II

1) $u = \frac{4 q_v}{\pi D^2} = 0,33 \text{ m.s}^{-1}$

2) $\Delta H_{sing} = \left(K_{mip} + 3K_{coude} + K_{clapet} + 2K_{conduite} \right) \times \frac{u^2}{2g} = 0,133 \approx 0,114 \text{ mCE}$

$\Delta H_{reg} = J \times L \Leftrightarrow \Delta H_{reg} = 7,75 \cdot 10^{-3} \times 650 = 0,504 \text{ mCE}$

3) $\Delta H_{tot} = \Delta H_{sing} + \Delta H_{reg} = 0,133 + 0,504 = 0,644 \text{ mCE}$

4) BERNOULLI entre A et B (nl) :

$$Z_A + \frac{P_A}{\rho g} + \frac{u_A^2}{2g} + HMT = Z_B + \frac{P_B}{\rho g} + \frac{u_B^2}{2g} + \Delta H_{tot}$$

$$\Leftrightarrow HMT = Z_B - Z_A + \frac{u_B^2}{2g} + \Delta H_{tot}$$

$$\Leftrightarrow HMT = 54 + \frac{0,33^2}{2 \times 9,81} + 0,644 \Leftrightarrow \underline{HMT = 54,65 \text{ mCE}}$$

EF : $\begin{cases} u_A = 0 \\ P_A = P_B = 0 \end{cases}$

5) $\mathcal{P}_{hyd} = \rho g \, HMT \times q_v = 10^3 \times 9,81 \times 54,65 \times \frac{10^{-2}}{3,6} = 14892 \text{ W} = 14,892 \text{ kW}$
$\approx 14,9 \text{ kW}$

6) $\eta = \frac{\mathcal{P}_{hyd}}{\mathcal{P}_{elec}} \Leftrightarrow \mathcal{P}_{elec} = \frac{\mathcal{P}_{hyd}}{\eta} = \frac{14892}{0,7} = 21,28 \cdot 10^3 \text{ W} = 21,28 \text{ kW}$

Soit : $21,28 \times 18 \times 7,7 \cdot 10^{-2} = 29,53 \approx 295 \text{ €} \Rightarrow 29 \text{ €}$ et 50 centimes €

7) $Re = \frac{u \times D \times \rho}{\mu} = 0,33 \times 300 \cdot 10^{-3} \times 10^6 = 1,17 \cdot 10^5$: turbulent (rugueux)

$\left(\frac{10^3}{10^{-3}} \right)$ car $Re > 4000$

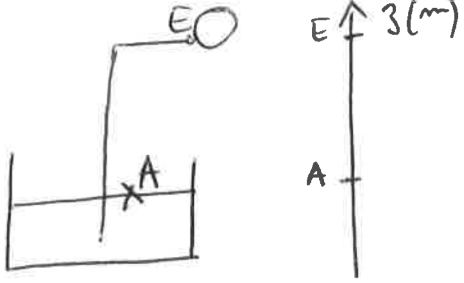
8) $\Delta H_{reg} = J \times L \Leftrightarrow \Delta H_{reg} = \frac{d}{D} \frac{u^2}{2g} \times L \Leftrightarrow d = \frac{\Delta H_{reg} \times D \times 2g}{u^2 \times L} = \frac{0,504 \times 0,3 \times 2 \times 9,81}{(0,33)^2 \times 650}$
$= 0,0291 \approx 0,03$

ou $J = \frac{d}{D} \frac{u^2}{2g} \Leftrightarrow d = \frac{J \times D \times 2g}{u^2}$

$\Leftrightarrow d = \frac{7,75 \cdot 10^{-3} \times 0,3 \times 2 \times 9,81}{0,33^2} = 0,0259 \approx 0,03$

9) Abaque $\left(\begin{matrix} Re = 1,17 \cdot 10^5 \approx 10^5 \\ d = 0,03 \end{matrix} \right)$ on trouve : $\frac{\varepsilon}{D} = 4 \cdot 10^{-3}$ donc $\frac{\varepsilon}{D} = 300 \times 4 \cdot 10^{-3} = 12 \cdot 10^{-1}$
$= 1,2 \text{ mm}$

10)



BER entre A et E : Pression Absolue

$$z_A + \frac{P_0}{\rho g} + 0 = z_E + \frac{P_E}{\rho g} + \frac{u_E^2}{2g} + \Delta H_{asp} \quad \begin{cases} \nearrow K\frac{u^2}{2g} \\ \searrow J \times \underbrace{L_{asp}}_{h} \end{cases}$$

$$\Leftrightarrow \left(\frac{P_E}{\rho g}\right)_{ABS} = \frac{P_0}{\rho g} - \left(\overbrace{z_E - z_A}^{h} + \frac{u_E^2}{2g} + J \times h + (K_{crép} + K_{va})\frac{u^2}{2g}\right)$$

$$\Leftrightarrow \left(\frac{P_E}{\rho g}\right)_{ABS} = \frac{P_0}{\rho g} - \left(h + J.h + \frac{u^2}{2g}\left(1 + K_{crép} + K_{vanne}\right)\right)$$

$$\Leftrightarrow \left(\frac{P_E}{\rho g}\right)_{ABS} = \frac{P_0}{\rho g} - \left(h(1+J) + \frac{u^2}{2g}\left(1 + K_{crép} + K_{vanne}\right)\right)$$

11)

$$h(1+J) = \frac{P_0}{\rho g} - \left(\frac{P_E}{\rho g}\right)_{ABS} - \frac{u^2}{2g}\left(1 + K_{crép} + K_{vanne}\right)$$

$$\Leftrightarrow h_{lim} = \left(\frac{1}{1+J}\right)\left(\frac{P_0}{\rho g} - \left(\frac{P_{vs}}{\rho g}\right)_{ABS} - \frac{u^2}{2g}\left(1 + K_{crép} + K_{vanne}\right)\right)$$

$$\Leftrightarrow h_{lim} = \frac{1}{1 + 7{,}75\,10^{-4}}\left(\underbrace{\frac{10^5 - 2455}{9{,}81 \times 10^3}}_{9{,}94} - \underbrace{\frac{(0{,}39)^2}{2 \times 9{,}81}\left(1 + 8 + 2\right)}_{0{,}085}\right) = 9{,}85\ m$$

(avec $P_{vs} = ?$ $\quad \ln P_{vs} = -\frac{5117}{(20+273)} + 25{,}27 \Leftrightarrow \ln P_{vs} = -17{,}46 + 25{,}27$

$\Leftrightarrow$ $P_{vs} = 2455\ Pa$

Si $h > h_{lim} \Rightarrow$ vaporisation de l'eau dans le conduit d'ASPIRATION

II)

1) Bernoulli entre A et B (niveau - surface libre) ..

$$z_A + \frac{P_A}{\rho g} + \frac{u_A^2}{2g} + HMT = z_B + \frac{P_B}{\rho g} + \frac{u_B^2}{2g} + \Delta H_{reg}$$ où $\Delta H_{reg} = J \times (L_1 + L_2)$

EF: $u_A = 0$, $P_A = P_B = 0$

$$HMT = \overbrace{z_B - z_A}^{a} + \frac{u^2}{2g}\left(1 + \frac{\lambda}{D}(L_1 + L_2)\right)$$

2) $u = \frac{4Q_v}{\pi D^2} \Leftrightarrow u^2 = \frac{16Q^2}{\pi^2 D^4}$

Soit $HMT = a + \frac{16Q^2}{\pi^2 \times D^4 \times 2 \times g}\left(1 + \frac{\lambda}{D}(L_1 + L_2)\right)$

$\Leftrightarrow HMT = 2 + \frac{8Q^2}{\pi^2 \times 10^{-4} \times 9{,}81}\left(1 + \frac{2 \cdot 10^{-2}}{10^{-1}}(\underbrace{20+10}_{3 \cdot 10^1})\right)$

$\Leftrightarrow HMT = 2 + \frac{8 \times Q^2}{\pi^2 \times 10^{-4} \times 9{,}81}(\underbrace{1 + 2 \cdot 10^{-1} \times 3 \cdot 10^1}_{7})$

$\Leftrightarrow HMT = 2 + \frac{8 \times 7}{\pi^2 \times 9{,}81} Q^2 \times 10^4 \Leftrightarrow HMT = 2 + 5783{,}88\, Q^2$

$\Leftrightarrow HMT = 2 + 5784\, Q^2$

Or, $-1815\, Q^2 - 35Q + 7 = 2 + 5784\, Q^2$

$\Leftrightarrow 7599\, Q^2 + 35Q - 5 = 0$

3) $\Delta = b^2 - 4ac = (35)^2 - 4(7599(-5)) = 153205$

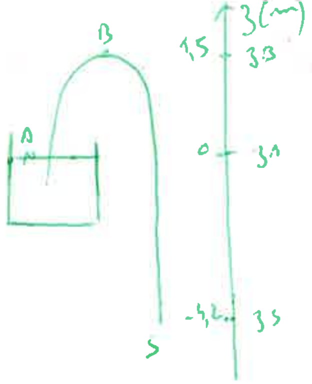
$$Q_1 = \frac{-35 - \sqrt{153205}}{2 \times 7599} < 0$$

$$Q_2 = \frac{-35 + \sqrt{153205}}{2 \times 7599} = 0{,}0235\ m^3 s^{-1} = 2{,}35 \cdot 10^{-2}\ m^3 s^{-1}$$

soit $84{,}6\ m^3 h^{-1}$

III)

1) cf. schéma



2) $q_v = u \times \frac{\pi D^2}{4}$

$\Leftrightarrow D = \left(\frac{4 q_v}{\pi \times u}\right)^{1/2}$ (2) ; u ?

Bernoulli entre A et S (réel) :

$$z_A + \frac{P_A}{\rho g} + \frac{u_A^2}{2g} = z_S + \frac{P_S}{\rho g} + \frac{u_S^2}{2g} + \Delta H_{A \to B} + \Delta H_{B \to S}$$

EF : $z_A = 0$, $P_A = P_S = 0$, $u_A = 0$, $u_S = u$ (même diamètre)

$$\frac{u_S^2}{2g} = -z_S - \Delta H_{A\to B} - \Delta H_{B \to S}$$

$$\Leftrightarrow \frac{u^2}{2g} + z_S + 1{,}5\frac{u^2}{2g} + 1\frac{u^2}{2g} = 0$$

$$\Leftrightarrow 3{,}5\frac{u^2}{2g} = -z_S \Leftrightarrow u = \left(-\frac{2 g z_S}{3{,}5}\right)^{1/2}$$

soit $u = \left(-\frac{2 \times 9{,}81 \times (-4{,}2)}{3{,}5}\right)^{1/2} = 4{,}85 \; m \cdot s^{-1}$ (1)

D'où (1) dans (2) : $D = \left(\frac{4 \times 85 \cdot 10^{-3}}{\pi \times 4{,}85}\right)^{1/2}$

$\Leftrightarrow D = 0{,}153 \; m$ soit 153 mm

$\frac{P_B}{\rho g}$? Bernoulli entre A et B (réel) :

$$z_A + \frac{P_A}{\rho g} + \frac{u_A^2}{2g} = \frac{P_B}{\rho g} + \frac{u_B^2}{2g} + z_B + \Delta H_{A \to B}$$

EF : $u_A = 0$, $u_B = u$, $P_A = 0$, $z_A = 0$

$$\frac{P_B}{\rho g} = -z_B - \frac{u^2}{2g} - 1{,}5\frac{u^2}{2g} \Leftrightarrow \frac{P_B}{\rho g} = -z_B - 2{,}5\frac{u^2}{2g}$$

$$\Leftrightarrow \frac{P_B}{\rho g} = -1{,}5 - 2{,}5 \times \frac{4{,}85^2}{2 \times 9{,}81} = -4{,}49 \; mCE$$

3) apparition de pression
Partie ... - fluide incompressible

4) H(A) en réel : 0 + 0 + 0 = 0 mCE où $H_i = z_i + \frac{P_i}{\rho g} + \frac{u_i^2}{2g}$

H(B) — : $1{,}5 + (-4{,}49) + \frac{4{,}85^2}{2 \times 9{,}81} = -1{,}8 \; mCE$

H(S) — : $-4{,}2 + 0 + \frac{4{,}85^2}{2 \times 9{,}81} = -3 \; mCE$

Le fluide se déplace de la charge hydraulique la plus élevée à la plus élevée