

13. ZADATAK

Izračunati tlak pod kojim se nalazi jedan mol zraka približnog sastava $y(\text{dušik})=0,79$ i $y(\text{kisik})=0,21$ pri temperaturi od 298 K, uz pretpostavku da se zrak vlada prema Redlich-Kwongovu modelu. Molarni volumen zraka pri tim uvjetima iznosi $v=2,48 \cdot 10^{-2} \text{ m}^3 \text{ mol}^{-1}$.

Parametre plinske smjese računati primjenom pravila miješanja.

Termodinamički parametri čistih tvari:

	T_K/K	p_K/bar
dušik (1)	126,2	33,9
kisik (2)	154,6	50,4

REDLICH KWONG (1949)

Prva moderna jednačba stanja trećeg stupnja

Jednačba

$$p = \frac{RT}{v-b} - \frac{a}{\sqrt{T}v(v+b)}$$

$$v^3 - \frac{RT}{p}v^2 - \left(b^2 + \frac{RTb}{p} - \frac{a}{p\sqrt{T}} \right)v - \frac{ab}{p\sqrt{T}} = 0$$

$$z^3 - z^2 - \left(\frac{b^2 p^2}{R^2 T^2} + \frac{pb}{RT} - \frac{ap}{R^2 T^2 \sqrt{T}} \right)z - \frac{abp^2}{R^3 T^3 \sqrt{T}} = 0$$

$$z^3 - z^2 + (A - B^2 - B)z - AB = 0$$

Parametri

$$a = \frac{\Omega_a R^2 T_K^{5/2}}{p_K} \quad b = \frac{\Omega_b R T_K}{p_K}$$

$$\Omega_a = \frac{1}{9(2^{1/3} - 1)} = 0,427480$$

$$\Omega_b = \frac{(2^{1/3} - 1)}{3} = 0,086640$$

$$A = \frac{ap}{R^2 T^{5/2}} = \frac{\Omega_a p_r}{T_r^{5/2}} \quad B = \frac{bp}{RT} = \frac{\Omega_b p_r}{T_r}$$

SMJESE REALNIH PLINOVA

Pravila miješanja

Redlich-Kwong

$$a = \sum_i \sum_j y_i y_j a_{ij}$$

$$b = \sum_i y_i b_i$$

$$A = \sum_i \sum_j y_i y_j A_{ij}$$

$$B = \sum_i y_i B_i$$

Dvokomponentne smjese

$$\begin{aligned} a_M &= a_{11}y_1^2 + a_{12}y_1y_2 + a_{21}y_2y_1 + a_{22}y_2^2 = \\ &= a_1y_1^2 + 2a_{12}y_1y_2 + a_2y_2^2 \end{aligned}$$

$$a_{11} = a_1$$

$$a_{22} = a_2$$

$$a_{12} = a_{21}$$

$$b = b_1y_1 + b_2y_2$$

Zadatak:

DUŠIK (1) – KISIK (2)

$$T = 298 \text{ K}$$

$$v = 2,48 \cdot 10^{-2} \text{ m}^3 \text{ mol}^{-1}$$

$$y_1 = 0,79$$

Parametri a i b pojedinačnih fluida

$$a_1 = \frac{\Omega_a R^2 T_{K1}^{2,5}}{p_{K1}} = \frac{0,42748 \cdot 8,314^2 \cdot 126,2^{2,5}}{33,9 \cdot 10^5} = 1,5595$$

$$b_1 = \frac{\Omega_b R T_{K1}}{p_{K1}} = \frac{0,08664 \cdot 8,314 \cdot 126,2}{33,9 \cdot 10^5} = 2,6816 \cdot 10^{-5}$$

$$a_2 = \frac{\Omega_a R^2 T_{K2}^{2,5}}{p_{K2}} = \frac{0,42748 \cdot 8,314^2 \cdot 154,6^{2,5}}{50,4 \cdot 10^5} = 1,7423$$

$$b_2 = \frac{\Omega_b R T_{K2}}{p_{K2}} = \frac{0,08664 \cdot 8,314 \cdot 154,6}{50,4 \cdot 10^5} = 2,2096 \cdot 10^{-5}$$

Pravila miješanja

$$\begin{aligned}a_{12} &= \sqrt{a_1 a_2} = \\&= \sqrt{1,5595 \cdot 1,7423} = 1,6484\end{aligned}$$

$$\begin{aligned}a_M &= \sum_i \sum_j y_i y_j a_{ij} = \\&= y_1^2 a_{11} + 2 y_1 y_2 a_{12} + y_2^2 a_{22} = \\&= 0,79^2 \cdot 1,5595 + 2 \cdot 0,79 \cdot 0,21 \cdot 1,6484 + 0,5^2 \cdot 1,7423 = \\&= 1,5971\end{aligned}$$

$$\begin{aligned}b_M &= \sum_i y_i b_i = \\&= y_1 b_1 + y_2 b_2 = 0,79 \cdot 2,6816 \cdot 10^{-5} + 0,21 \cdot 2,2096 \cdot 10^{-5} = \\&= 2,5825 \cdot 10^{-5}\end{aligned}$$

Tlak

$$\begin{aligned}p &= \frac{RT}{v - b_M} - \frac{a_M}{\sqrt{T} v (v + b_M)} \\p &= \frac{8,314 \cdot 298}{2,48 \cdot 10^{-2} - 2,5825 \cdot 10^{-5}} - \\&\quad - \frac{1,5971}{\sqrt{298} \cdot 2,48 \cdot 10^{-2} (2,48 \cdot 10^{-2} + 2,5825 \cdot 10^{-5})}\end{aligned}$$

$$p = 100006,24 - 150,58$$

$$p = 99855,66 \text{ Pa}$$