4. FLUXU NEURGAILUAK (II)

1. PRESIO ETA ABIADURAREN NEURKETA.
2. PRESIOPEAN DIREN HODIEN EMARI BOLUMETRIKOAREN NEURKETA.
3. ZULOETAN ZEHARREKO ISURKETA.
4. SIFOIA.
5. ZULODUN BILTEGIAREN HUSTUKETA DENBORA.

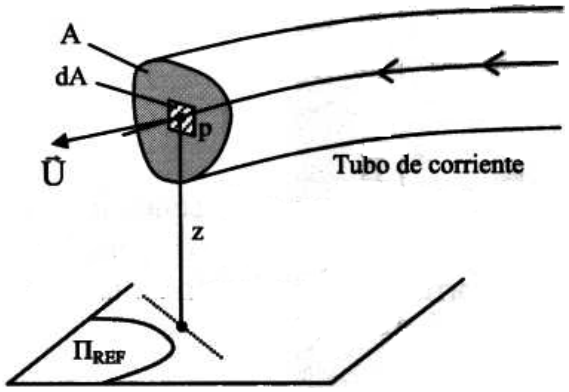
1. PRESIOA ETA ABIADURA NEURKETA.
    1. KOTA PIEZOMETRIKOAREN KONSTANTZIA.
    2. PRESIO NEURKETA.
        1. PITOT HODIA EDO PRESIO TOTALA NEURTZEKO ZUNDA.
        2. PIEZOMETROA EDO PRESIO ESTATIKOA NEURTZEKO ZUNDA.
    3. ABIADURA NEURKETA. PRANDTL HODIA EDO PRESIO DINAMIKOA NEURTZEKO ZUNDA.
    4. ABIADURA NEURTZEKO BESTELAKO GAILUAK (LIBURUTIK)
2. PRESIOPEAN DIREN HODIETATIK DARABILEN EMARIAREN NEURKETARAKO TRESNERIA.
    1. ZUZENKETA KOEFIZIENTEAK: DESKARGA, ABIADURA ETA BENA LIKIDOAREN UZKURDURA KOEFIZIENTEAK.
    2. VENTURIA.
    3. TOBERA.
    4. DIAFRAGMA.
    5. EMARIA NEURTZEKO BESTELAKO GAILUAK (LIBURUTIK).
    6. ISURBIDEAK.
        1. I. ERREKTANGULARRAK.
        2. I. EZ-ERREKTANGULARRAK.
3. ZULOETAN ZEHARREKO ISURKETA (F. PERFEKTO ETA KONPRIMAEZIN BATEN KASUERAKO). TORRICELLIren TMA.
4. SIFOIA.
5. ZULODUN BILTEGIAREN HUSTUKETA DENBORA.

1. PRESIOA ETA ABIADURA NEURKETA.

1. KOTA PIEZOMETRIKOAREN KONSTANTZIA

BERNOUILLI KORRONTE LERRO BATI APLIKATUTA :

1. ERREG. IRAUNKORRA
2. KB ZURRUA ETA FINKOA
3. F. PERFEKTOA We ETA Q GABE
4. F. KONPRIMAEZINA



Kota piezometrikoa :

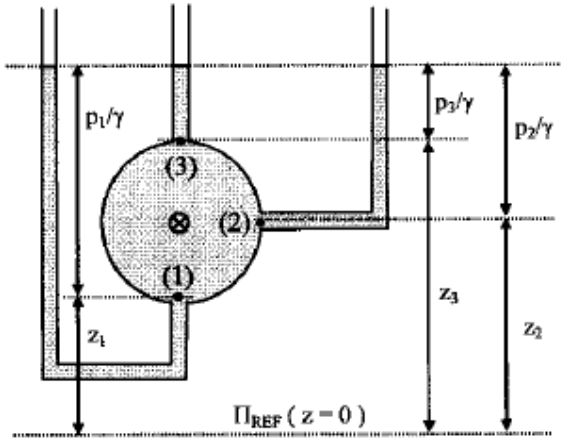
$$\frac{p_1}{\gamma} + z_1 = \frac{p_2}{\gamma} + z_2 = \frac{p}{\gamma} + z = kte$$

Fluxuaren altuera totala edo "Bernouilli":

$$\frac{p_1}{\gamma} + z_1 + \frac{U_1^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{U_2^2}{2g} = \frac{p}{\gamma} + z + \frac{U^2}{2g} = H$$

AZALERAK BALIO BAKARRA AURKEZTUKO DU

PUNTUARI DAGOKIONA



Kota piezometrikoa kte mantentzen denez : $\frac{p_1}{\gamma} + z_1 = \frac{p_2}{\gamma} + z_2 = \frac{p}{\gamma} + z = kte$

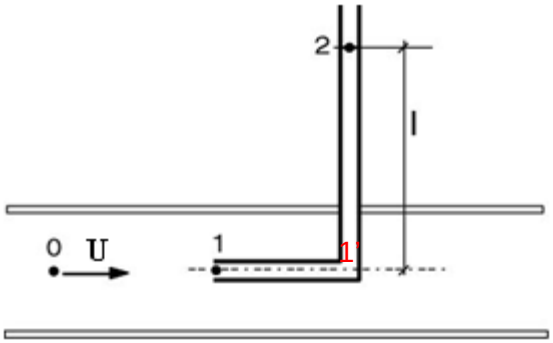
Korronte LERRO bati dagokion BERNOUILLIREN eta ENERGI MEKANIKOAREN adierazpenak korronte HODI batentzat ere dira aplikagarriak :

$$B\Big|_1^2 \Rightarrow \frac{p_1}{\gamma} + z_1 + \alpha_1 \frac{U_1^{\,2}}{2g} = \frac{p_2}{\gamma} + z_2 + \alpha_2 \frac{U_2^{\,2}}{2g} = \frac{p}{\gamma} + z + \alpha \frac{U^2}{2g} = H$$

$$E_M E_O\Big|_1^2 \Rightarrow \frac{p_1}{\gamma} + z_1 + \alpha_1 \frac{U_1^{\,2}}{2g} = \frac{p_2}{\gamma} + z_2 + \alpha_2 \frac{U_2^{\,2}}{2g} + \Delta H_1^2$$

2. PRESIO NEURKETA.

1. PITOT HODIA EDO PRESIO TOTALA NEURTZEKO ZUNDA.



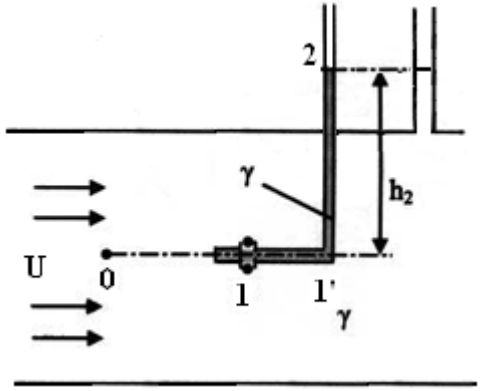
$$\frac{p_0}{\gamma}+\frac{U_0^{\,2}}{2}+z_0=\frac{p_1}{\gamma}+\frac{U_1^{\,2}}{2g}+z_1$$

$$U_1=0\Rightarrow \frac{p_0}{\gamma}+\frac{U_0^{\,2}}{2}+z_0=\frac{p_1}{\gamma}+z_1$$

$$p_1=p_{1'}=\gamma l$$

$$\underbrace{p_1}_{p\ total}=\underbrace{p_0}_{p\ estatikoa}+\underbrace{\rho\frac{U_0^{\,2}}{2}}_{p\ dinamikoa}=\gamma l$$

2. PIEZOMETROA EDO PRESIO ESTATIKOA NEURTZEKO ZUNDA.



$$\frac{p_0}{\gamma}+\frac{U_0^{\,2}}{2}+z_0=\frac{p_1}{\gamma}+\frac{U_1^{\,2}}{2g}+z_1$$

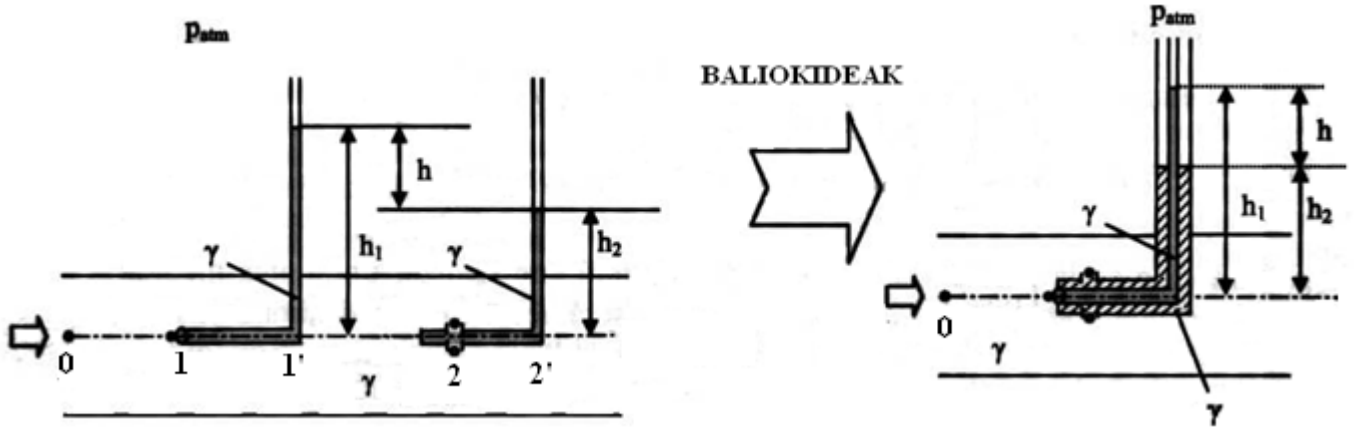
$$U_0=U_1\Rightarrow p_0=p_1=p_{1'}$$

$$p_{1'}=\gamma h_2$$

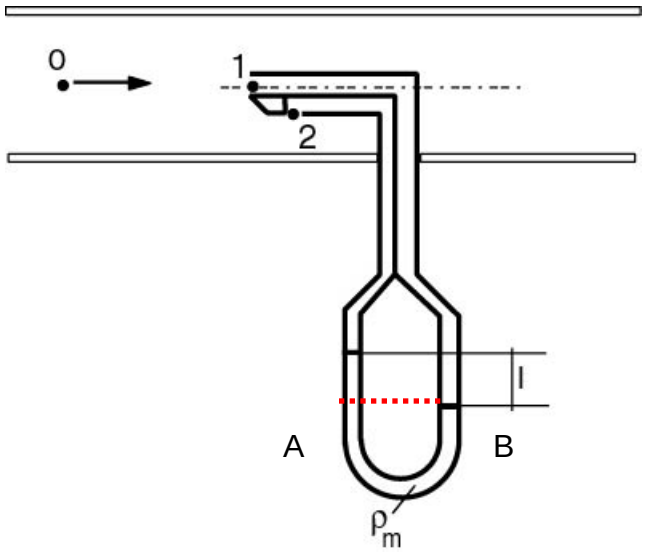
$$\underbrace{p_0}_{p\ estatikoa}=p_{1'}=\gamma h_2$$

3. ABIADURA NEURKETA. PRANDTL HODIA EDO PRESIO DINAMIKOA NEURTZEKO ZUNDA.

PRANDTL HODIA = PITOT HODIA + PIEZOMETROA



$$\left.\begin{aligned} p_1 &= p_0 + \rho\frac{U_0^{\,2}}{2} \\ \underbrace{p_1}_{p\ totala} &= \underbrace{p_0}_{p\ estatikoa} + \underbrace{\rho\frac{U_0^{\,2}}{2}}_{p\ dinamikoa} \\ p_2 &= \underbrace{p_0}_{p\ estatikoa} \end{aligned}\right\} \Rightarrow \left\{\begin{aligned} p_{1'} &= p_1 \\ p_{1'} &= p_{atm} + \gamma h_1 \\ p_{2'} &= p_2 \\ p_{2'} &= p_{atm} + \gamma h_2 \end{aligned}\right\} \Rightarrow \left\{\begin{aligned} \underbrace{p_1}_{p\ totala} &= \underbrace{p_0}_{p\ estatikoa} + \underbrace{\rho\frac{U_0^{\,2}}{2}}_{p\ dinamikoa} \\ p_{atm} + \gamma h_1 &= p_{atm} + \gamma h_2 + \rho\frac{U_0^{\,2}}{2} \\ \gamma(h_1 - h_2) &= \rho\frac{U_0^{\,2}}{2} \end{aligned}\right.$$



$$p_1 = p_0 + \rho\frac{U_0^{\,2}}{2}$$

$$\underbrace{p_1}_{\text{p totala}} = \underbrace{p_0}_{\text{p estatikoa}} + \underbrace{\rho\frac{U_0^{\,2}}{2}}_{\text{p dinamikoa}}$$

$$p_2 = \underbrace{p_0}_{\text{p estatikoa}}$$

$$\Rightarrow \begin{cases} p_A = p_B \\ p_A = p_2 + \gamma h_2 + \gamma_m l \\ p_B = p_1 + \gamma h_1 \end{cases} \Rightarrow \begin{cases} p_2 + \gamma h_2 + \gamma_m l = p_1 + \gamma h_1 \\ p_2 - p_1 = \gamma(h_1 - h_2) - \gamma_m l \\ p_0 - \left(p_0 + \rho\frac{U_0^{\,2}}{2} \right) = \gamma[(h_1 - h_2) - \gamma_{rHg} l] \\ -\rho\frac{U_0^{\,2}}{2} = \gamma(l - \gamma_{rHg} l) = gl(\rho - \rho_{r\,Hg}) \\ \rho\frac{U_0^{\,2}}{2} = gl(\rho_{Hg} - \rho) \end{cases}$$

LABURPENA:

1. PITOT HODIAK, JARIAKIN BATEN PRESIO TOTALA ADIERAZIKO DU.
2. HODI ESTATIKO BATEK EDO PIEZOMETRO BATEK PRESIO ESTATIKOA ADIERAZIKO DU.
3. PRANDTL-en HODI BATEK, BAKARRIK ADIERAZIKO DU PRESIO DINAMIKOA, ETA BERAZ JARIAKINAREN ABIADURA, SOILIK JARIAKINA KONPRIMAEZINA DENEAN.

$$\rho = KTE \Rightarrow PRANDTL \Rightarrow p_{DINAMIKOA} = \frac{1}{2}\rho U^2$$

$$\rho \neq KTE \Rightarrow PRANDTL \Rightarrow \Delta p = p_{TOTALA} - p_{ESTATIKOA}$$

4. PRANDTL-en HODIAK ADIERAZTEN DUEN ABIADURA BERE KOKAPENARI DAGOKIONA IZANGO DA.

4. ABIADURA NEURTZEKO BESTELAKO GAILUAK (LIBURUTIK).

2. PRESIOPEAN DIREN HODIETATIK DARABILEN EMARIAREN NEURKETARAKO TRESNA DEPRIMOGENEOAK.

1. ZUZENKETA KOEFIZIENTEAK: ABIADURA, BENA LIKIDOAREN UZKURDURA ETA DESKARGA KOEFIZIENTEAK.

1. ABIADURA KOEFIZIENTEA.

$$C_v = \frac{U_R}{U_T}$$

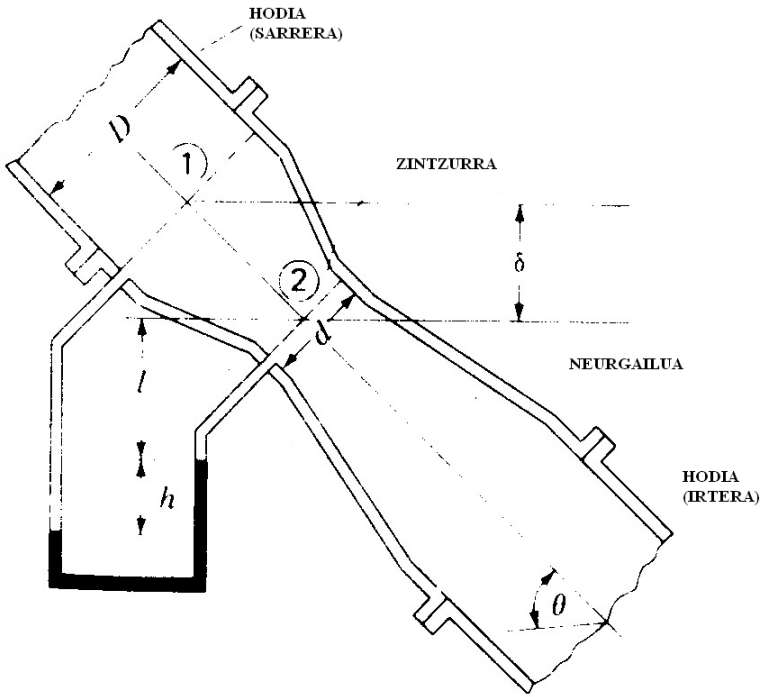
2. BENA LIKIDOAREN UZKURDURA KOEFIZIENTEA.

$$C_c = \frac{A_R}{A_T}$$

3. DESKARGA KOEFIZIENTEA.

$$C_d = \frac{Q_R}{Q_T} = \frac{A_R U_R}{A_T U_T} = \frac{A_R}{A_T}\frac{U_R}{U_T} = C_c C_v$$

2.VENTURI HODIA EDO VENTURIMETROA.



$$\left.\begin{aligned}&\frac{p_1}{\gamma}+z_1+\frac{U_{1T}{}^2}{2g}=\frac{p_2}{\gamma}+z_2+\frac{U_{2T}{}^2}{2g}\\&Q_T=A_{1T}U_{1T}=A_{2T}U_{2T}\end{aligned}\right\}\Rightarrow\frac{p_1}{\gamma}+z_1+\frac{1}{2g}\left(\frac{Q_T}{A_{1T}}\right)^2=\frac{p_2}{\gamma}+z_2+\frac{1}{2g}\left(\frac{Q_T}{A_{2T}}\right)^2$$

$$\Rightarrow Q_T=\frac{A_{2T}}{\sqrt{1-\left(\frac{A_{2T}}{A_{1T}}\right)^2}}\sqrt{2g\left[\left(\frac{p_1-p_2}{\gamma}\right)+(z_1-z_2)\right]}$$

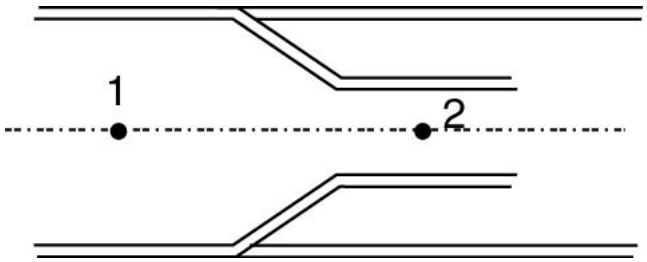
$$\frac{A_{2T}}{A_{1T}}=\frac{D_{2T}{}^2}{D_{1T}{}^2};\ \beta=\frac{D_{2T}}{D_{1T}}\Rightarrow Q_T=\frac{A_{2T}}{\sqrt{1-\beta^4}}\sqrt{2g\left[\left(\frac{p_1-p_2}{\gamma}\right)+(z_1-z_2)\right]}=U_{2T}A_{2T}$$

Venturiak duen manometroak adierazitakoa $\Rightarrow\frac{p_1-p_2}{\gamma}+\delta=h(\gamma_{r_{man}}-1)$

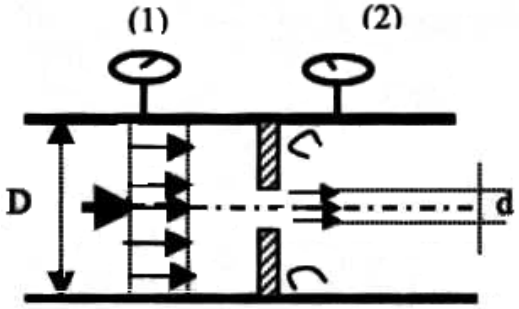
$$Q_R=U_{2R}A_{2R}=C_vU_{2T}C_cA_{2T}=C_vC_cQ_T=C_dQ_T$$

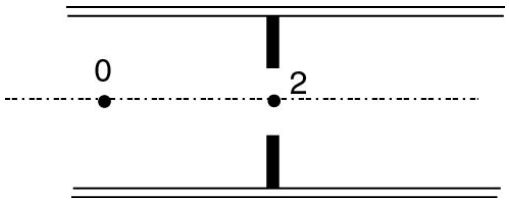
$$Q_R=C_d\frac{A_{2T}}{\sqrt{1-\beta^4}}\sqrt{2g\left(h(\gamma_{r_{man}}-1)\right)}$$

3. TOBERA.



4. DIAFRAGMA.

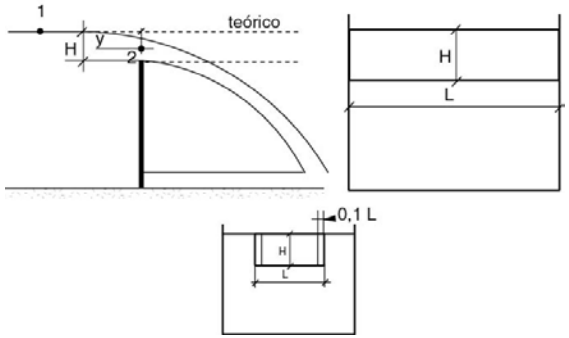




5. EMARIA NEURTZEKO BESTELAKO GAILUAK (LIBURUTIK).

5.ISURBIDEAK.

1. I. ERREKTANGULARRAK



$$\frac{p_1}{\rho g}+z_1+\frac{U_1{}^2}{2g}=\frac{p_2}{\rho g}+z_2+\frac{U_2{}^2}{2g}$$

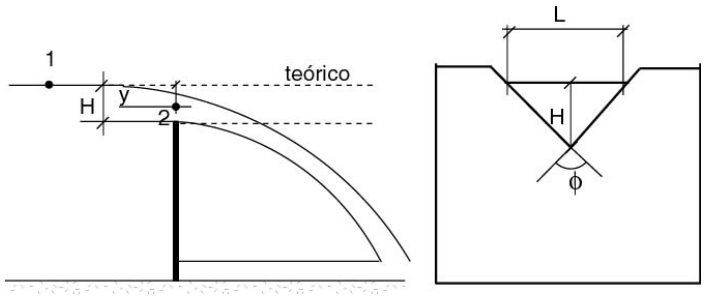
$$0+H+0=0+H-y+\frac{U_2{}^2}{2g}\Rightarrow U_2=\sqrt{2gy}$$

$$Q_T=\int U_2\,dA=\int_0^H U\,L\,dy=\sqrt{2g}\,L\int_0^H\sqrt{y}\,dy$$

$$=\frac{2}{3}\sqrt{2g}\,LH^{\frac{3}{2}}$$

$$\Rightarrow Q_R=C_dQ_T=C_d\,\frac{2}{3}\sqrt{2g}\,LH^{\frac{3}{2}}$$

2. I. EZ-ERREKTANGULARRAK.



Aurreko kasuan bezela :

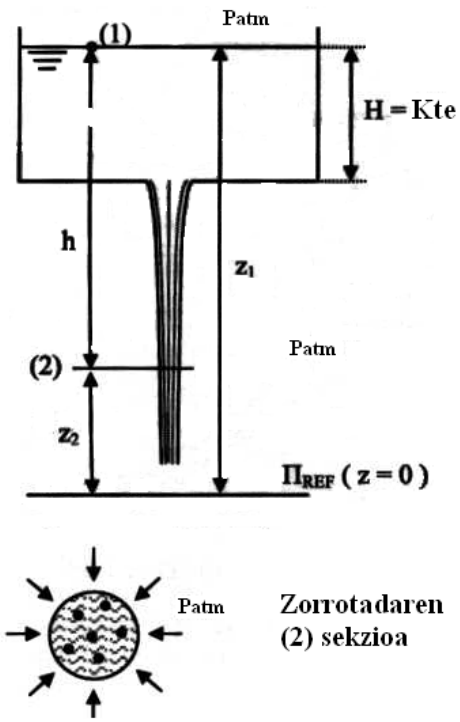
$$U_2=\sqrt{2gy};\ Q_t=\int U_2\,dA=\int_0^H U_2(xdy),\ non\ \frac{x}{H-y}=\frac{L}{H}$$

$$\left.\begin{aligned}Q_t&=\int_0^H vxdy=\sqrt{2g}\,\frac{L}{H}\int_0^H y^{\frac{1}{2}}(H-y)dy=\frac{4}{15}\sqrt{2g}\,\frac{L}{H}H^{\frac{5}{2}}\\ tg(\frac{\phi}{2})&=\frac{L}{2H}\end{aligned}\right\}$$

$$Q_t=\frac{4}{15}\sqrt{2g}\,\frac{L}{H}H^{\frac{5}{2}}=\frac{8}{15}\sqrt{2g}\,tg(\frac{\phi}{2})H^{\frac{5}{2}}$$

$$Q_T=CQ_t=C\,\frac{4}{15}\sqrt{2g}\,\frac{L}{H}H^{\frac{5}{2}}=C\,\frac{8}{15}\sqrt{2g}\,tg(\frac{\phi}{2})H^{\frac{5}{2}};\ non\ C\approx\%42$$

3. ZULOETAN ZEHARREKO ISURKETA (F. PERFEKTO ETA KONPRIMAEZIN BATEN KASURAKO). TORRICELLIren TMA.



Jariakinaren erorketa abiadura :

$$B_{1/2} \Rightarrow \frac{p_1}{\gamma} + \frac{U_1^{\,2}}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{U_2^{\,2}}{2g} + z_2$$

$$z_1 - z_2 = h = \frac{U_2^{\,2}}{2g} \Rightarrow U_2 = \sqrt{2gh}$$

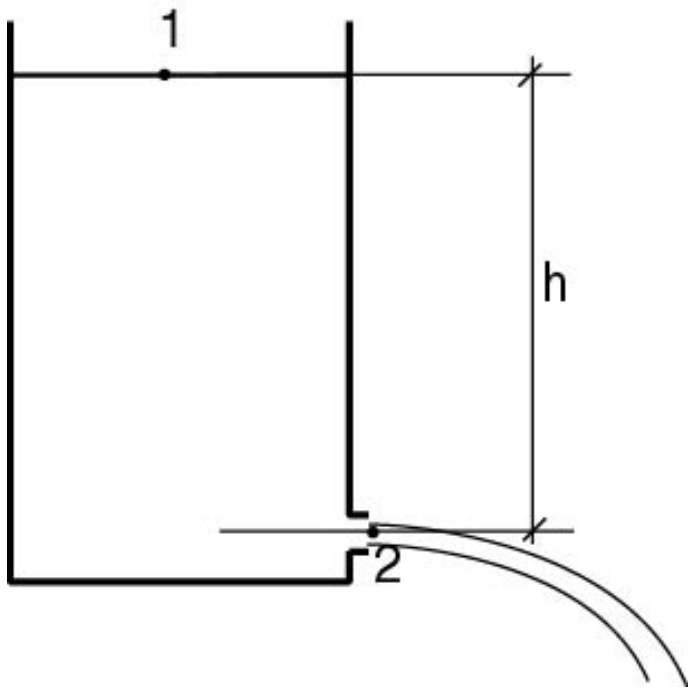
Zorrotadaren (2) *sekzioaren azalera* :

$$Q = Kte \Rightarrow Q = U_2 A_2 \Rightarrow A_2 = \frac{Q}{\sqrt{2gh}}$$

$$A_{irteera} = \frac{Q}{\sqrt{2gH}}$$

$$A_2 = \frac{Q}{\sqrt{2gh}} \Rightarrow h \to \infty;\ A_2 \to 0$$

1. TORRICELLIREN TMA: Deposito baten irteera abiadura.



Jariakinaren irteera abiadura :

$$B_{1/2} \Rightarrow \frac{p_1}{\gamma} + \frac{U_1^{\,2}}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{U_2^{\,2}}{2g} + z_2$$

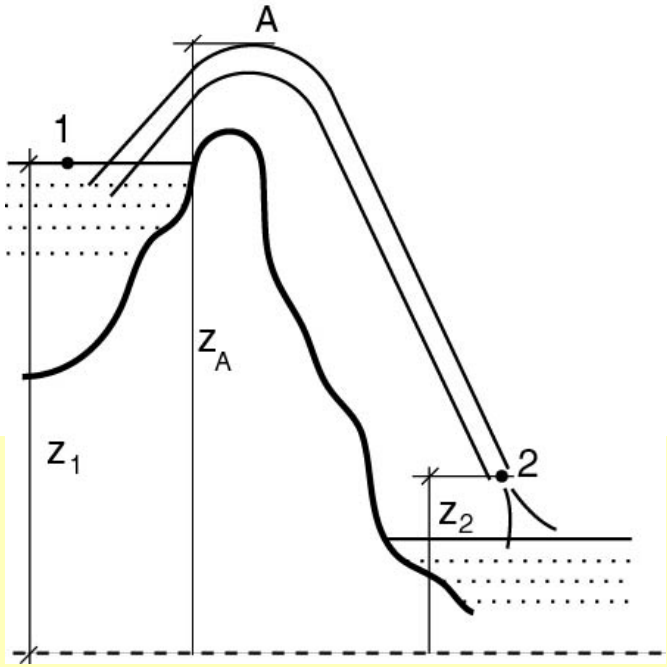
$$z_1 - z_2 = h = \frac{U_2^{\,2}}{2g} \Rightarrow U_2 = \sqrt{2gh}$$

Depositotik darion emaria :

$$\Rightarrow Q = A\sqrt{2gh}$$

$$\Rightarrow \textit{Errealitatean} : Q = C_d A\sqrt{2gh}$$

4. SIFOIA



$$\left.\begin{aligned} H_1 &= \frac{p_1}{\gamma} + z_1 + \frac{U_1^2}{2g} = 0 + 0 + z_1 \\ H_2 &= \frac{p_2}{\gamma} + z_2 + \frac{U_2^2}{2g} = 0 + z_2 + \frac{U_2^2}{2g} \end{aligned}\right\} \frac{U_2^2}{2g} = (z_1 - z_2)$$

$$H_A = \frac{p_A}{\gamma} + z_A + \frac{U_A^2}{2g} = \{U_2 = U_A\} \Rightarrow \frac{p_A}{\gamma} = H_A - z_A - \frac{U_2^2}{2g} = H_A - z_A - (z_1 - z_2)$$

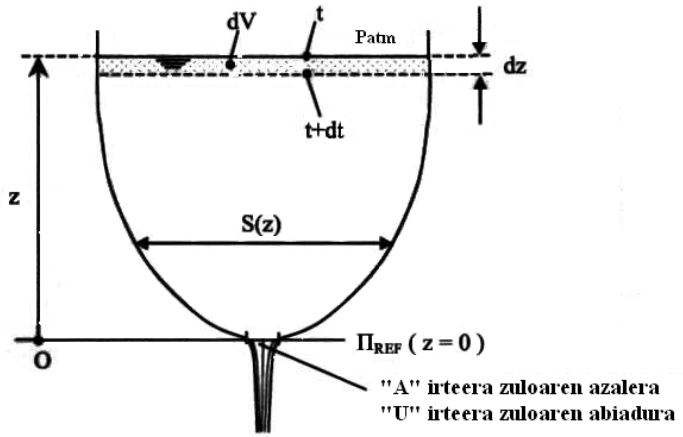
$$\frac{p_A}{\gamma} = H_A - z_A - H_1 + z_2 = \left\{\begin{aligned} \mu &= 0 \\ H_1 &= H_2 = H_A \end{aligned}\right\} = -(z_A - z_2) < 0 \text{ (}depresioa\text{)}$$

$$\textit{Limitean, eta kabitazioa saihesteko} \Rightarrow \frac{P_A}{\gamma} \geq \frac{P_s(T = 20^o C)}{\gamma} = \frac{2330 - 101330}{\gamma} = -10 \geq -(z_A - z_2) \Rightarrow 10 \geq (z_A - z_2)$$

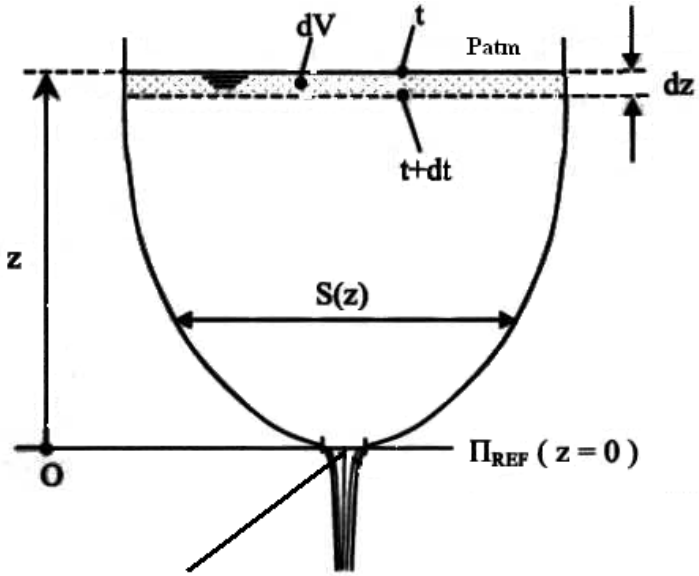
$$Q \uparrow\uparrow\uparrow \Rightarrow p_A \downarrow\downarrow\downarrow$$

5. ZULODUN BILTEGIAREN HUSTUKETA DENBORA.

1. Aztergai dugun egoera F. ALDAKOR bat da:
    1. Depositoaren azalera aldakorra da.
    2. Depositoaren gainazal askearen maila aldatuz doa jariakina depositotik ateratzen den heinean.
2. Azterketa Bernouilliren bitartez egin dezakegu, nahiz eta F. Aldakorra izan:
    1. S(z)>>>>”A”→hustuketa geldoa da.
    2. “δt” →0.



3. Hustuketa denboraren azterketa:
    1. Depositoan gertatzen den bolumen aldaketa denbora tarte batetan da irteera zulotik ateratzen den emaria
    2. “δt” →0 →Q ≈Kte eta U ≈Kte →Torricelli aplikagarria da.



"A" irteera zuloaren azalera
"U" irteera zuloaren abiadura

$$\left.\begin{array}{l} dV = S(z)dz = -Qdt = -AUdt \\ Torricelli \Rightarrow U = \sqrt{2gz} \end{array}\right\} S(z)dz = -A\sqrt{2gz}dt$$

$$S(z)dz = -A\sqrt{2gz}dt \Rightarrow dt = -\frac{S(z)}{A\sqrt{2gz}}dz$$

$$\int_{t=0}^{t=T} dt = -\int_{z=H}^{z=0} \frac{S(z)}{A\sqrt{2gz}}dz$$

$$S(z) = Kte \Rightarrow T = -\frac{S}{A\sqrt{2g}}\int_{z=H}^{z=0} \frac{1}{\sqrt{z}}dz = -\frac{S}{A\sqrt{2g}}\left[2z^{1/2}\right]_H^0$$

$$T = \frac{2S\sqrt{H}}{A\sqrt{2g}}$$

$$Suposatuz\ U = Kte \Rightarrow T = \frac{V}{Q} = \frac{SH}{AU} = \frac{S\sqrt{H}}{A\sqrt{2g}}$$