6416.2 × 10−6 at 4000 psig606050.20.797 ...

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