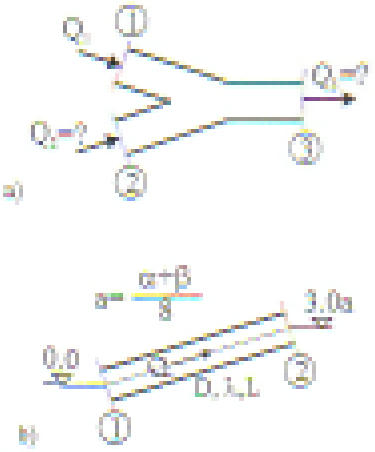
ZADACI ZA OVERU PRISUSTVA NA VEŽBAMA

ZADATAK 4.1

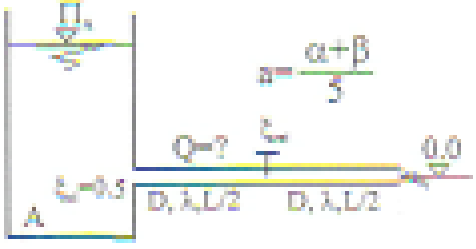
a) Na slici je prikazana račva kroz koju protiče voda, a strelicama su prikazani smerovi toticanja. Prečnik D_1 je poznat i iznosi (150+2β) mm. Prečnici D_2 i D_3 su takođe poznati i iznose $D_2=1.2D_1$ i $D_3=2D_2$. Brzina u preseku 1 je poznata i iznosi α/5 m/s. Odrediti protok i brzine u presecima 2 i 3, ako je $V_2=1.3V_1$.

b) Na slici je prikazana cev dužine 6β m, prečnika (150+2β) mm i koeficijenta trenja, λ=0.03. Ako je brzina u cevi poznata i iznosi (1+α/8) m/s, odrediti gubitak energije između preseka 1 i 2. Ako je pritisak u preseku 1, p_1=15β kPa, odrediti pritisak u preseku 2. Slobodnom rukom skicirati energetsku i pijezometarsku liniju. Gustina vode, ρ=1 kg/dm³.



ZADATAK 4.2

Iz rezervoara A konstantno ističe voda, cevovodom koji ima slobodan kraj na koti 0.0 m, dužine L=2β m, prečnik D=150+β mm i koeficijent trenja, λ=0.022. Na sredini cevovoda, nalazi se zatvarač sa poznatim koeficijentom lokalnog gubitka, ξ_{zat}=α. Ako je kota nivoa vode u rezervoaru konstantna i iznosi Π_A=2α m, odrediti protok kroz cevovod. Nacrtati energetsku i pijezometarsku liniju. Preporučena vertikalna razmera 1:100 (ili 1:200).



ZADACI KOJI SE OCENJUJU NA NAREDNOM ČASU

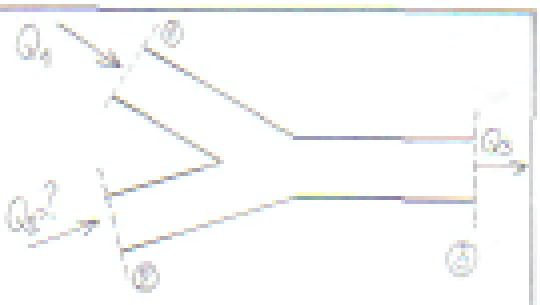
ZADATAK 4.3

Rezervoari A i B spojeni su cevovodom promenljivog prečnika. Kote nivoa vode u rezervoarima su konstantne i iznose, Π_A=(0.0+α) m i Π_B=(0.0-α) m. Cevovod ima ukupnu dužinu L=6β m, prečnika D_1=200+β/2 mm i D_2=280-β/2 mm i konstantan koeficijent trenja, λ=0.030. Ako je koeficijent lokalnog gubitka na sužanju, $\xi_{suž}$=α/10, odrediti protok kroz cevovod. Nacrtati energetsku i pijezometarsku liniju u odgovarajućoj razmeri.

ZADATAK 4.4

Rezervoari A i B su spojeni cevovodom ukupne dužine L=6β m, konstantnog prečnika D=(150+β) mm i promenljivog koeficijenta trenja, λ_1=0.020 i λ_2=0.035. Rezervoar A je zatvoren sad i u njemu se nalazi vazduh pod nepoznatim pritiskom. Kote nivoa slobodnih u oba rezervoara su konstantne i poznate, $z_A=\Pi_A$=0.0 m. Ako je poznato da je brzina u cevovodu V=(1+α/20) m/s, odrediti pritisak vazduha u rezervoaru A. Ako je kota diferencijalnog manometra, prikazanog na slici, z_m= α/3 m, odrediti njegovo čitanje. Nacrtati E i Π liniju u odgovarajućoj razmeri.

Задатак 41



а)

$D_1 = 216.6\,mm = 0.2166\,m$

$D_2 = 259.32\,mm = 0.25932\,m$

$D_3 = 519.84\,mm = 0.51984\,m$

$V_1 = 1.2\,\frac{m}{s}$

$V_2 = 1.5\,V_3$

$A_1 = \frac{D_1^2\pi}{4} = \frac{0.2166^2\pi}{4} = 0.0368\,m^2$ $\quad Q_1 = V_1 A_1 = 1.2 \cdot 0.0368 = 0.0442\,\frac{m^3}{s}$

$A_2 = \frac{D_2^2\pi}{4} = \frac{0.25932^2\pi}{4} = 0.0531\,m^2$ $\quad Q_2 = V_2 A_2 = 0.0531 \cdot 1.5 V_3 = 0.0796 V_3$

$A_3 = \frac{D_3^2\pi}{4} = \frac{0.51984^2\pi}{4} = 0.2122\,m$ $\quad Q_3 = V_3 A_3 = 0.2122\,V_3$

$Q_1 + Q_2 = Q_3$

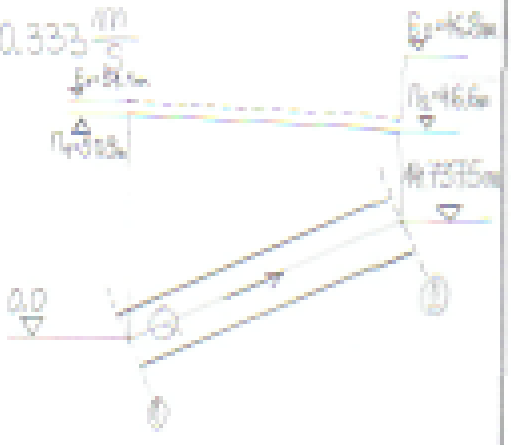
$0.0442 + 0.0796 V_3 = 0.2122 V_3 \Rightarrow V_3 = 0.333\,\frac{m}{s}$

$0.0442 = 0.1327 V_3$

$V_2 = 1.5 V_3 = 0.5\,\frac{m}{s}$

$Q_2 = 0.0796 \cdot 0.333 = 0.0265\,\frac{m^3}{s}$

$Q_3 = 0.2122 \cdot 0.333 = 0.0707\,\frac{m^3}{s}$



б) $L = 193.8\,m$

$D = 0.2166\,m$

$\lambda = 0.03$

$V = 1.75\,\frac{m}{s}$

$p_1 = 439.5\,kPa$

$f = 1000\,\frac{kg}{m^3}$

пресек 1 $E_1 = \Pi_1 + \frac{V_1^2}{2g}$, $V_2 = V_1 = 1.75\,\frac{m}{s}$ $\quad Q = \frac{D^2\pi}{4} V_1 = 0.0645\,\frac{m^3}{s}$

пресек 2 $E_2 = \Pi_2 + \frac{V_2^2}{2g}$

$E_1 = E_2 + \Delta E_{1-2}$

$\frac{p_1}{fg} + Z_1 = \Pi_1 \quad \Pi_1 = 50.917\,m$

$E_1 = 50.917 + \frac{1.75^2}{2 \cdot 9.81} = 51.073\,m$

$\Delta E_{1-2} = E_{1in} = \lambda \frac{L V^2}{D 2g} = 0.03 \frac{193.8 \cdot 1.75^2}{0.2166 \cdot 2 \cdot 9.81} = 4.32\,m$

$E_2 = E_1 - \Delta E_{1-2} = 51.073 - 4.32 = 46.753\,m$

$p_2 = (\Pi_2 - Z_2) \cdot fg = 312.5\,kPa$

$\Pi_2 = E_2 - \frac{V_2^2}{2g} = 46.753 - \frac{1.75^2}{2 \cdot 9.81} = 46.6\,m$

Задатак 42

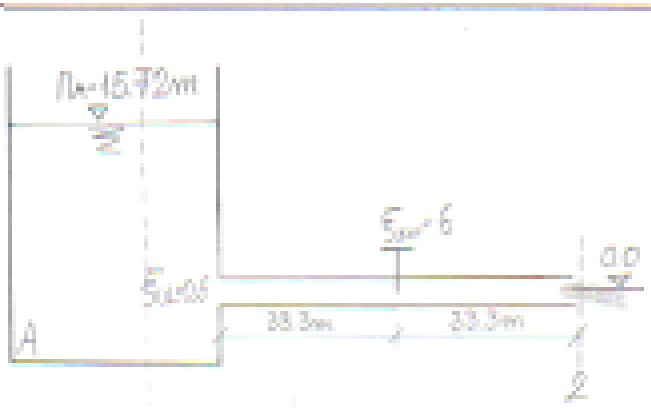
$L=66.6m$

$D=183.3mm=0.1833m$

$\lambda=0.022$

$\xi_{ost}=6$

$\Pi_A=15.72m$



$E_1=E_2+\Delta E_{1-2}$

$E_1=\Pi_1+\frac{V_1^2}{2g}$; $V_1=0$

$E_1=\Pi_1=15.72m$

$E_2=\Pi_2+\frac{V_2^2}{2g}$; $\Pi_2=0$ $E_2=\frac{V_2^2}{2g}=0.051\,V_2^2$

$\Delta E_{1-2}=\xi_{ul}\cdot\frac{V_2^2}{2g}+\lambda\frac{\frac{L}{2}V_2^2}{2Dg}+\xi_{min}\cdot\frac{V_2^2}{2g}+\lambda\frac{\frac{L}{2}V_2^2}{2Dg}=\xi_{ul}\frac{V_2^2}{2g}+\lambda\frac{LV_2^2}{2Dg}+\xi\frac{V_2^2}{2g}$

$\Delta E_{1-2}=0.5\cdot\frac{V_2^2}{2\cdot9.81}+0.022\cdot\frac{66.6\cdot V_2^2}{2\cdot0.1833\cdot9.81}+6\cdot\frac{V_2^2}{2\cdot9.81}=0.0255V_2^2+0.4079V_2^2+0.3058V_2^2$

$\Delta E_{1-2}=0.7387V_2^2$

$E_1=E_2+\Delta E_{1-2}$

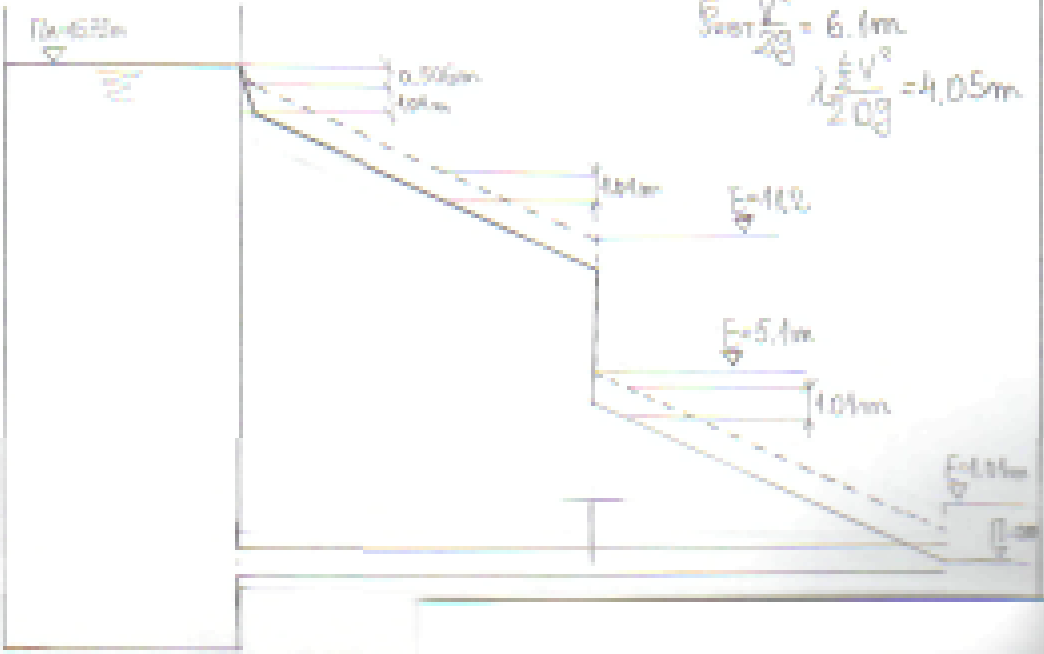
$15.72=0.051V_2^2+0.7387V_2^2$; $15.72=0.7897V_2^2$ $V_2=4.46\frac{m}{s}$

$Q=AV_2=\frac{D^2\pi}{4}V_2=\frac{0.1833^2\pi}{4}\cdot4.46=0.1177\frac{m^3}{s}$

$\frac{V^2}{2g}=1.01m$ $\xi_{ul}\frac{V^2}{2g}=0.506m$

$\xi_{ost}\frac{V^2}{2g}=6.1m$

$\lambda\frac{\frac{L}{2}V^2}{2Dg}=4.05m$



Задача 4.3

$П_A = 7.86m$

$П_B = -7.86m$

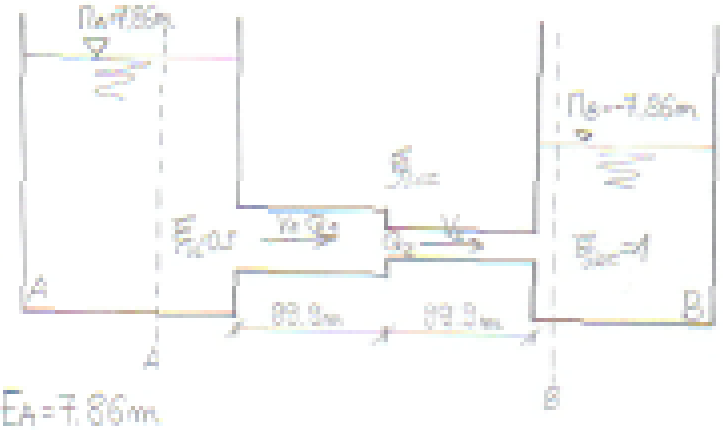
$L = 199.8m$

$D_1 = 216.65mm = 0.21665m$

$D_2 = 183.35mm = 0.18335m$

$\lambda = 0.030$

$\xi_{вход} = 0.6$



$E_A = П_A + \frac{V_A^2}{2g}$, $V_A = 0$, $E_A = 7.86m$

$E_B = П_B + \frac{V_B^2}{2g}$, $V_B = 0$, $E_B = -7.86m$

$E_A = E_B + \Delta E_{A-B}$

$\Delta E_{A-B} = \xi_{вх}\frac{V_1^2}{2g} + \lambda\frac{L}{D_1}\frac{V_1^2}{2g} + \xi_{вых}\frac{V_2^2}{2g} + \lambda\frac{L}{D_2}\frac{V_2^2}{2g} + \xi_{вых}\cdot\frac{V_2^2}{2g}$

$\Delta E_{A-B} = 0.5\frac{V_1^2}{2\cdot 9.81} + 0.03\cdot\frac{99.9V_1^2}{0.21665\cdot 2\cdot 9.81} + 0.6\cdot\frac{V_2^2}{2\cdot 9.81} + 0.03\cdot\frac{99.9\cdot V_2^2}{0.18335\cdot 2\cdot 9.81} + 1\cdot\frac{V_2^2}{2\cdot 9.81}$

$\Delta E_{A-B} = 0.0255V_1^2 + 0.7051V_1^2 + 0.0306V_2^2 + 0.8331V_2^2 + 0.051V_2^2$

$\Delta E_{A-B} = 0.7306V_1^2 + 0.9147V_2^2$

$\Delta E_{A-B} = E_A - E_B = 15.72m \Rightarrow 0.7306V_1^2 + 0.9147V_2^2 = 15.72$

$Q_1 = Q_2 = Q$

$A_1 = \frac{D_1^2\pi}{4} = \frac{0.21665^2\pi}{4} = 0.0368m^2$

$A_2 = \frac{D_2^2\pi}{4} = \frac{0.18335^2\pi}{4} = 0.0264m$

$A_1V_1 = A_2V_2$

$0.0368V_1 = 0.0264V_2 \Rightarrow V_1 = 0.7174V_2$

$0.7306(0.7174V_2)^2 + 0.9147V_2^2 = 15.72$

$0.376V_2^2 + 0.9147V_2^2 = 15.72$

$1.2907V_2^2 = 15.72$

$V_2 = 3.4899\frac{m}{s} \approx 3.5\frac{m}{s}$

$V_1 = 2.5037\frac{m}{s} \approx 2.5\frac{m}{s}$

$Q = A_1V_1 = 0.0368\cdot 2.5 = 0.092\frac{m^3}{s}$

$E_1 = E_A - \xi_{sol} \frac{V_1^2}{2g} = 7.86 - 0.5 \frac{2.5^2}{2 \cdot 9.81} = 7.70\,m$

$\Delta E_{A-1} = 0.16\,m$

$E_2 = E_1 - \lambda \frac{L_{A1}}{4R} \frac{V_1^2}{2g} = 7.70 - 0.03 \cdot \frac{99.9 \cdot 2.5^2}{4 \cdot 0.2466 \cdot 9.81} = 3.25\,m$

$\Delta E_{1-2} = 4.4\,m$

$E_2' = E_2 - \xi_{Prec} \frac{V_2^2}{2g} = 3.25 - 0.6 \frac{3.5^2}{2 \cdot 9.81} = 2.88\,m$

$\Delta E_{2-2'} = 0.37\,m$

$E_3 = E_2' - \lambda \frac{L_{A3}}{4R} \frac{V_2^2}{2g} = 2.88 - 0.03 \frac{99.9 \cdot 3.5^2}{4 \cdot 0.1623 \cdot 9.81} = -7.26$

$\Delta E_{2-3} = 10.21\,m$

$E_B = E_2 - \xi_{Usc} \cdot \frac{V_2^2}{2g} = -7.32 - 1 \frac{3.5^2}{2 \cdot 9.81} = -7.86\,m$

$\Delta E_{3-B} = 0.68\,m$

$\Pi_1 = E_1 - \frac{V_1^2}{2g} = 7.70 - \frac{2.5^2}{2 \cdot 9.81} = 7.36\,m$

$\Delta \Pi_{A-1} = 7.86 - 7.36 = 0.5\,m$

$\Pi_2 = E_2 - \frac{V_2^2}{2g} = 3.25 - \frac{3.5^2}{2 \cdot 9.81} = 2.93\,m$

$\Delta \Pi_{1-2} = 4.44\,m$

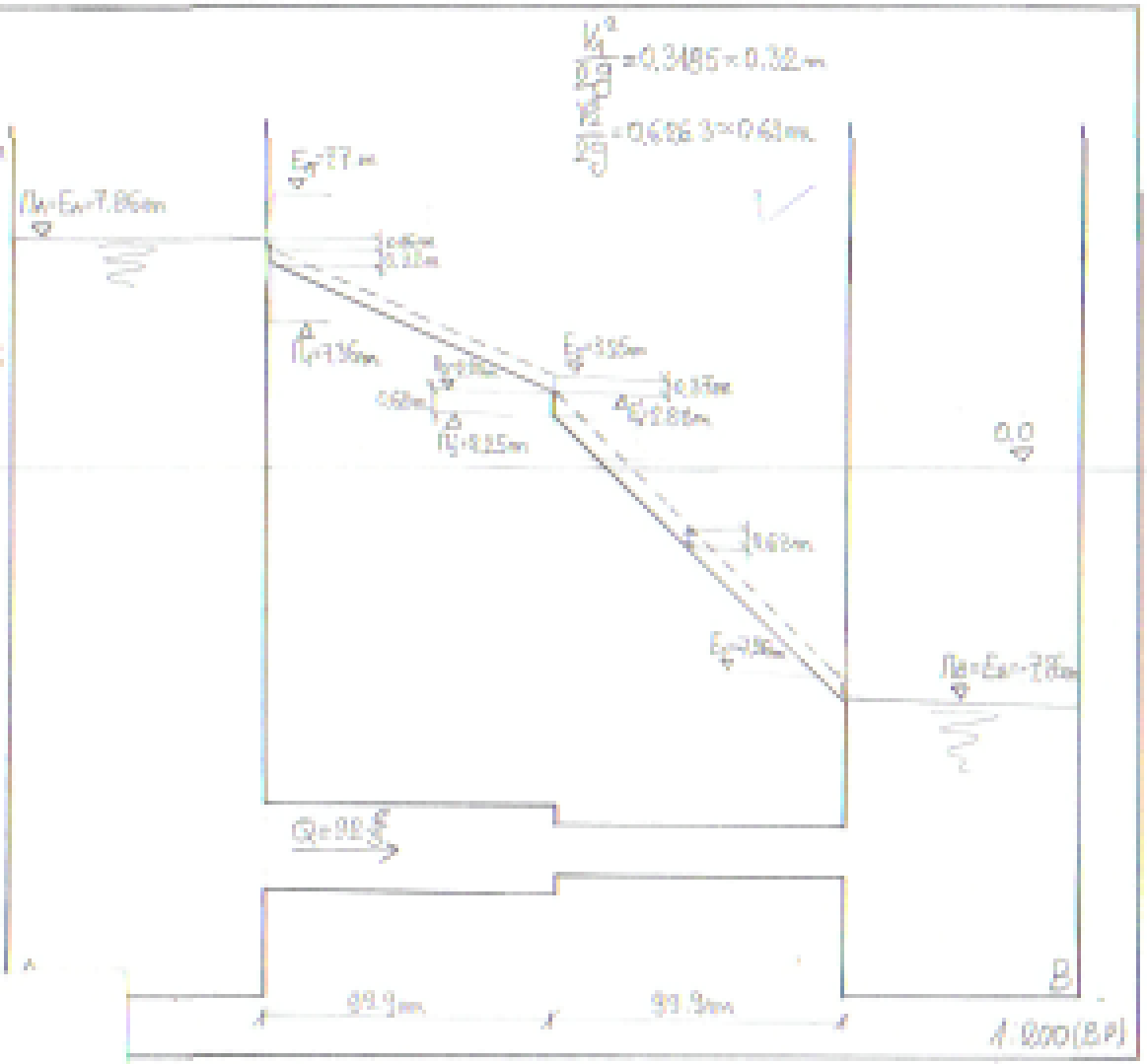
$\Pi_2' = E_2' - \frac{V_2^2}{2g} = 2.88 - \frac{3.5^2}{2 \cdot 9.81} = 2.25$

$\Delta \Pi_{2-2'} = 0.63\,m$

$\Pi_3 = E_3 - \frac{V_2^2}{2g} = -7.26 - \frac{3.5^2}{2 \cdot 9.81} = -7.86$

$\frac{V_1^2}{2g} = 0.3185 \approx 0.32\,m$

$\frac{V_2^2}{2g} = 0.6363 \approx 0.63\,m$



Zadatak 4.4

$L = 198.8\,m$

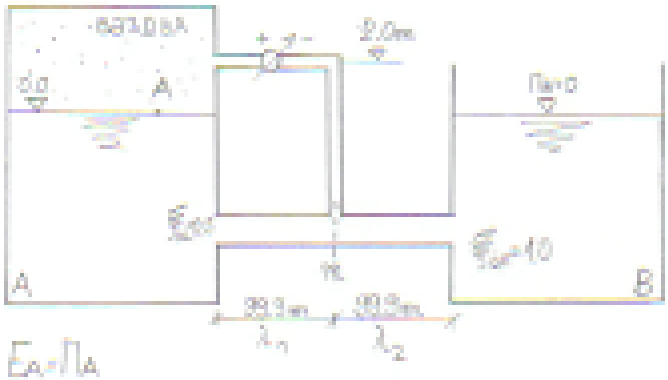
$D_1 = 183.3\,mm = 0.1833\,m$

$\lambda_1 = 0.020$

$\lambda_2 = 0.035$

$V_0 = 1.3\,\frac{m}{s}$

$z_m = 2\,m$



$E_A = \Pi_A + \frac{V_A^2}{2g}$; $V_A = 0$ $E_A = \Pi_A$

$E_B = \Pi_B + \frac{V_B^2}{2g}$; $V_B = 0$; $E_B = 0\,m$

$E_A = E_B + \Delta E_{A-B}$

$E_A = \Delta E_{A-B}$

$\Pi_A = \Delta E_{A-B}$

$\Delta E_{A-B} = \sum \zeta_{ul} \cdot \frac{V^2}{2g} + \lambda_1 \frac{\frac{L}{2} V^2}{D 2g} + \lambda_2 \frac{\frac{L}{2} V^2}{D 2g} + \sum \zeta_{izl} \frac{V^2}{2g}$

$\Delta E_{A-B} = 0.5 \cdot \frac{1.3^2}{2 \cdot 9.81} + 0.02 \cdot \frac{99.3 \cdot 1.3^2}{2 \cdot 0.1833 \cdot 9.81} + 0.035 \frac{99.3 \cdot 1.3^2}{2 \cdot 0.1833 \cdot 9.81} + \frac{1.3^2}{2 \cdot 9.81}$

$\Delta E_{A-B} = 0.0431 + 0.9389 + 1.6431 + 0.0861 = 2.7112\,m$

$\Pi_A = \Delta E_{A-B} = 2.7112 \approx 2.71\,m$

$\frac{p_A}{\rho g} + z_A = \Pi_A$, $z_A = 0$

$p_A = \Pi_A \rho g = 2.71 \cdot 9.81 \cdot 1000 = 26585\,Pa = 26.59\,kPa$

$p_{vak} = p_A = 26.59\,kPa$

$E_A = E_1 + \Delta E_{A-1}$

$\Delta E_{A-m} = \sum \zeta_{ul} \frac{V^2}{2g} + \lambda_1 \frac{\frac{L}{2} V^2}{2gD} = 0.5 \frac{1.3^2}{2 \cdot 9.81} + 0.02 \cdot \frac{99.3 \cdot 1.3^2}{2 \cdot 9.81 \cdot 0.1833} = 0.9820\,m$

$E_m = E_A - \Delta E_{A-m} = 2.71 - 0.9820 = 1.728\,m$

$E_m = \Pi_m + \frac{V^2}{2g}$ $\Pi_m = E_m - \frac{V^2}{2g} = 1.728 - \frac{1.3^2}{2 \cdot 9.81} = 1.6419 = 1.64\,m$

$\Delta p_m = p_m^+ - p_m^-$ $\Delta p_m = 26.59 - (-3.53) = 30.12\,kPa$

$p_m^+ = p_{vak} = 26.59\,kPa$

$p_m^- = (\Pi_m - z_m)\rho g = (1.64 - 2) \cdot 1000 \cdot 9.81 = -3.53\,kPa$

$\Delta E_{ul} = \xi_{ul} \frac{v^2}{2g} = 0,5 \cdot \frac{1.3}{2 \cdot 9.81} = 0.0431m$

$\Delta E_{lin_1} = \lambda_1 \frac{l}{d} \frac{v^2}{2g} = 0.9329m$

$\Delta E_{lin_2} = \lambda_2 \frac{l}{d} \frac{v^2}{2g} = 1.6431m$

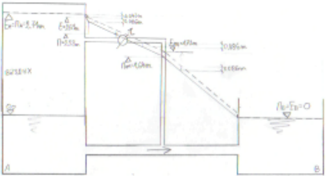
$\Delta E_{iz} = \xi_{iz} \frac{v^2}{2g} = 0.0861m$

$П_{ul} = П_A - \frac{v^2}{2g} = 2.71 - 0.0431 - \frac{1.3^2}{2 \cdot 9.81}$

$\Delta П_{ul} = 2.71 - 2.58m = 0.13m$

$П_{p} = 1.64m$

$\frac{v^2}{2g} = \frac{1.3^2}{2 \cdot 9.81} = 0.0861m$

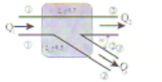


вертикална размера 1:50

ZADACI ZA OVERU PRISUSTVA NA VEŽBAMA

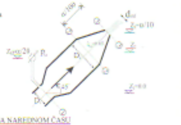
(Napomena: slike koristi u nastavku, a ne u opštim brojevima)

ZADATAK 5.1



Za potrebe dimenzionisanja ankernog bloka (sprečava oštećenja na cevovodu pri promeni pravca), potrebno je odrediti silu $-\vec{K}$ (sila fluida na konturu). Prečnici cevovoda su: $D_1=D_2=(120+\beta)$ mm i $D_3=D_1-60$ mm. Protok $Q_2=Q_3=(10+\alpha)$ L/s, a u preseku 2-2 je registrovan pritisak od $p_2=\beta$ KPa. Gustina vode iznosi $\rho_v=1$ kg/dm^3.
Napomena: *Cevovod je u horizontalnoj ravni na koti z=0.0 m.*

ZADATAK 5.2



Kroz deo cevi kružnog poprečnog preseka promenljivog prečnika ($D_1=3(\alpha+\beta)$ mm, $D_2=5(\alpha+\beta)$ mm) koja se završava mlaznikom (od preseka 2-2 do preseka 3-3) prečnika $d_{ml}=2(\alpha+\beta)$ mm, protiče voda protokom $Q=15+\dfrac{\beta}{2}$ L/s. Ukoliko koeficijent lokalnog gubitka na mlazniku iznosi $\xi_{ml}=0.05$ (od preseka 2-2 do preseka 3-3), a linijski gubici na mlazniku se zanemaruju, izračunati silu na mlaznik ($-\vec{K}$). Nakon toga odrediti i čitanje na manometru p_M ukoliko ukupan gubitak energije (lin.+lok.) između preseka 1 i 2 iznosi 20% brzinske visine u preseku 2. Gustina vode iznosi $\rho_v=1$ kg/dm^3.

ZADACI KOJI SE OCENJUJU NA NAREDNOM ČASU

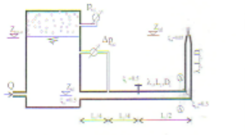
ZADATAK 5.3

Iz rezervoara pod pritiskom voda ističe u atmosferu. Prečnici cevovoda su $D_1=100+\dfrac{\alpha+\beta}{10}$ mm, $D_2=D_1-20$ mm i $d_{ml}=50$ mm. Dužina horizontalne cevi je $L_1=10$ m a koeficijenti linijskih gubitka su $\lambda_1=0.015$ i $\lambda_2=0.02$. Kota nivoa vode u rezervoaru je $z_{nivoa}=8$ m. Kota ulaza vode u cevovod je $z_{ul}=4$ m i kota izlaza $z_{iz}=8$ m, a pritisak koji pokazuje manometar $p_{M1}=5\beta$ kPa. Odrediti:

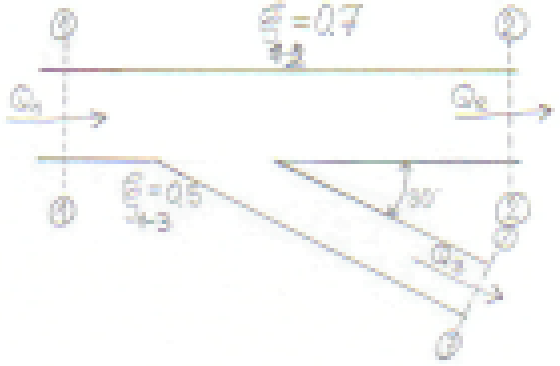
1. protok kroz instalaciju Q,
2. pijezometarsku kotu Π_{A-A} u preseku A-A,
3. pritisak koji pokazuje diferencijalni manometar Δp_{M2},
4. postaviti dinamičku jednačinu od preseka A-A do izlaza i izračunati silu vode na konturu ($-\vec{K}$) u horizontalnom ($-\vec{K}_x$) i vertikalnom ($-\vec{K}_y$) pravcu,
5. presečne sile u preseku A-A (M, N i T) koje nastaju od sile na konturu i težine cevi koja je jednaka G=900 N/m' (obratiti pažnju da je sopstvena težina vode uračunata u silu $-\vec{K}$).

Nacrtati Π i E liniju u pogodnoj razmeri.

Napomena: *Primer crtanja Π i E linije za vertikalne cevi se može videti u zbirci na sajtu Mehanika fluida->Literatura (Tečenje pod pritiskom - Zadatak 2.2)*



Задатак 5.1



$Q_1 = Q_2 = 153.3\,mm = 0.1533\,m$

$Q_3 = 93.3\,mm = 0.0933\,m$

$Q_2 = Q_3 = 16\,\frac{l}{s} = 0.016\,\frac{m^3}{s}$

$P_2 = 33.3\,kPa$

$\rho = 1000\,\frac{kg}{m^3}$

$Q_1 = Q_2 + Q_3 = 0.032\,\frac{m^3}{s}$

$A_1 = \frac{D_1^2 \pi}{4} = \frac{0.1533^2 \pi}{4} = 0.01846\,m^2$

$A_2 = A_1 = 0.01846\,m^2$

$A_3 = \frac{D_3^2 \pi}{4} = \frac{0.0933^2 \pi}{4} = 0.00684\,m^2$

$V_1 = \frac{Q_1}{A_1} = \frac{0.032}{0.01846} = 1.73\,\frac{m}{s}$

$V_2 = \frac{Q_2}{A_2} = \frac{0.016}{0.01846} = 0.87\,\frac{m}{s}$

$V_3 = \frac{Q_3}{A_3} = \frac{0.016}{0.00684} = 2.34\,\frac{m}{s}$

$I_1 = \rho Q_1 V_1 = 1000 \cdot 0.032 \cdot 1.73 = 55.36\,N$

$I_2 = \rho Q_2 V_2 = 1000 \cdot 0.016 \cdot 0.87 = 13.92\,N$

$I_3 = \rho Q_3 V_3 = 1000 \cdot 0.016 \cdot 2.34 = 37.44\,N$

$\frac{P_2}{\rho g} = \Pi_2 = \frac{33300}{1000 \cdot 9.81} = 3.394\,m$

$E_2 = \Pi_2 + \frac{V_2^2}{2g} = 3.394 + \frac{0.87^2}{2 \cdot 9.81} = 3.433\,m$

$E_1 = E_2 + \Delta E_{1-2} \qquad \Delta E_{1-2} = \xi_{1-2} \frac{V_2^2}{2g} = 0.7 \cdot \frac{0.87^2}{2 \cdot 9.81} = 0.027\,m$

$E_1 = 3.433 + 0.027 = 3.46\,m$

$E_1 = \Pi_1 + \frac{V_1^2}{2g}$

$\Pi_1 = E_1 - \frac{V_1^2}{2g} = 3.46 - \frac{1.73^2}{2 \cdot 9.81} = 3.307\,m$

$\frac{P_1}{\rho g} = \Pi_1 \quad P_1 = \Pi_1 \rho g = 3.307 \cdot 1000 \cdot 9.81 = 32446.91\,Pa \approx 32.45\,kPa$

$E_1 = E_3 + \Delta E_{1-3} \qquad \Delta E_{1-3} = \xi_{1-3} \frac{V_3^2}{2g} = 0.5 \cdot \frac{2.34^2}{2 \cdot 9.81} = 0.1395\,m$

$E_3 = E_1 - \Delta E_{1-3} = 3.46 - 0.1395 = 3.32\,m$

$E_3 = \Pi_3 + \frac{V_3^2}{2g}$

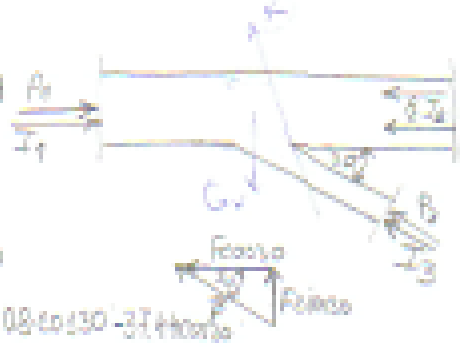
$\Pi_3 = E_3 - \frac{V_3^2}{2g} = 3.32 - \frac{2.34^2}{2 \cdot 9.81} = 3.04\,m$

$\frac{P_3}{\rho g} = \Pi_3 \quad P_3 = \Pi_3 \rho g = 3.04 \cdot 1000 \cdot 9.81 = 29835.9\,Pa$

$P_1 = P_1 A_1 = 32446.91 \cdot 0.01846 = 598.97\,N$

$P_2 = P_2 A_2 = 33300 \cdot 0.01846 = 614.718\,N$

$P_3 = P_2 A_3 = 29835.9 \cdot 0.00684 = 204.08\,N$



$-\vec{K} = \vec{P_1} + \vec{I_1} + \vec{P_2} + \vec{I_2} \;/\; \vec{x}$

X: $-K_x = P_1 + I_1 - P_2 - I_2 - P_3 \cos 30 - I_3 \cos 30$

$-K_x = 598.97 + 55.36 - 614.718 - 13.32 - 204.08 \cos 30 - 39.44 \cos 30$

$-K_x = -183.47 \qquad K_x = 183.47$

Y: $-K_y = P_3 \sin 30 + I_3 \sin 30 = 204.08 \cdot \sin 30 + 39.44 \cdot \sin 30 = 120.76$

$K_y = -120.76$

$-K_x = -183.47\,N$

$-K_y = 120.76$

$K = \sqrt{K_x^2 + K_y^2} = \sqrt{183.47^2 + 120.76^2} = 219.646\,N$

Задатак 5.2

$D_1 = 117.9\,mm = 0.1179\,m$

$D_2 = 196.5\,mm = 0.1965\,m$

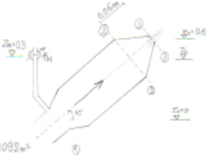
$d_{ml} = 78.6\,mm = 0.0786\,m$

$Q = 31.65\,\frac{l}{s} = 0.03165\,\frac{m^3}{s}$

$\xi_{ml} = 0.05$

$\Delta E_{1-2} = 0.2\,\frac{V_2^2}{2g}$

$\rho = 1000\,\frac{kg}{m^3}$



$A_1 = \frac{D_1^2\pi}{4} = \frac{0.1179^2\pi}{4} = 0.01092\,m^2$

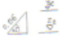
$A_2 = \frac{D_2^2\pi}{4} = \frac{0.1965^2\pi}{4} = 0.03033\,m^2$

$A_{ml} = \frac{d_{ml}^2\pi}{4} = \frac{0.0786^2\pi}{4} = 0.00485\,m^2$

$V_1 = \frac{Q}{A_1} = \frac{0.03165}{0.01092} = 2.899\,\frac{m}{s} \approx 2.9\,\frac{m}{s}$

$V_2 = \frac{Q}{A_2} = \frac{0.03165}{0.03033} = 1.044\,\frac{m}{s}$

$V_{ml} = \frac{Q}{A_{ml}} = \frac{0.03165}{0.00485} = 6.53\,\frac{m}{s}$



$Z_3 - Z_2 = 0.06\sin 45$

$Z_2 = Z_3 - 0.06\sin 45 = 0.6 - 0.06\sin 45 = 0.558\,m$

$I_2 = \rho Q V_2 = 1000 \cdot 0.03165 \cdot 1.044 = 33.03\,N$

$I_{ml} = \rho Q V_{ml} = 1000 \cdot 0.03165 \cdot 6.53 = 806.67\,N$

$E_3 = \Pi_3 + \frac{V_3^2}{2g}$, $\Pi_3 = Z_3 = 0.6\,m$, $p_3 = 0$ $P_3 = 0$

$E_3 = 0.6 + \frac{6.53^2}{2 \cdot 9.81} = 2.773\,m$

$E_2 = E_3 + \Delta E_{2-3}$ $\Delta E_{2-3} = \xi_{ml} \cdot \frac{V_{ml}^2}{2g} = 0.05 \cdot \frac{6.53^2}{2 \cdot 9.81} = 0.109\,m$

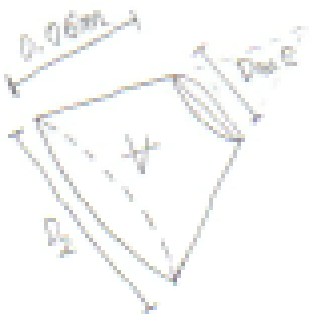
$E_2 = 2.773 + 0.109 = 2.882\,m$

$E_0 = \Pi_2 + \frac{v_2^2}{2g}$ $\Pi_2 = E_2 - \frac{v_2^2}{2g} = 2.880 - \frac{1.044^2}{2 \cdot 9.81} = 2.82$ m

$P_2 = \Pi_2 \cdot \rho g = 2.82 \cdot 1000 \cdot 9.81 = 27727.45$ Pa $= 27.73$ kPa

$P_2 = P_2 \cdot A_2 = 27727.45 \cdot 0.03033 = 840.86$ N

$V = \frac{H}{3}(A_2 + A_{вис} + \sqrt{A_2 A_{вис}})$

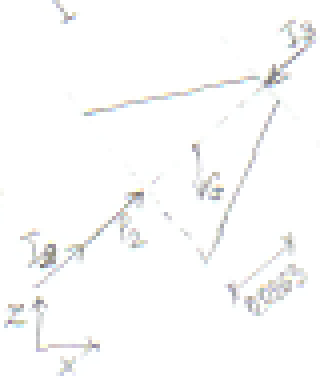


$V = \frac{0.06}{3}(0.03033 + 0.00485 + \sqrt{0.03033 \cdot 0.00485})$

$V = 0.000918 m^3 \approx 1\ell$

$G = \rho g V = 9.02$ N

$-\vec{R} = \vec{T_2} + \vec{P_2} + \vec{T_3} + \vec{G} \;/\; \sum \vec{x}$



$-Rx = T_2 \cos 45 + P_2 \cos 45 - T_3 \cos 45$

$-Rx = 33.03 \cos 45 + 840.86 \cos 45 - 206.67 \cos 45$

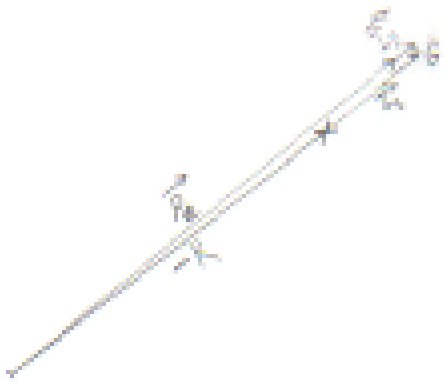
$-Rx = 471.73$ N

$-Rz = T_2 \cos 45 + P_2 \cos 45 - T_3 \cos 45 - G$

$-Rz = 33.03 \cos 45 + 840.86 \cos 45 - 206.67 \cos 45 - 9.28$

$-Rz = 462.51$ N

$R = \sqrt{Rx^2 + Rz^2} = \sqrt{471.73^2 + 462.51^2} = 660.7$ N



$E_1 = E_2 + \Delta E_{1-2}$

$E_2 = 2.882m \quad \Delta E_{1-2} = 0.2 \frac{V_2^2}{2g} = 0.2 \cdot \frac{1.044^2}{2 \cdot 9.81} = 0.011m$

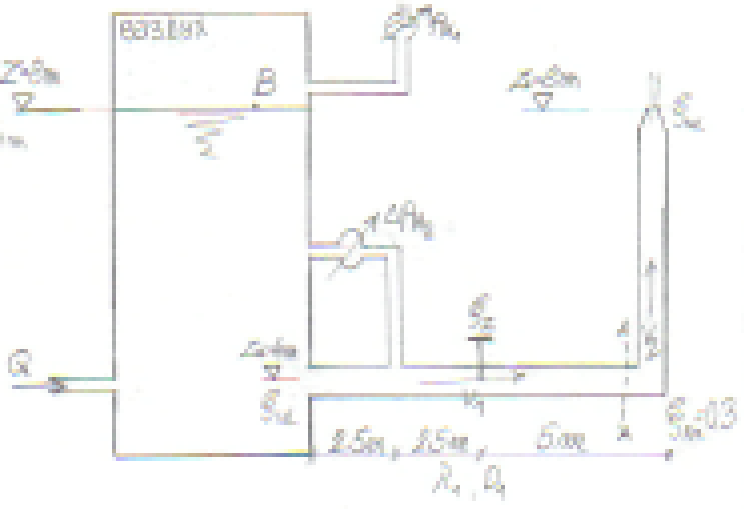
$E_1 = 2.882 + 0.011m = 2.893m$

$E_1 = \Pi_1 + \frac{V_1^2}{2g} \quad \Pi_1 = 2.893 - \frac{2.9^2}{2 \cdot 9.81} = 2.46m$

$\frac{P_M}{\rho g} + Z_{sm} = \Pi_1$

$P_M = (\Pi_1 - Z_m)\rho g = (2.46 - 0.3) \cdot 1000 \cdot 9.81 = 21232.33 Pa = 21.23 kPa$

Задатак 5.3



$D_1 = 103.93\text{mm} = 0.10393\text{m}$

$D_2 = 83.93\text{mm} = 0.08393\text{m}$

$d_{mc} = 50\text{mm} = 0.05\text{m}$

$L_1 = 10\text{m}$

$\lambda_1 = 0.015$

$\lambda_2 = 0.02$

$Z_{ulaz} = 8\text{m}$

$Z_{DL} = 4\text{m}$

$Z_{izl} = 0\text{m}$

$P_{M_1} = 166.5\text{kPa}$

$\xi_{ul} = 0.5$

$\xi_{ok} = 0.5$

$\xi_{kol} = 0.3$

$\xi_{mc} = 0.05$

$L_2 = Z_{ulaz} - Z_{DL} = 4\text{m}$

1. $P_B = P_{M_1} = 166.5\text{kPa}$

$$\frac{P_A}{\rho g} + Z_B = \Pi \qquad \Pi = \frac{166500}{1000 \cdot 9.81} + 8 = 24.97\text{m}$$

$E_R = E_{ul} + \Delta E_{ul-mc}$

$$E_R = \Pi + \frac{V_R^2}{2g} \quad ; V_R = 0 \qquad E_R = \Pi = 24.97\text{m}$$

$$E_{mc} = \Pi_{ul} + \frac{V_{mc}^2}{2g} = 8 + \frac{V_{mc}^2}{2g}$$

$$\Delta E_{ul-mc} = \xi_{ul} \cdot \frac{V_1^2}{2g} + \xi_{ul} \cdot \frac{V_1^2}{2g} + \lambda_1 \cdot \frac{L_1 V_1^2}{D_1 2g} + \xi_{kol} \cdot \frac{V_2^2}{2g} + \lambda_2 \cdot \frac{L_2 V_2^2}{D_2 2g} + \xi_{mc} \cdot \frac{V_{mc}^2}{2g} =$$

$$= 0.5 \cdot \frac{V_1^2}{2 \cdot 9.81} + 0.5 \cdot \frac{V_1^2}{2 \cdot 9.81} + 0.015 \cdot \frac{10 \cdot V_1^2}{0.10393 \cdot 2 \cdot 9.81} + 0.3 \cdot \frac{V_2^2}{2 \cdot 9.81} +$$

$$+ 0.02 \cdot \frac{4 V_2^2}{0.08393 \cdot 2 \cdot 9.81} + 0.05 \cdot \frac{V_{mc}^2}{2g}$$

$$\Delta E_{R-mc} = 0.0255 V_1^2 + 0.0255 V_1^2 + 0.0736 V_1^2 + 0.0153 V_2^2 + 0.0486 V_2^2 +$$

$$+ 0.0025 V_{mc}^2$$

$$\Delta E_{R-mc} = 0.1845 V_1^2 + 0.0639 V_2^2 + 0.0025 V_{mc}^2$$

Q: $A_1V_1 = A_2V_2 = A_{mc}V_{mc}$

$A_1 = \frac{D_1^2\pi}{4} = \frac{0.10393^2\pi}{4} = 0.0085 m^2$

$A_2 = \frac{D_2^2\pi}{4} = \frac{0.08395^2\pi}{4} = 0.0055 m^2$

$A_{mc} = \frac{D_{mc}^2\pi}{4} = \frac{0.05^2\pi}{4} = 0.002 m^2$

$V_1 = \frac{A_{mc}V_{mc}}{A_1} = \frac{0.002 \cdot V_{mc}}{0.0085} = 0,2314 V_{mc}$

$V_2 = \frac{A_{mc}V_{mc}}{A_2} = \frac{0.002 V_{mc}}{0.0055} = 0,355 V_{mc}$

$\Delta E_{kmc} = 0.1245 \cdot (0.2314)^2 V_{mc}^2 + 0.0639 \cdot (0.355)^2 V_{mc}^2 + 0.0025 V_{mc}^2 = 0.0173 V_{mc}^2$

$E_k = E_{kmc} + \Delta E_{k-mc}$

$24.97 = 8 + 0.0509 V_{mc}^2 + 0.0173 V_{mc}^2$

$0.0682 V_{mc}^2 = 16,9725$

$V_{mc}^2 = 248.744$

$V_{mc} = 15.77 \frac{m}{s}$

$V_1 = 0.2314 \cdot 15.77 = 3.65 \frac{m}{s}$

$V_2 = 0.355 \cdot 15.77 = 5,597 \frac{m}{s} \approx 5.6 \frac{m}{s}$

$Q = 15.77 \cdot 0.002 = 0.030967 \frac{m^3}{s} = 30.967 \frac{l}{s} \approx 31 \frac{l}{s}$

2. $E_k = E_{A-A} + \Delta E_{k-A}$

$\Delta E_{k-A} = \xi_{ul} \frac{V_1^2}{2g} + \xi_z \cdot \frac{V_1^2}{2g} + \lambda_1 \frac{L V_1^2}{D_1 2g} = 0.5 \cdot \frac{3.65^2}{2 \cdot 9.81} + 0.5 \cdot \frac{3.65^2}{2 \cdot 9.81} + 0.015 \cdot \frac{10 \cdot 3.65^2}{0.10393 \cdot 2 \cdot 9.81} =$

$= 1.659 m$

$E_{A-A} = E_k - \Delta E_{k-A} = 24.97 - 1.659 = 23.31 m$

$E_{A-A} = \Pi_A + \frac{V_1^2}{2g}$

$\Pi_A = E_{A-A} - \frac{V_1^2}{2g} = 23.31 - \frac{3.65^2}{2 \cdot 9.81} = 22.63 m$

3. $\Delta p_{M_2} = ?$

$E_R = E_{M_2} + \Delta E_{R-M_2}$

$\Delta E_{R-M_2} = \zeta_{ul} \frac{V_1^2}{2g} + \lambda_1 \cdot \frac{L}{d} \frac{V_1^2}{2g} = 0.5 \frac{3.65^2}{2 \cdot 9.81} + 0.015 \cdot \frac{2.5 \cdot 3.65^2}{2 \cdot 0.1033 \cdot 9.81} = 0.584\,m$

$E_{M_2} = E_R - \Delta E_{R-M_2} = 24.97 - 0.584 = 24.388\,m$

$E_{M_2} = \Pi_{M_2} + \frac{V_1^2}{2g}$

$\Pi_{M_2} = E_{M_2} - \frac{V_1^2}{2g} = 24.388 - \frac{3.65^2}{2 \cdot 9.81} = 23.71\,m$

$p_M^+ = \rho g (\Pi_R - Z_{M_2}) = 1000 \cdot 9.81 \cdot 24.97 - 1000 \cdot 9.81 \cdot Z_M = 244980 - 9810 Z_M$

$p_M^- = \rho g (\Pi_{M_2} - Z_{M_2}) = 1000 \cdot 9.81 \cdot 23.71 - 1000 \cdot 9.81 \cdot Z_M = 232582.251 - 9810 Z_M$

$\Delta p_{M_2} = p_M^+ - p_M^- = 244980 - 9810 Z_M - (232582.251 - 9810 Z_M)$

$= 244980 - 9810 Z_M - 232582.251 + 9810 Z_M =$

$= 12397.75\,Pa = 12.4\,kPa$

4. $-\vec{K_1} = \vec{P_A} + \vec{I_A} + \vec{P_{mc}} + \vec{I_{mc}} + \vec{G_v}$

$P_A = p_A \cdot A_{A-A}$

$A_{A-A} = A_1 = 0.0085\,m^2 \qquad Z_A = Z_{\Sigma L} = 4\,m$

$\frac{p_A}{\rho g} + Z_A = \Pi_A \qquad p_A = (\Pi_A - Z_A) \cdot \rho \cdot g = (22.63 - 4) \cdot 1000 \cdot 9.81 = 182739\,Pa$

$P_A = 0.0085 \cdot 182739 = 1550.7\,N$

$I_A = \rho Q V_1 = 1000 \cdot 0.030967 \cdot 3.65 = 113\,N$

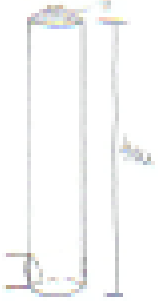
$P_{mc} = 0$

$I_{mc} = \rho Q V_{mc} = 1000 \cdot 0.030967 \cdot 15.77 = 488.41\,N$

$G = \rho g V$

$V = A_1 \cdot L_2 = 0.0055 \cdot 4 = 0.0221\,m^3 \approx 22.1\,\ell$

$G = 1000 \cdot 9.81 \cdot 0.0221 = 217.1\,N$

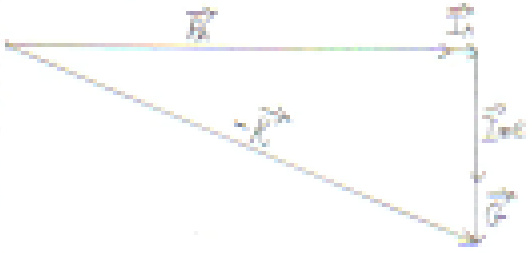


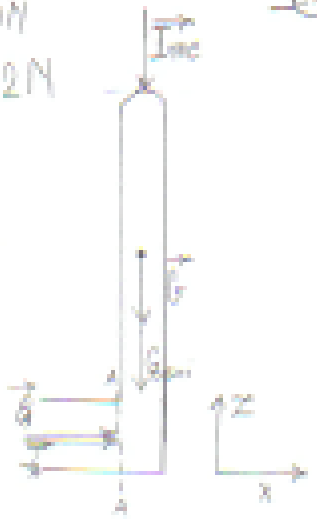
$-\vec{K} = \vec{I_A} + \vec{P_A} + \vec{I_{me}} + \vec{G_v} \,/\cdot \vec{i}$

$-K_x = I_A + P_A = 113 + 1550.7 = 1663.8\,N$

$-K_z = -I_{me} - G = -488.41 - 217.1 = -705.50\,N$

$K = \sqrt{(-K_x)^2 + (-K_z)^2} = \sqrt{1663.8^2 + (-705.5)^2} = 1807.2\,N$





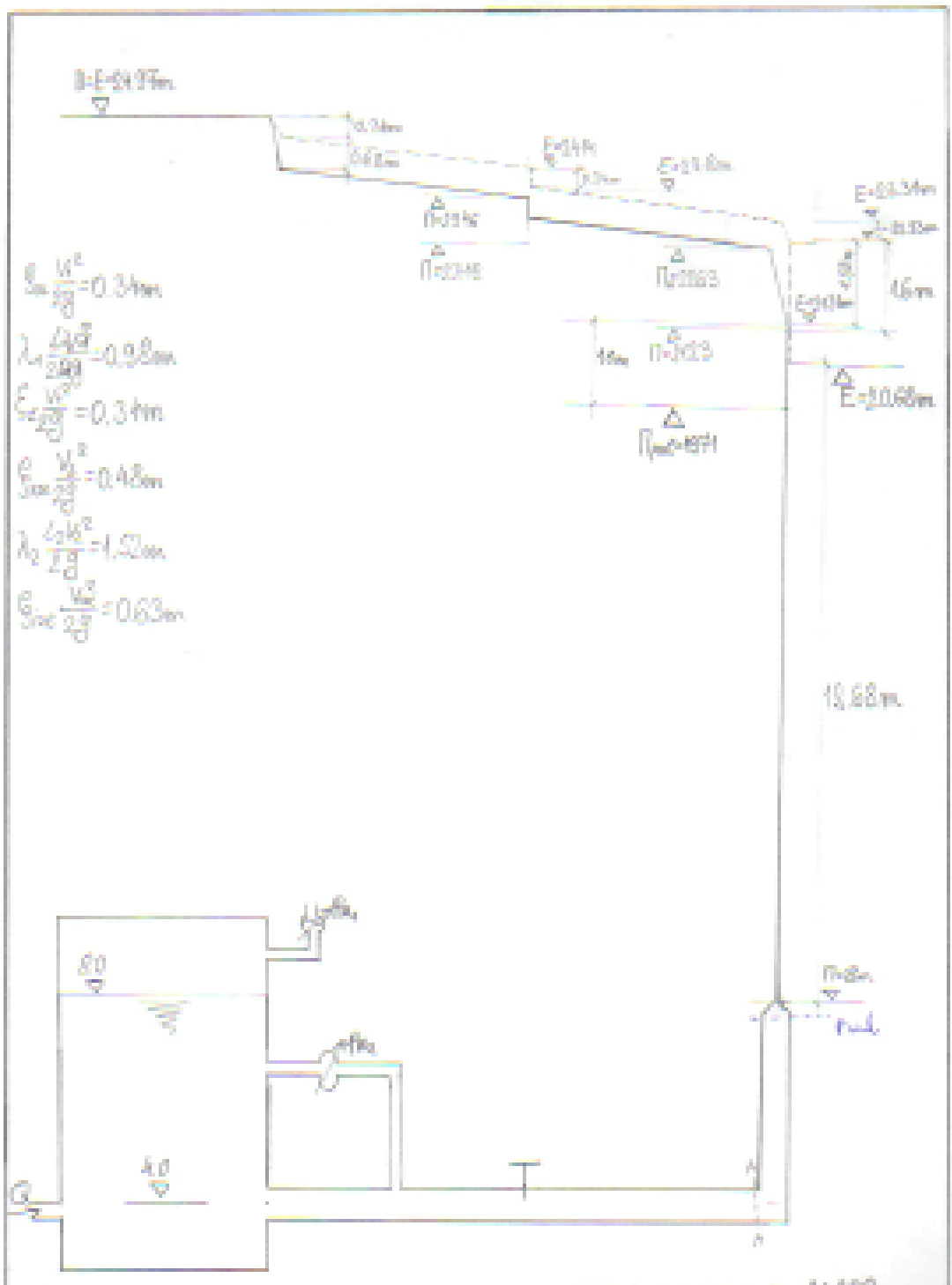
5. $G_{cevi} = G \cdot 4m = 3600\,N$

$G = G_{cevi} + G_v = 3600 + 217.1\,N = 3817.1\,N$

$N = P_A + I_A = 1663.8\,N$

$T = G + I_{me} = 3817.1 + 488.41 = 4305.5\,N$

$M = G \cdot \frac{D_p}{2} + I_{me} \cdot \frac{D}{2} = (3817.1 + 488.41) \cdot \frac{0.02333}{2} = 180.68\,Nm$



$\frac{V^2}{2g}=0.34m$

$\lambda_1 \frac{L_1 V^2}{2gR}=0.98m$

$\xi_c \frac{V^2}{2g}=0.34m$

$\xi_{3ax} \frac{V_1^2}{2g}=0.48m$

$\lambda_2 \frac{L_2 V_2^2}{2gR}=1.52m$

$\xi_{вых} \frac{V_2^2}{2g}=0.63m$

$\frac{V_1^2}{2g}=0.68m$

$\frac{V_2^2}{2g}=1.6m$

$\frac{V_{вых}^2}{2g}=12.68m$

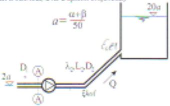
ZADACI ZA OVERU PRISUSTVA NA VEŽBAMA

ZADATAK 6.1

(Napomena: slike kotirati u metrima, a ne u opštim brojevima)

Na cevovoda kao na slici (L_2=15($\alpha+\beta$) m, D_1= 200 + β mm, D_2= 250 + β mm, λ_2=0.02, ξ_{kol}=0.3) postavljena je pumpa (η_P=0.65). Kroz cevovod protiče Q=80+ β L/s a u preseku A-A neposredno ispred pumpe (na koti z=2a) je registrovan pritisak od $p_A = \beta$ kPa. Izračunati visina dizanja pumpe (H_P) i snaga pumpe (S_P). Nacrtati pijezometarsku i energetsku liniju u pogodnoj razmeri.

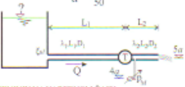
$$a=\frac{\alpha+\beta}{50}$$



ZADATAK 6.2

Na cevovodu kao na slici (L_1=250+ β m, L_2=3 β m,D_1= 200 + β mm, D_2= 250 + β mm, λ_1=0.015, λ_2=0.02, ξ_{ul}=0.5) postavljena je turbina (η_T=0.85, S_T= β/2 kW). Neposredno iza turbine nalazi se manometar na kome se registruje pritisak $p_M = \beta/2$ KPa. Izračunati protok kroz cevovod (Q), pad turbine (H_T) i nivo u rezervoaru.

$$a=\frac{\alpha+\beta}{50}$$



ZADACI KOJI SE OCENJUJU NA NAREDNOM ČASU

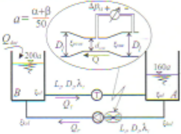
ZADATAK 6.3

U sistemu na slici voda se pumpa iz rezervoara A u rezervoar B noću u periodu niže tarife električne energije i u vremenskom intervalu T_1=8h. U rezervoar B konstantno dotiče proticaj Q_{dot}=0.2+α/100 m³/s. Narednog dana je potrebno ukupnu količinu dotekle vode u rezervoar B propustiti kroz turbinu u vremenskom intervalu T_2=12h. Na delu cevovoda ispred pumpe postavljeno je Venturijevo suženje na kome se nalazi diferencijalni manometar koji registruje pritisak $\Delta p_M = -4a$ kPa .

Karakteristike cevovoda su:

- L_1=3km, D_1=550+ β mm, λ_1=0.025
- L_2=2.5km, D_2=760+ β mm, λ_2=0.02
- ξ_{kol}=0.3, ξ_{ul} =0.5

$$a=\frac{\alpha+\beta}{50}$$



Potrebno je izračunati:

a) Proticaj kroz donji cevovod (Q_P) koristeći čitanje na dif. manometru na Venturijevom suženja
($d_{min} = D_1$ - 120mm,
ξ_{kon} = 0.25, ξ_{difuz} = 1.1),

b) Visinu dizanja pumpe (H_P) i snagu pumpe (S_P) ako je koef. korisnog dejstva η_P=0.7,

c) Protok kroz gornji cevovod (Q_T) iz uslova da se u intervalu T_2=12 h kroz turbinu propušta celokupna količina vode dovedena u rezervoar B u toku prethodnog dana,

d) Pad turbine (H_T) i snagu turbine (S_T) ako je η_T=0.85 i

e) Odnos energije koja se utroši na pumpanje (Ep [kWh]) i energije koju proizvede turbina (Et [kWh]).

Задатак 6.1

$L_2 = 589.5\,m$

$D_1 = 233.3\,mm = 0.2333\,m$

$D_2 = 283.3\,mm = 0.2833\,m$

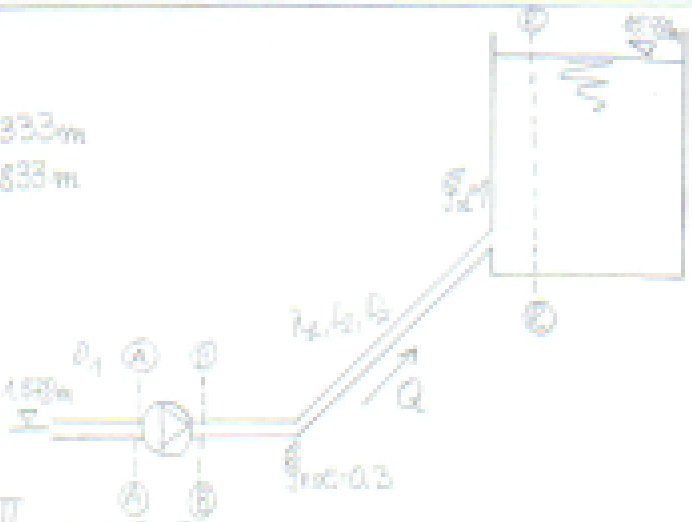
$\lambda_2 = 0.02$

$\zeta_{ivx} = 0.3$

$\eta_C = 0.65$

$Q = 113.3\,\frac{l}{s}$

$p_A = 333\,kPa$



$$A_1 = \frac{D_1^2 \pi}{4} = \frac{0.2333^2 \pi}{4} = 0.0427\,m^2$$

$$A_2 = \frac{D_2^2 \pi}{4} = \frac{0.2833^2 \pi}{4} = 0.063\,m^2$$

$$V_1 = \frac{Q}{A_1} = \frac{0.1133}{0.0427} = 2.653\,\frac{m}{s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.1133}{0.063} = 1.798\,\frac{m}{s}$$

$$E_A = \Pi_A + \frac{V_1^2}{2g}$$

$$\frac{p_A}{\gamma g} + z_A = \Pi_A \qquad \Pi_A = \frac{333.00}{1000 \cdot 9.81} + 1.572 = 4.366\,m$$

$$E_A = 4.366 + \frac{2.653^2}{2 \cdot 9.81} = 5.325\,m$$

$$E_R = \Pi_R + \frac{V_R^2}{2g} = 15.72\,m \qquad \Pi_R = 15.72\,m$$

$$E_B = E_R + \Delta E_{B-R}$$

$$\Delta E_{B-R} = \lambda_2 \frac{L_2 V_2^2}{2 D_2 g} + \zeta_{ivx} \frac{V_2^2}{2g} + \zeta_{izl} \frac{V_2^2}{2g} = 0.02 \cdot \frac{589.5 \cdot 1.798^2}{2 \cdot 0.2833 \cdot 9.81} + 0.3 \cdot \frac{1.798^2}{2 \cdot 9.81} +$$

$$+ 1 \cdot \frac{1.798^2}{2 \cdot 9.81} = 6.85 + 0.049 + 0.165 = 7.064\,m$$

$$E_B = 15.72 + 7.064 = 22.784\,m$$

$$E_B = \Pi_B + \frac{V_2^2}{2g}$$

$$\Pi_B = E_B - \frac{V_2^2}{2g} = 22.784 - \frac{1.798^2}{2 \cdot 9.81} = 22.619\,m$$

$H_p = E_B - E_A = 11.734 - 5.365 = 17.459\,m$

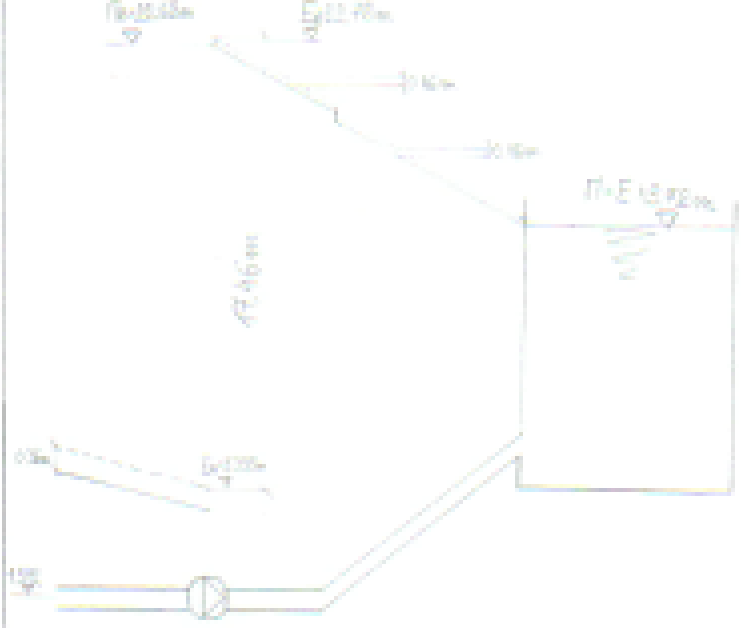
$N_p = \frac{1}{\eta_p} \rho g Q H_p = \frac{1000 \cdot 9.81 \cdot 0.133 \cdot 17.459}{0.65} = 29854.16\,W = 29.85\,kW$

$\frac{V_3^2}{2g} = 0.36\,m.$

$\frac{V_2^2}{2g} = 0.16\,m.$

$\zeta_{вх} \frac{V_2^2}{2g} = 0.16\,m.$

$\zeta_{пов} \frac{V_2^2}{2g} = 0.049\,m.$



Вертикальный масштаб 1:50

Задатак 6.2

$L_1 = 1833\,m$

$L_2 = 99.9\,m$

$D_1 = 2333\,mm = 0.2333\,m$

$D_2 = 2833\,mm = 0.2833\,m$

$\lambda_1 = 0.015$

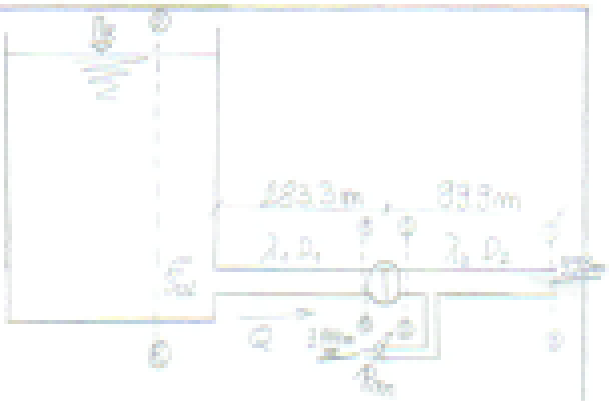
$\lambda_2 = 0.02$

$\zeta_{ul} = 0.5$

$\eta_T = 0.85$

$S_T = 16.65\,kW$

$P_{Tm} = 16.65\,kPa$



$A_1 = \frac{D_1^2 \Pi}{4} = \frac{0.2333^2 \Pi}{4} = 0.0427\,m^2$

$A_2 = \frac{D_2^2 \Pi}{4} = \frac{0.2833^2 \Pi}{4} = 0.063\,m^2$

$E_2 = E_3 + \Delta E_{2-3}$

$E_2 = \Pi_2 + \frac{V_2^2}{2g}$

$\frac{P_{2m}}{\rho g} + z_m = \Pi_2 \quad \Pi_2 = \frac{16650}{1000 \cdot 9.81} + 3.144 = 4.84\,m$

$E_3 = \Pi_3 + \frac{V_3^2}{2g} \quad \Pi_3 = 3.93\,m$

$\Delta E_{2-3} = \lambda_2 \frac{L_2 V_2^2}{D_2 2g} = 0.02 \frac{99.9\, V_2^2}{2 \cdot 0.2833 \cdot 9.81} = 0.359 V_2^2$

$4.84 + \frac{V_2^2}{2g} = 3.93 + \frac{V_2^2}{2g} + 0.359 V_2^2$

$0.359 V_2^2 = 0.91 \quad V_2 = 1.592\,\frac{m}{s}$

$Q = A_2 V_2 = 1.592 \cdot 0.063 = 0.1003\,\frac{m^3}{s} = 100.3\,\frac{l}{s}$

$S_T = \rho g Q H_T \eta_T$

$H_T = \frac{S_T}{\rho g Q \eta_T} = \frac{16650}{1000 \cdot 9.81 \cdot 0.1003 \cdot 0.85} = 19.9\,m$

$E_2 = \pi_2 + \frac{v_2^2}{2g} = 4.84 + \frac{1.539^2}{2 \cdot 9.81} = 4.969\,m$

$v_2 = \frac{Q}{A_1} = \frac{0.1003}{0.0427} = 2.349\,\frac{m}{s}$

$E_1 = E_2 + H_T = 4.969 + 19.9 = 24.869\,m$

$E_R = E_1 + \Delta E_{R-1}$

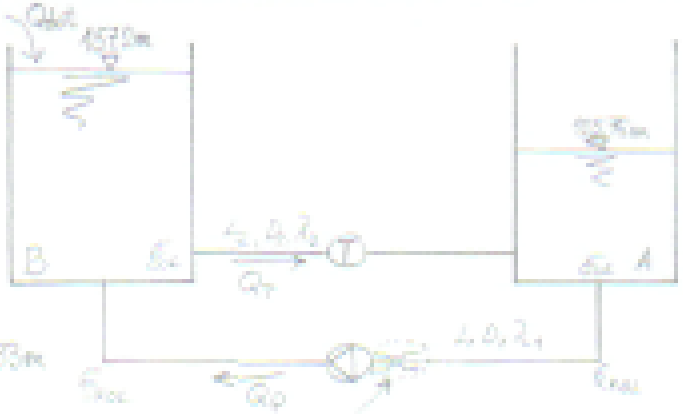
$\Delta E_{R-1} = \zeta_{ust} \frac{w^2}{2g} + \lambda_1 \frac{l_1 w^2}{2 D_1 g} = 0.5 \cdot \frac{2.349^2}{2 \cdot 9.81} + 0.015 \cdot \frac{883.3 \cdot 2.349^2}{2 \cdot 0.2333 \cdot 9.81} =$

$= 0.141 + 5.123 = 5.264\,m$

$E_R = 24.869 + 5.264 = 30.136\,m$

$E_R = \Pi_R + \frac{v_R^{2=0}}{2g}$; $\Pi_R = E_R = 30.136\,m$

Завдання 6.3



$T_1 = 8\,h$

$Q_{доп} = 0.86\,\frac{m^3}{s}$

$T_2 = 12\,h$

$\Delta P_м = -3.144\,MPa$

$l_1 = 3000\,m$

$D_1 = 583.3\,mm = 0.5833\,m$

$\lambda_1 = 0.025$

$l_2 = 2500\,m$

$D_2 = 733.3\,mm = 0.7333\,m$

$\lambda_2 = 0.02$

$\zeta_{вх} = 0.3$

$\zeta_{кл} = 0.5$

а) $d_{вент} = 463.3\,mm = 0.4633\,m$

$\zeta_{вих} = 0.25$

$\zeta_{вх} = 1.1$

$A_1 = \frac{D_1^2 \pi}{4} = \frac{0.5833^2 \pi}{4} = 0.2672\,m^2$

$A_{вент} = \frac{d_{вент}^2 \pi}{4} = \frac{0.4633^2 \pi}{4} = 0.1686\,m^2$

$\Delta P_м = P_м'' - P_м'$

$P_м'' = \rho g \Pi_{вент}$

$P_м' = \rho g \Pi_1$

$\Delta P_м = \rho g \Pi_{вент} - \rho g \Pi_1 = \rho g (\Pi_{вент} - \Pi_1)$

$\Pi_{вент} - \Pi_1 = \frac{\Delta P_м}{\rho g} = \frac{-3144}{1000 \cdot 9.81} = -0.3205\,m$

$E_1 = E_{вент} + \Delta E_{1\text{-}вент}$

$E_1 = \Pi_1 + \frac{V_1^2}{2g}$

$E_{vent} = \Pi_{vent} + \frac{V_{vent}^2}{2g}$

$\Delta E_{A\text{-}vent} = \xi_{brusc} \frac{V_{vent}^2}{2g}$

$Q: A_1 V_1 = A_{vent} V_{vent} \quad V_{vent} = \frac{A_1}{A_{vent}} V_1 = \frac{0.1672}{0.1686} V_1 = 1.5848 V_1$

$\Pi_1 + \frac{V_1^2}{2g} = \Pi_{vent} + \frac{V_{vent}^2}{2g} + \xi_{brusc} \frac{V_{vent}^2}{2g}$

$\frac{V_1^2}{2g} - \frac{V_{vent}^2}{2g} - \xi_{brusc} \frac{V_{vent}^2}{2g} = \Pi_{vent} - \Pi_1$

$0.051 V_1^2 - 0.051(1.5848 V_1^2) - 0.25 \cdot 0.051(1.5848 V_1^2) = -0.3205$

$0.051 V_1^2 - 0.1281 V_1^2 - 0.032 V_1^2 = -0.3205$

$-0.1094 V_1^2 = -0.3205$

$V_1 = 1.714 \frac{m}{s}$

$V_{vent} = 1.5848 \cdot 1.714 = 2.716 \frac{m}{s}$

$Q_p = A_1 V_1 = 0.1672 \cdot 1.714 = 0.1597 \frac{m^3}{s} = 459.7 \frac{L}{s}$

b)

$\xi_v = 0.7$

$E_A = E_B + \Delta E_{A\text{-}B} - H_p$

$E_A = \Pi_A + \frac{V_A^{2=0}}{2g} = \Pi_A = 125.76 m$

$E_B = \Pi_B + \frac{V_B^{2=0}}{2g} = \Pi_B = 157.2 m$

$$\Delta E_{A-B} = \lambda_1 \frac{L_A V_A^2}{2 D_A g} + \xi_{wx} \frac{V_A^2}{2g} + 2 \cdot \xi_{cm} \frac{V_A^2}{2g} - \xi_{exc} \frac{V_A^2}{2g} + \Delta E_{vent}$$

$$\Delta E_{vent} = \xi_{exc} \frac{V_{vent}^2}{2g} + \xi_{Tmm} \frac{V_A^2}{2g} = 0.25 \cdot \frac{1.746^2}{2 \cdot 9.81} + 1.1 \cdot \frac{1.714^2}{2 \cdot 9.81} = 0.09333 + 0.16477$$

$$= 0.2587 mm.$$

$$\Delta E_{A-B} = 0.025 \cdot \frac{3000 \cdot 1.714^2}{2 \cdot 0.5833 \cdot 9.81} + 0.5 \cdot \frac{1.714^2}{2 \cdot 9.81} + 2 \cdot 0.3 \cdot \frac{1.714^2}{2 \cdot 9.81} + 1 \cdot \frac{1.714^2}{2 \cdot 9.81} + 0.2587 =$$

$$= 13.253 + 0.075 + 0.0838 + 0.1497 + 0.2587 = 13.8262 m.$$

$$125.76 = 157.2 + 13.8262 - Hp$$

$$Hp = 51.2662 m.$$

$$S_p = \frac{\rho g Q_p Hp}{\eta_p} = \frac{1000 \cdot 9.81 \cdot 0.4597 \cdot 51.2662}{0.7} = 330275.68 W =$$

$$= 330.28 kW$$

c) $V_p = Q_p \cdot T_1 = 0.4597 \cdot 8 \cdot 60 \cdot 60 = 13239.36 m^3$

$V_{dot} = Q_{dot} \cdot T_{min} = 0.26 \cdot 24 \cdot 60 \cdot 60 = 22464 m^3$

$V_{uk} = V_p + V_{dot} = 13239.36 + 22464 = 35703.36 m^3$

$Q_T = \frac{V_{uk}}{T_2} = \frac{35703.36}{12 \cdot 60 \cdot 60} = 0.8265 \frac{m^3}{s}$

d) $A_2 = \frac{D_2^2 \pi}{4} = \frac{0.7933^2 \pi}{4} = 0.494 m^2$

$V_2 = \frac{Q_T}{A_2} = \frac{0.8265}{0.494} = 1.673 \frac{m}{s}$

$E_B = E_A + H_t + \Delta E_{A-B}$

$E_B = 157.2 m.$

$E_A = 125.76 m.$

$\Delta E_{A-B} = \xi_{wx} \frac{V_2^2}{2g} + \lambda_2 \frac{L_2 V_2^2}{2 D_2 g} + \xi_{exc} \frac{V_2^2}{2g} = 0.5 \frac{1.673^2}{2 \cdot 9.81} + 0.02 \frac{1500 \cdot 1.673^2}{2 \cdot 0.7933 \cdot 9.81} + 1 \frac{1.673^2}{2 \cdot 9.81}$

$\Delta E_{AB} = 0.0913 + 8.9314 + 0.1827 = 9.2054$ m.

$H_T = E_B - E_A - \Delta E_{AB} = 157.2 - 125.76 - 9.2054 = 22.2346$ m.

$S_T = 9.8 Q_{HT} \eta_T = 1000 \cdot 9.81 \cdot 0.8265 \cdot 22.2346 \cdot 0.85 = 153235.75 W$

$= 153.24 kW$

e) $E_P = S_P \cdot T_1 = 330.28 \cdot 8 = 2642.24 kWh$

$E_T = S_T \cdot T_2 = 153.24 \cdot 12 = 1838.88 kWh$

$\frac{E_P}{E_T} = \frac{2642.24}{1838.88} = 1.437$