Stromingsleer – antwoorden tentamen 12 april 2011

1. D
2. A
3. C
4. C
5. B
6. D
7. C

Zie volgende pagina's voor de uitwerkingen van de open vragen.

Open vraag 1

a) $Q = 340\ \ell/\text{min} \stackrel{\wedge}{=} \dfrac{340 \times 10^{-3}\ m^3}{60\,s} = 5{,}67 \times 10^{-3}\ m^3/s$

$V = \dfrac{Q}{A} = \dfrac{5{,}67 \times 10^{-3}\ m^3/s}{\frac{\pi}{4}(0{,}05\ m)^2} = 2{,}89\ m/s$

$Re = \dfrac{Vd}{\nu} = \dfrac{(2{,}89\ m/s)(0{,}05\ m)}{10^{-6}\ m^2/s} = 143 \times 10^3$

b) $\varepsilon/d = \dfrac{50 \times 10^{-6}\ m}{0{,}05\ m} = 0{,}001 \Rightarrow$ opzoeken in Moody diagram:

$f = 0{,}022$

c)

scherpe inlaat	$K = 0{,}42$	
open globe valve	$= 6{,}9$	(alt 4)
bocht met $\frac{R}{d} = \frac{30{,}5\ cm}{5\ cm} = 6$, $\frac{\varepsilon}{d} = 0{,}001$	$= 0{,}15$	
elbow, 90° screwed, $d \simeq 2$ in	$= 0{,}95$	
half-open gate valve	$= 3{,}8$	(alt 2,7)
plotselinge verwijding	$= 1{,}0$	
	$\Sigma K = 13{,}22$	

122 m buis: $f\frac{L}{d} = 53{,}7$

(alt. 130 m buis: $f\frac{L}{d} = 57{,}2$)

d) $(\cancel{p} + \cancel{\tfrac{1}{2}\rho V^2} + \rho g z)_1 - (\cancel{p} + \cancel{\tfrac{1}{2}\rho V^2} + \rho g z)_2 + \Delta p_{pump} = (\Sigma K + f\tfrac{L}{d})\tfrac{1}{2}\rho$

$\Delta p = \rho g (z_2 - z_1) + (\Sigma K + f\frac{L}{d}) \cdot \frac{1}{2}\rho V^2$

$\Delta p = (10^3\ kg/m^3)(9{,}8\ m/s^2)(40 - 7\ m) + (13{,}2 + 53{,}7) \cdot \frac{1}{2}(10^3\ kg/$ $\cdot (2{,}89\ m/$

$= 323\,400 + 279\,378\ Pa$

$= 602{,}8\ kPa$

Vermogen $\dot{W} = \Delta P_{pump} \cdot Q = 3{,}42\ kW$ (alt 3,50 kW)

Open vraag 2

a) $Re = \frac{\rho V d}{\mu}$ $\quad \rho = 1{,}2\ kg/m^3 \quad V_0 = 100\ m/s, \quad d = 20\times10^{-6}\ m$

$\mu = 18\times10^{-6}\ Pa\cdot s$

$$Re = \frac{(1{,}2\ kg/m^3)(100\ m/s)(20\times10^{-6}\ m)}{18\times10^{-6}\ kg/(m\cdot s)} = 133\ [-]$$

b) $f(T, \rho_d, \mu_a, d) = const \Rightarrow T^\alpha \rho^\beta \mu^\gamma d^\delta = const \Rightarrow$

$[T]^\alpha \left[\frac{M}{L^3}\right]^\beta \left[\frac{M}{LT}\right]^\gamma [L]^\delta = const \Rightarrow$

$T^{\alpha-\gamma} M^{\beta-\gamma} L^{-3\beta-\gamma+\delta} = const \Rightarrow \begin{cases} \alpha-\gamma=0 \\ \beta+\gamma=0 \\ -3\beta-\gamma+\delta=0 \end{cases} \Rightarrow \begin{cases} \alpha=\gamma \\ \beta=-\gamma \\ \delta=-2\gamma \end{cases}$

neem $\gamma = 1 \Rightarrow T\cdot\rho^{-1}\mu^1 d^{-2} = const$

$\Rightarrow T = const\cdot\frac{d^2}{\mu/\rho} = const\cdot\frac{d^2}{\nu}$ $\quad (\nu = \mu/\rho)$

[in opgave staat ρ_a, moet zijn ρ_d]

c) $Re = 133$ (zie a) $\quad C_D = \frac{24}{Re} = 0{,}18$, diagram $C_D \approx 1$

V neemt af. (teken $\frac{24}{Re}$ in diagram) $\Rightarrow$

deze benadering is alleen geldig voor $Re < 1$

d) $m\frac{dV}{dt} = -D \quad D = C_D\cdot\frac{1}{2}\rho V^2\cdot A = \frac{24}{Re}\cdot\frac{1}{2}\rho V^2\cdot\frac{\pi}{4}d^2 =$

$= \frac{24\mu}{\rho V d}\cdot\frac{1}{2}\rho V^2\cdot\frac{\pi}{4}d^2 = 3\pi\mu V d$

e) $m = \rho\cdot\mathcal{V} = \rho\cdot\frac{\pi}{6}d^3 \Rightarrow \rho\frac{\cancel{\pi}}{6}d^{\cancel{3}\,2}\frac{dV}{dt} = -3\cancel{\pi}\mu V\cancel{d}$

$\boxed{\text{let op } \mu \to \text{lucht},\ \rho \to \text{druppel}}$

$\frac{1}{V}\frac{dV}{dt} = -18\frac{\mu_a/\rho_d}{d^2}$

$V = V_0\exp(-t/T) \Leftarrow \ln V = -18\frac{\mu_a t}{\rho_d d^2} + const$

met $T = \frac{\rho_d d^2}{18\mu_a}$

f) $s = \int_0^t V(\tau)\,d\tau = \int_0^t V_0\exp(-\tau/T)\,d\tau = TV_0[1-\exp(-t/T)]$

$s_0 = \lim_{t\to\infty} TV_0[1-\exp(-t/T)]$

$= TV_0$

$T_0 = \frac{(10^3\ kg/m^3)(20\times10^{-6}\ m)^2}{18\times(18\times10^{-6}\ Pa\cdot s)} = 1{,}23\ ms$

$s_0 = (1{,}23\times10^{-3}\ s)(100\ m/s) = 0{,}12\ m.$