Reservoir Engineering Π

Reservoir fluid properties

By

Assist lect. Farah N. Almohammad

Viscosity of Natural Gas

- The viscosity of a fluid is a measure of its internal friction resistance to flow.

- Gas, having significantly lower viscosity than oil and water, tends to dominate multiphase flow in the reservoir.

- So, the knowledge of natural gas viscosity is essential for the studies on the dynamic/flow behavior of a gas through reservoirs.

- The gas viscosity is not commonly measured in the laboratory because it can be estimated precisely from empirical correlations

Viscosity of Natural Gas

- Like all intensive properties,the viscosity of a natural gas can be completely described by the following function:

- $\mu_g = f(P, T, \gamma_g)$

- This relationship states that gas viscosity is a function of pressure, temperature, and composition of the gas.

Carr-Kobayashi-Burrows Correlation Method

1. Calculate the pseudo-critical pressure, pseudo-critical temperature, and apparent molecular weight from the specific gravity or the composition of the natural gas. Corrections to these pseudocritical properties for the presence of the nonhydrocarbon gases (CO_2, N_2, and H_2S) should be made if they are present in concentrations greater than 5 mole percent.

2. Obtain the viscosity of the natural gas at one atmosphere and thetemperature of interest from Figure 1. This viscosity, as denoted by μ_1, must be corrected for the presence of nonhydrocarbon components.

$$\mu_1 = \mu_{1\,uncorrected} + (\Delta\mu)_{N2} + (\Delta\mu)_{CO2} + (\Delta\mu)_{H2S}$$

Carr-Kobayashi-Burrows Correlation Method

3. Calculate the pseudo-reduced pressure and temperature.

4. From the pseudo-reduced temperature and pressure, obtain the viscosity ratio (μg/μ1) from Figure 2. The term μg represents the viscosity of the gas at the required conditions.

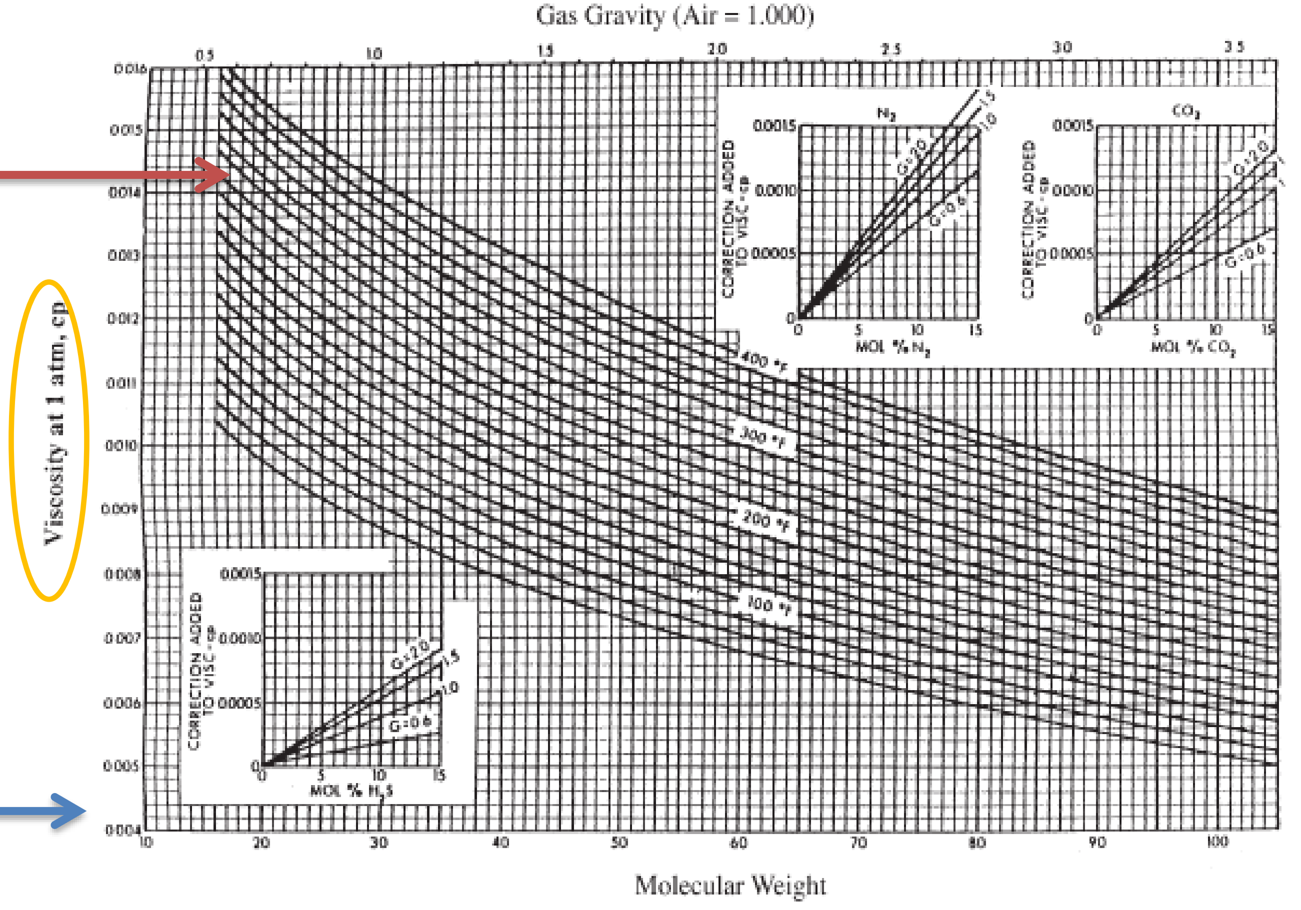
5. The gas viscosity, μg, at the pressure and temperature of interest is calculated by multiplying the viscosity at one atmosphere and system temperature, μ1, by the viscosity ratio

Carr-Kobayashi-Burrows Correlation Method

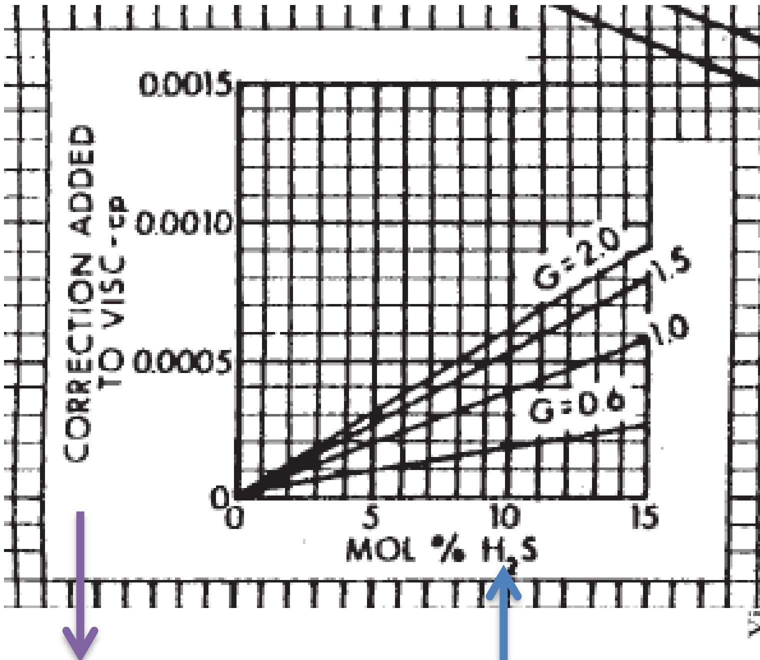
T (°F)

μ1

Ma gas

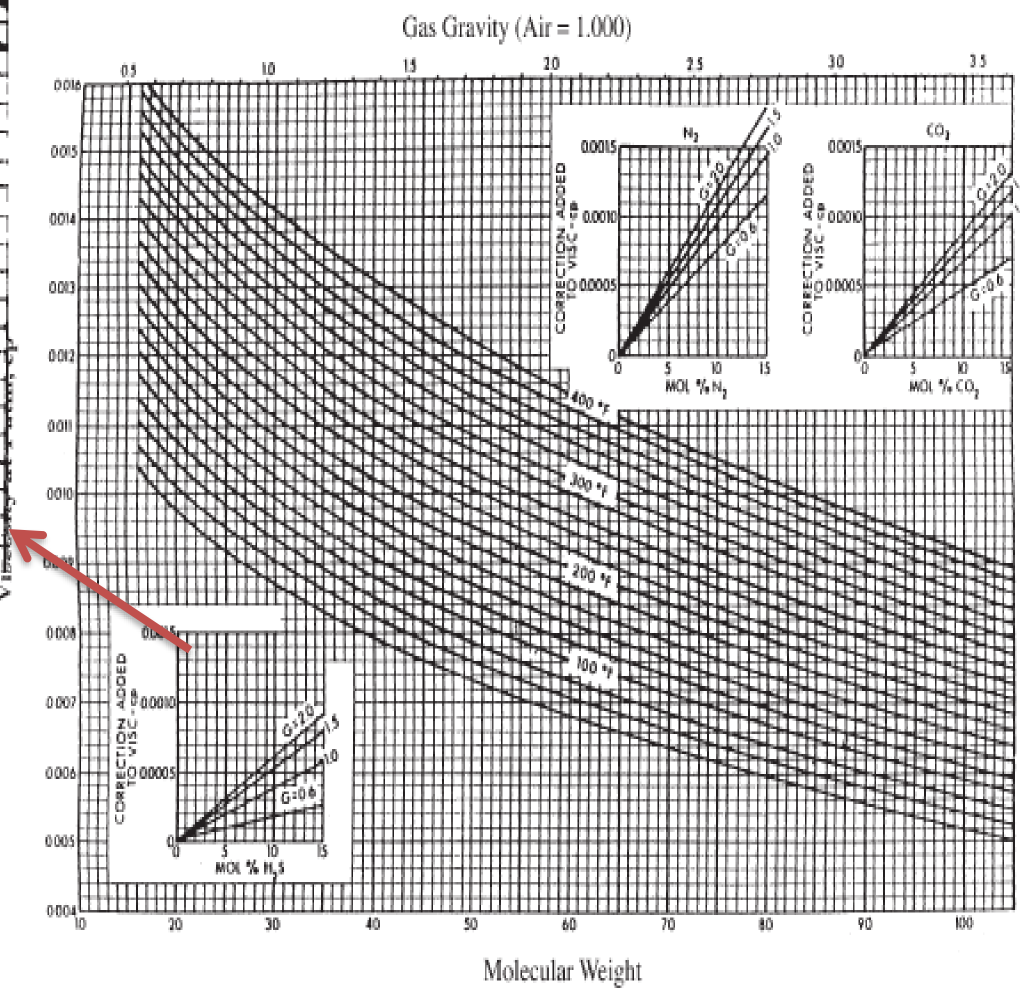


Carr-Kobayashi-Burrows Correlation Method

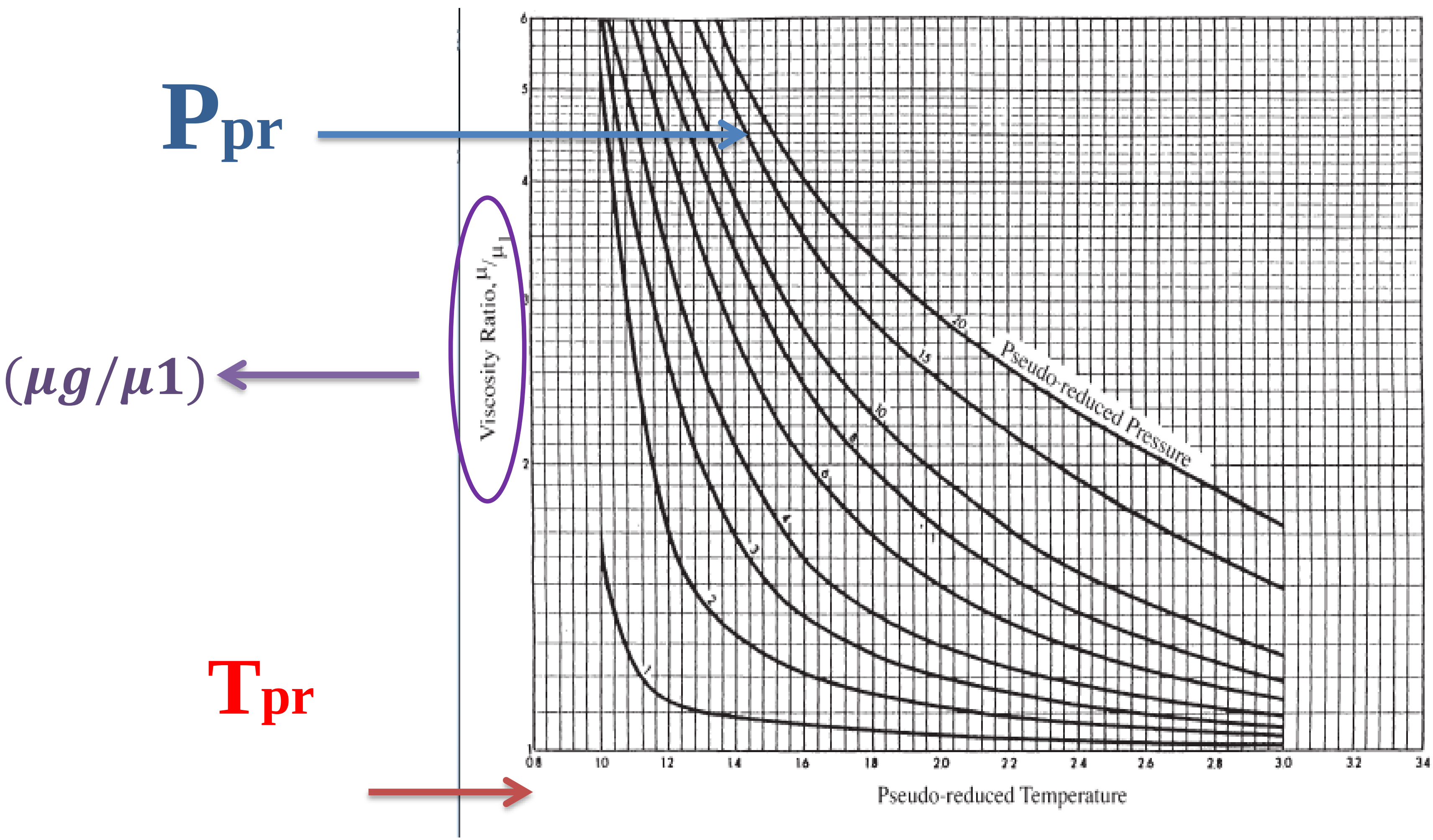


$(\Delta\mu)_{H2S}$

Mole fraction of H2S in %



Carr-Kobayashi-Burrows Correlation Method



Carr-Kobayashi-Burrows Correlation Method

Example:

A gas well is producing at a rate of 15,000 ft3/day from a gas reservoir at an average pressure of 2,000 psia and a temperature of 140°F. The specific gravity is 0.72. Calculate the gas viscosity.

Carr-Kobayashi-Burrows Correlation Method

Solution

Step 1. Calculate the apparent molecular weight of the gas:

$$M_a = (0.72)(28.96) = 20.85$$

Step 2. Determine the viscosity of the gas at 1 atm and 140°F from Figure 1 :

$$\mu_1 = 0.0113$$

Step 3. Calculate p_{pr} and T_{pr}:

$$p_{pr} = 2.99$$

$$T_{pr} = 1.52$$

Step 4. Determine the viscosity rates from Figure 2

$$\frac{\mu_g}{\mu_1} = 1.5$$

Step 5. Solve for the viscosity of the natural gas:

$$\mu_g = \frac{\mu_g}{\mu_1}(\mu_1) = (1.5)(0.0113) = 0.01695 \text{ cp}$$

The Lee-Gonzalez-Eakin Method

The authors expressed the gas viscosity in terms of the reservoir temperature, gas density, and the molecular weight of the gas.

- $\mu_g = 10^{-4}\, K \exp\left(X \left(\frac{\rho_g}{62.4}\right)^{Y}\right)$

- $K = \frac{(9.4+0.02 M_a) T^{1.5}}{209+19 M_a+T}$

- $X = 3.5 + \frac{986}{T} + 0.01\, M_a$

- $Y = 2.4 - 0.2\, X$

The Lee-Gonzalez-Eakin Method

- ρg = gas density at reservoir pressure and temperature, lb/ft3
- T = reservoir temperature, °R
- Ma = apparent molecular weight of the gas mixture

- The correlation is less accurate for gases with higher specific gravities.

- The authors pointed out that the method cannot be used for sour gases.

The Lee-Gonzalez-Eakin Method

- **Example**
- A gas well is producing at a rate of 15,000 ft3/day from a gas reservoir at an average pressure of 2,000 psia and a temperature of 140°F. The specific gravity is 0.72. Calculate the gas viscosity.

The Lee-Gonzalez-Eakin Method

Step 1. Calculate the gas density from Equation .

$$\rho_g = \frac{(2000)(20.85)}{(10.73)(600)(0.78)} = 8.3\ \text{lb/ft}^3$$

Step 2. Solve for the parameters K, X, and Y

$$K = \frac{[9.4 + 0.02(20.85)](600)^{1.5}}{209 + 19(20.85) + 600} = 119.72$$

$$X = 3.5 + \frac{986}{600} + 0.01(20.85) = 5.35$$

$$Y = 2.4 - 0.2(5.35) = 1.33$$

Step 3. Calculate the viscosity from Equation .

$$\mu_g = 10^{-4}(119.72)\exp\left[5.35\left(\frac{8.3}{62.4}\right)^{1.33}\right] = 0.0173\ \text{cp}$$