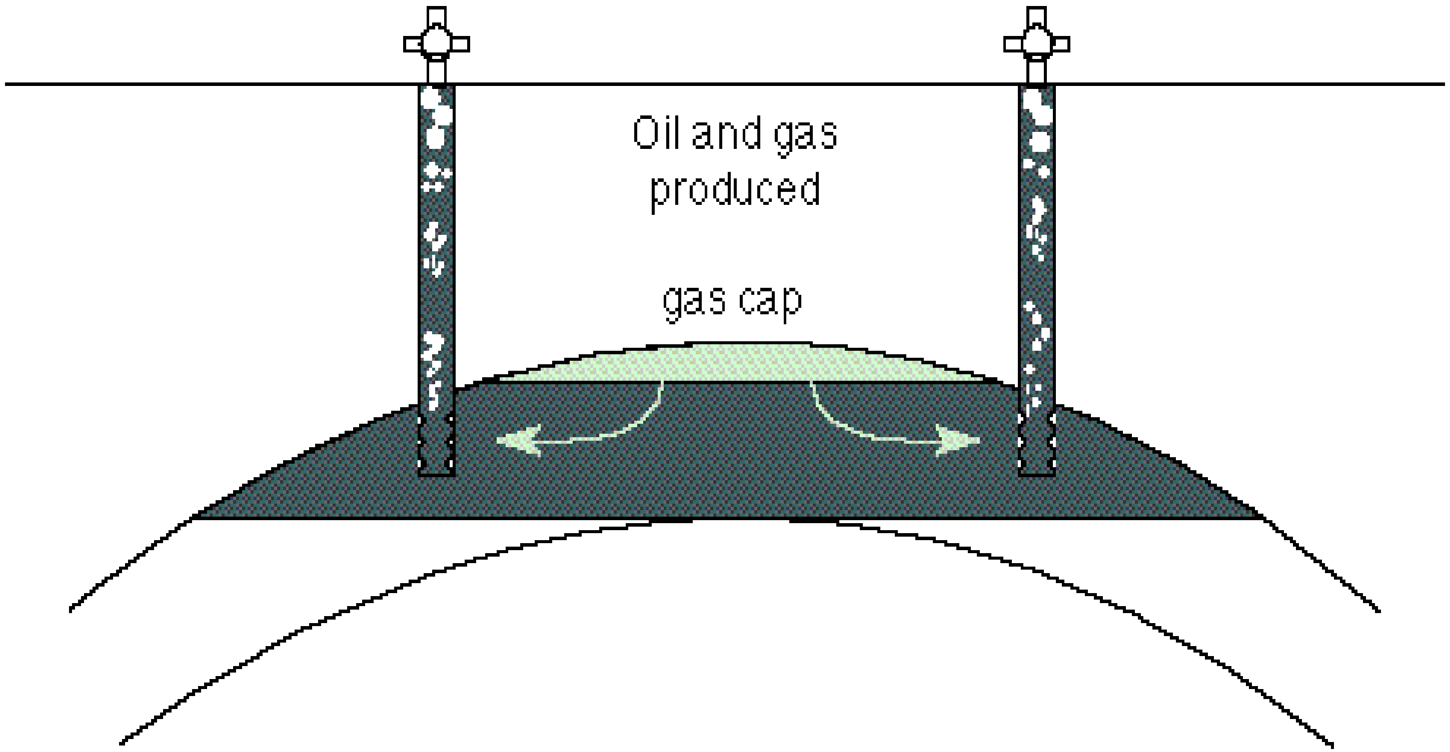
Lecture 3

Chapter 3
Production fromTwo-Phase Reservoir



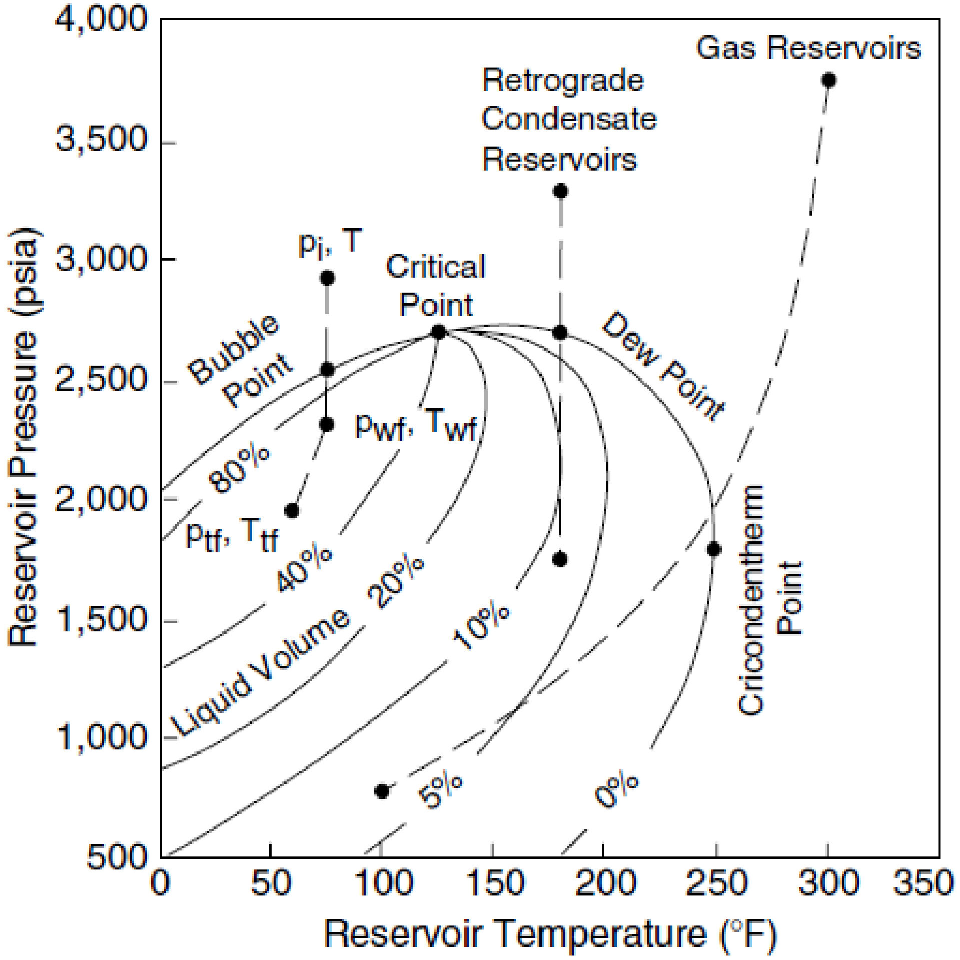
Introduction

- The performance relationships presented in Chapter 2 were for single-phase oil wells and, while gas may come out of solution after oil enters the well, the use of those relationships does not consider free gas to be present in the reservoir. Expansion of oil itself as a means of recovery is a highly inefficient mechanism because of the oil’s small compressibility.

- It is likely that even in the best cases, keeping the bottomhole pressure above the bubble point pressure would result in a very small fractional recovery of the OOIP. Therefore, frequently, oil will be produced along with free gas in the reservoir, either because the reservoir pressure is below the bubble point pressure (saturated reservoirs) or because the flowing bottomhole pressure is set below that point to provide adequate driving force.
- Figure 3-1 is the schematic of a classic phase diagram.

Figure 3-1

Schematic phase diagram of a hydrocarbon mixture



Oil Inflow Performance For a Two-Phase Reservoir

- Vogel(1968) introduced relationship for q_o based on a number of history matching simulations. The relationship $q_{o,max}$ is

$$\frac{q_o}{(q_o)_{\max}} = 1 - 0.2\left(\frac{p_{wf}}{\bar{p}_r}\right) - 0.8\left(\frac{p_{wf}}{\bar{p}_r}\right)^2$$

---- eq. 3-51

- For pseudo-steady state,

$$q_{o,max} = \left(\frac{1}{1.8}\right)\frac{k_o h\bar{p}}{141.2B_o\mu_o\left[\ln\left(\frac{0.472r_e}{r_w}\right)+s\right]} \quad \text{-eq. 3-52}$$

and therefore

$$q_o = \frac{k_o h\bar{p}\left[1-0.2\left(\frac{p_{wf}}{\bar{p}}\right)-0.8\left(\frac{p_{wf}}{\bar{p}}\right)^2\right]}{254.2B_o\mu_o\left[\ln\left(\frac{0.472r_e}{r_w}\right)+s\right]} \quad \text{--eq.3-53}$$

Example 3-5

Calculation of inflow performance using Vogel's correlation

- Develop an IPR curve for the well described in Appendix B. The drainage radius is 1490 ft and the skin effect is zero.

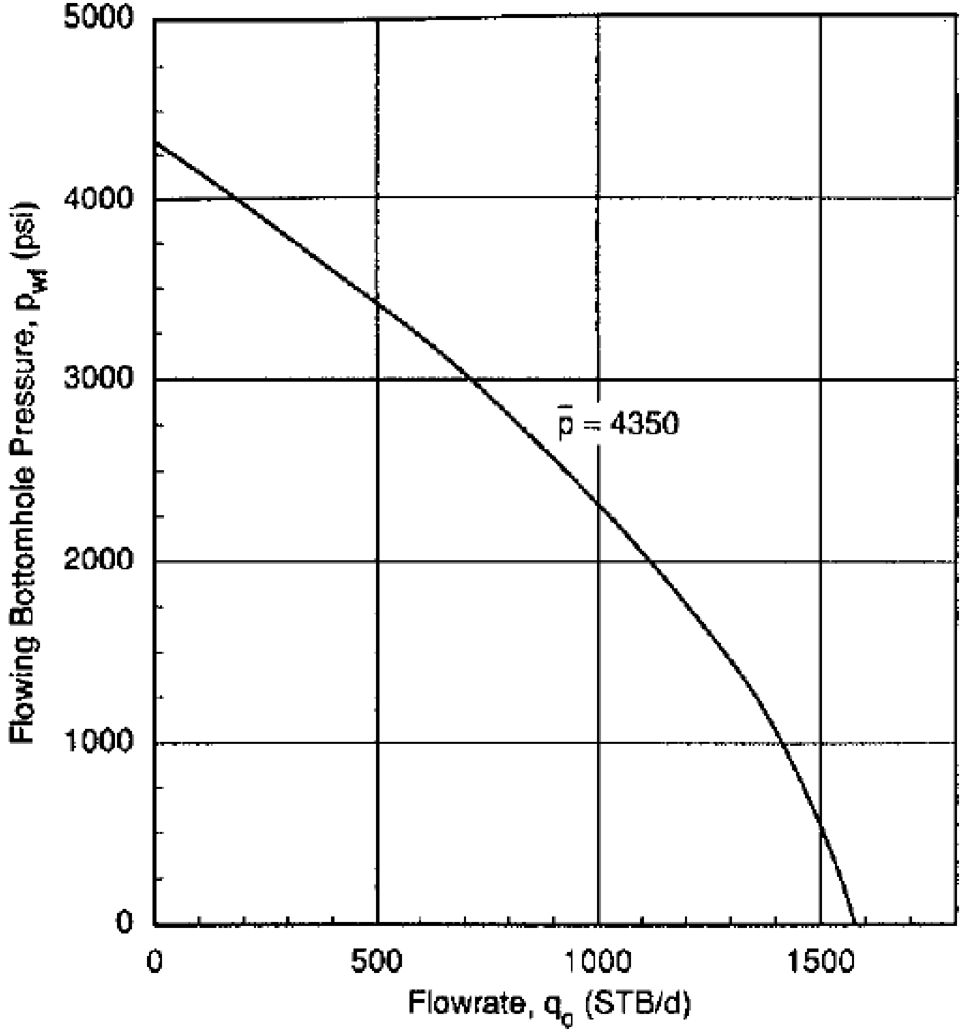
Solution: Equation 3-53 for $\bar{p}$=4350 psi becomes

$$q_o = \frac{2018}{\overline{B}_o}\left[1-0.2\left(\frac{p_{wf}}{\overline{p}_r}\right)-0.8\left(\frac{p_{wf}}{\overline{p}_r}\right)^2\right]$$

= 707 STB/D

and the plot of IPR curve for this well show in Fig. 3-6

Figure 3-6
Inflow performance curve for a two-phase well



Generalized Vogel Inflow Performance

- If the reservoir pressure is above the bubble point and yet the flowing bottomhole pressure is below, a generalized inflow performance cab be written. This can be done for transient, steady state, and pseudo-steady state.

At first, q_b, the flow rate, where $p_{wf} = p_b$, can be written as:

$$q_b = \frac{kh(p_i - p_b)}{141.2B\mu(p_D + s)} \quad \text{--- eq. 3-55}$$

Where $p_D = \ln\left(\frac{r_e}{r_w}\right)$ for steady state

$p_D = \ln\left(\frac{0.472 r_e}{r_w}\right)$ for pseudo-steady state

- The productivity index above the bubble point is simply

$$J = \frac{q_b}{p_i - p_b} \qquad \text{---- eq. 3-56}$$

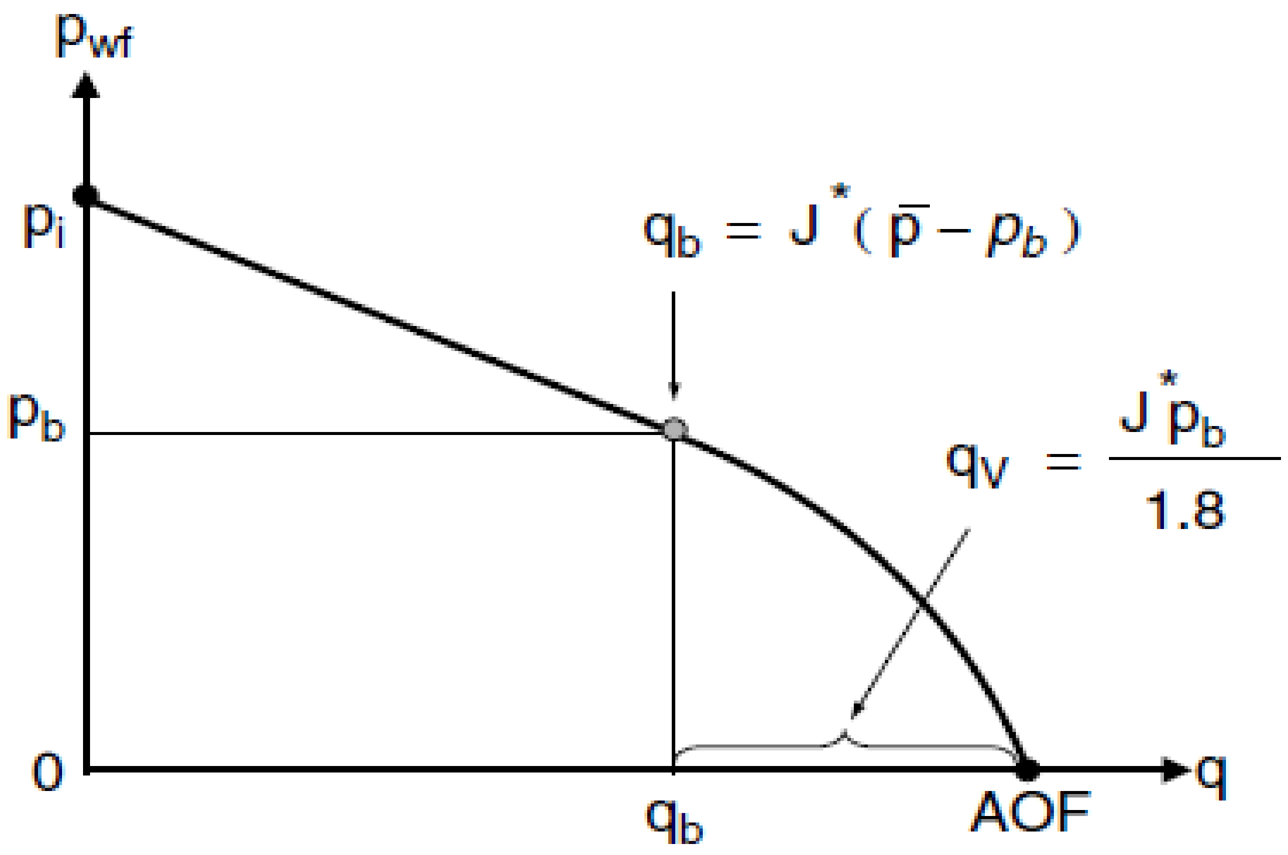
and is related to q_v (v is for Vogel flow) by

$$q_v = \frac{p_b J}{1.8} \qquad \text{---- eq. 3-57}$$

Finally,(Eq.3-58)

$$q_o = q_b + q_v \left[1 - 0.2 \left(\frac{p_{wf}}{P_b} \right) - 0.8 \left(\frac{p_{wf}}{P_b} \right)^2 \right]$$

Generalized Vogel IPR model for partial two-phase reservoirs



Fetkovich's Approximation

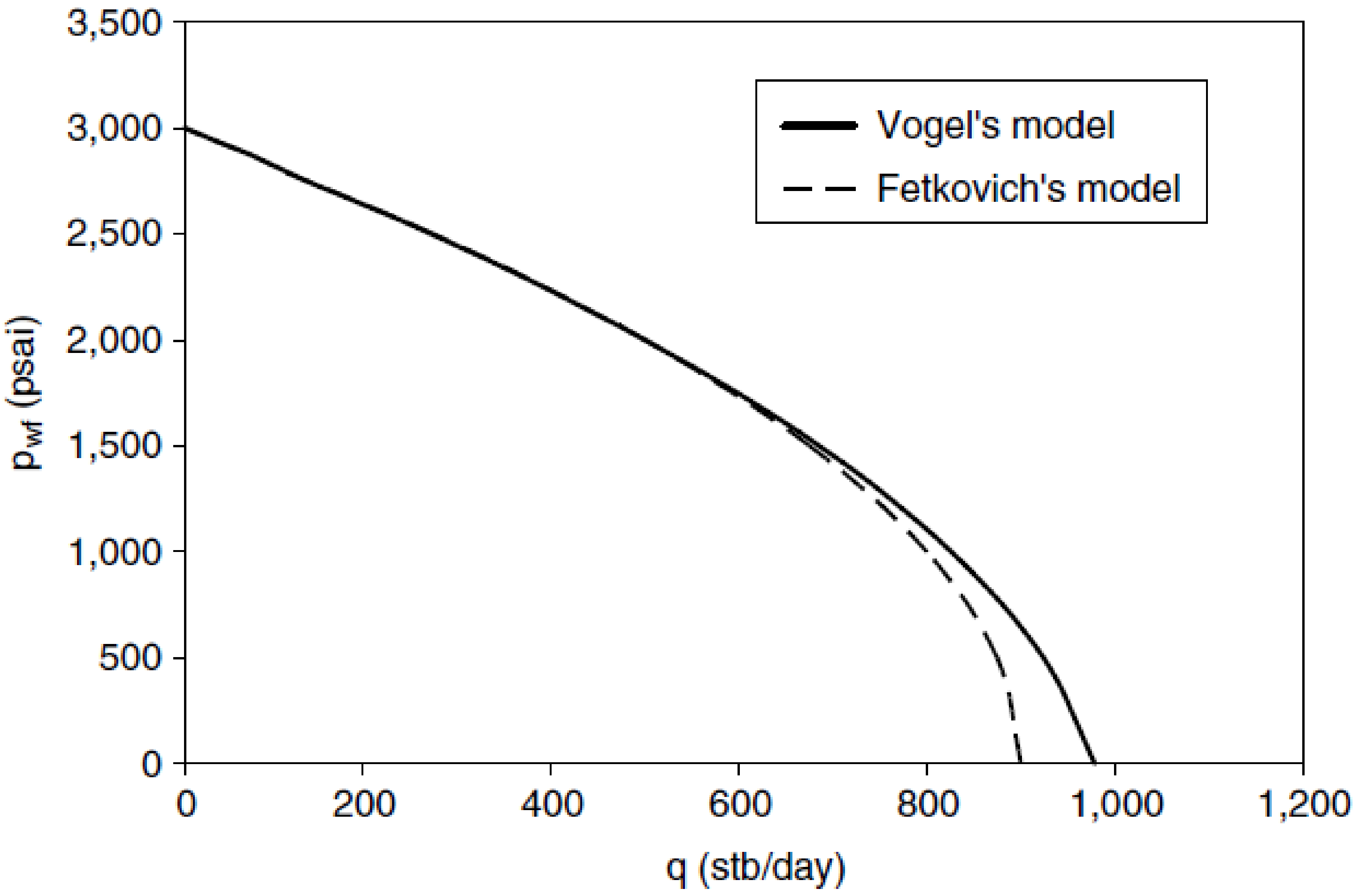
- Vogel's correlation, normalizing q_o by $q_{o,max}$, is frequently not in accordance with field data. Fetkovich (1973) suggested a normalization with $q_{o,max} = Cp^{-2n}$, and in a flow equation of the form:

$$q_o = C(\bar{p}^2 - p_{wf}^2)^n \qquad \text{--- eq. 3-59}$$

the relationship becomes

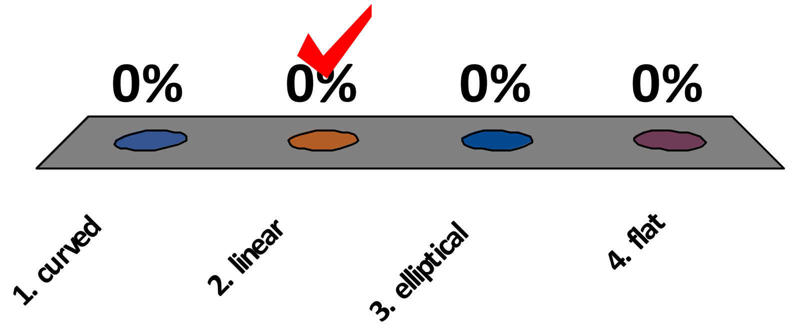
$$\frac{q_o}{(q_o)_{\max}} = \left[1 - \left(\frac{P_{wf}}{\bar{P}}\right)^2\right]^n$$

Example of Vogel and Fetkovich's IPR



An undersaturated oil reservoir IPR typically has what shape?

1. 1. curved
2. 2. linear
3. 3. elliptical
4. 4. flat



A horizontal well is most beneficial in a thick reservoir with low vertical permeability.

A. True
B. False