10. ZADATAK

Izračunati gustoću smjese etena(1) i kisika(2) sastava y_1=0,254 pri temperaturi od 25 °C i tlaku od 100 atm, uz pretpostavku da se plinska smjesa pri tim uvjetima vlada prema korigiranoj općoj plinskoj jednadžbi stanja. Koeficijent kompresibilnosti promatrati kao dvoparametarsku veličinu, $z_M=f(p_{rM}, T_{rM})$

a) Koeficijent kompresibilnosti računati kao aditivno svojstvo s obzirom na sastav plinske smjese
b) Koeficijent kompresibilnosti računati na temelju prethodno izračunatih pseudokritičnih parametara u skladu s Kayevim i Prausnitz-Gunnovim pravilom

Podaci:

	T_K/K	p_K/atm	v_K/(cm^{3}mol^{-1})	z_K	M/(g mol^{-1})
eten(1)	282,9	50,8	130,4	0,280	28,054
kisik(2)	154,8	49,7	73,4	0,288	31,999

Zadatak a):

ETEN(1) – KISIK(2)

$T = 25\ °\text{C}=298{,}15\ \text{K}$

$p = 100\ \text{atm}$

$y_1 = 0{,}254$

Aditivni koeficijent kompresibilnosti:

$$pv = zRT$$

$$z_\text{M} = \sum y_\text{i} z_\text{i}$$

Reducirani parametri

$$p_{\text{r}1} = \frac{p}{p_{\text{K}1}} = \frac{100}{50{,}8} = 1{,}97 \qquad p_{\text{r}2} = \frac{p}{p_{\text{K}2}} = \frac{100}{49{,}7} = 2{,}01$$

$$T_{\text{r}1} = \frac{T}{T_{\text{K}1}} = \frac{298{,}15}{282{,}9} = 1{,}05 \qquad T_{\text{r}2} = \frac{T}{T_{\text{K}2}} = \frac{298{,}15}{154{,}8} = 1{,}93$$

Očitavanje z_i:

- Grafički prikaz z=f(p_r,T_r)
- Tablični prikaz: Lee-Kessler (tablica $z^{(0)}$=f(p_r,T_r)) interpolacija?

Grafički prikaz $z=\mathrm{f}(p_\mathrm{r},T_\mathrm{r})$

$z_1 = 0,34 \qquad z_2 = 0,955$

$$z_\mathrm{M} = \sum y_\mathrm{i} z_\mathrm{i} = 0,254 \cdot 0,34 + \left(1 - 0,254\right) \cdot 0,955 = 0,80$$

$$v = \frac{z_\mathrm{M} RT}{p} = \frac{0,80 \cdot 8,314 \cdot 298,15}{100 \cdot 101325} = 1,957 \cdot 10^{-4}\ \mathrm{m^3 mol^{-1}}$$

$$\bar{M} = \sum y_\mathrm{i} M_\mathrm{i} = 0,254 \cdot 28,054 + \left(1 - 0,254\right) \cdot 31,999$$

$$\bar{M} = 30,997\ \mathrm{g\ mol^{-1}}$$

$$\rho = \frac{\bar{M}}{v} = \frac{30,997 \cdot 10^{-3}}{1,957 \cdot 10^{-4}} = 158,4\ \mathrm{kg\ m^{-3}}$$

Tablični prikaz $z=f(p_r,T_r)$

$$p_{r1} = 1,97\Big|_{1,500}^{2,000} \qquad p_{r2} = 2,01 \approx 2,00$$

$$T_{r1} = 1,05 \qquad T_{r2} = 1,93\Big|_{1,9}^{2,0}$$

$$z\left(p_{r1} = 1,97\right) = 0,3131 + \frac{0,3452 - 0,3131}{2,000 - 1,500}\left(1,97 - 1,500\right)$$

$$z\left(p_{r1} = 1,97\right) = 0,3433$$

$$z\left(T_{r2} = 1,93\right) = 0,9456 + \frac{0,9599 - 0,9456}{2,00 - 1,90}\left(1,93 - 1,90\right)$$

$$z\left(T_{r2} = 1,93\right) = 0,9499$$

$$z_M = \sum y_i z_i = 0,254 \cdot 0,3433 + \left(1 - 0,254\right) \cdot 0,9499 = 0,7958$$

$$v = \frac{z_M RT}{p} = \frac{0,7958 \cdot 8,314 \cdot 298,15}{100 \cdot 101325} = 1,9468 \cdot 10^{-4}\ \mathrm{m^3 mol^{-1}}$$

$$\bar{M} = \sum y_i M_i = 0,254 \cdot 28,054 + \left(1 - 0,254\right) \cdot 31,999$$

$$\bar{M} = 30,997\ \mathrm{g\ mol^{-1}}$$

$$\rho = \frac{\bar{M}}{v} = \frac{30,997 \cdot 10^{-3}}{1,9468 \cdot 10^{-4}} = 159,2\ \mathrm{kg\ m^{-3}}$$

Zadatak b):

ETEN(1) – KISIK(2)

$T = 25\ °\text{C}=298{,}15\ \text{K}$

$p = 100\ \text{atm}$

$y_1 = 0{,}254$

Kay (1936)

$$v_{\text{KM}} = \sum y_{\text{i}} v_{\text{Ki}}$$
$$T_{\text{KM}} = \sum y_{\text{i}} T_{\text{Ki}}$$
$$p_{\text{KM}} = \sum y_{\text{i}} p_{\text{Ki}}$$

Prausnitz i Gunn (1958)

$$v_{\text{KM}} = \sum y_{\text{i}} v_{\text{Ki}}$$
$$T_{\text{KM}} = \sum y_{\text{i}} T_{\text{Ki}}$$
$$z_{\text{KM}} = \sum y_{\text{i}} z_{\text{Ki}}$$
$$p_{\text{KM}} = \frac{z_{\text{KM}} R T_{\text{KM}}}{v_{\text{KM}}}$$

$$v_{\text{KM}} = 0{,}254 \cdot 130{,}4 + (1 - 0{,}254) \cdot 73{,}4 = 87{,}878\ \text{cm}^3\text{mol}^{-1}$$
$$T_{\text{KM}} = 0{,}254 \cdot 282{,}9 + (1 - 0{,}254) \cdot 154{,}8 = 187{,}33\ \text{K}$$
$$z_{\text{KM}} = 0{,}254 \cdot 0{,}280 + (1 - 0{,}254) \cdot 0{,}288 = 0{,}286$$
$$p_{\text{KM}} = \frac{0{,}286 \cdot 8{,}314 \cdot 187{,}33}{87{,}878 \cdot 10^{-6}} = 5{,}068162\ \text{MPa}$$

Očitavanje z_i:

- Grafički prikaz z=f(p_r,T_r)
- Tablični prikaz: Lee-Kessler (tablica $z^{(0)}$=f(p_r,T_r)) interpolacija?

$$p_{rM} = \frac{p}{p_{KM}} = \frac{100 \cdot 101325}{5,068162 \cdot 10^6} \approx 2,00$$

$$T_{rM} = \frac{T}{T_{KM}} = \frac{298,15}{187,33} = 1,5917 \approx 1,6$$

Grafički prikaz z=f(p_r,T_r)

$$z_M = 0,89$$

$$v = \frac{z_M RT}{p} = \frac{0,89 \cdot 8,314 \cdot 298,15}{100 \cdot 101325} = 2,1773 \cdot 10^{-4} \text{ m}^3\text{mol}^{-1}$$

$$\bar{M} = \sum y_i M_i = 0,254 \cdot 28,054 + \left(1 - 0,254\right) \cdot 31,999$$

$$\bar{M} = 30,997 \text{ g mol}^{-1}$$

$$\rho = \frac{\bar{M}}{v} = \frac{30,997 \cdot 10^{-3}}{2,1773 \cdot 10^{-4}} = 142,4 \text{ kg m}^{-3}$$

Tablični prikaz $z=\mathrm{f}(p_\mathrm{r},T_\mathrm{r})$

$$z_\mathrm{M} = 0,8738$$

$$v = \frac{z_\mathrm{M} RT}{p} = \frac{0,8738 \cdot 8,314 \cdot 298,15}{100 \cdot 101325} = 2,128 \cdot 10^{-4}\ \mathrm{m^3 mol^{-1}}$$

$$\bar{M} = \sum y_\mathrm{i} M_\mathrm{i} = 0,254 \cdot 28,054 + \left(1 - 0,254\right) \cdot 31,999$$

$$\bar{M} = 30,997\ \mathrm{g\ mol^{-1}}$$

$$\rho = \frac{\bar{M}}{v} = \frac{30,997 \cdot 10^{-3}}{2,128 \cdot 10^{-4}} = 145,0\ \mathrm{kg\ m^{-3}}$$