Losses in pipes

Types of losses

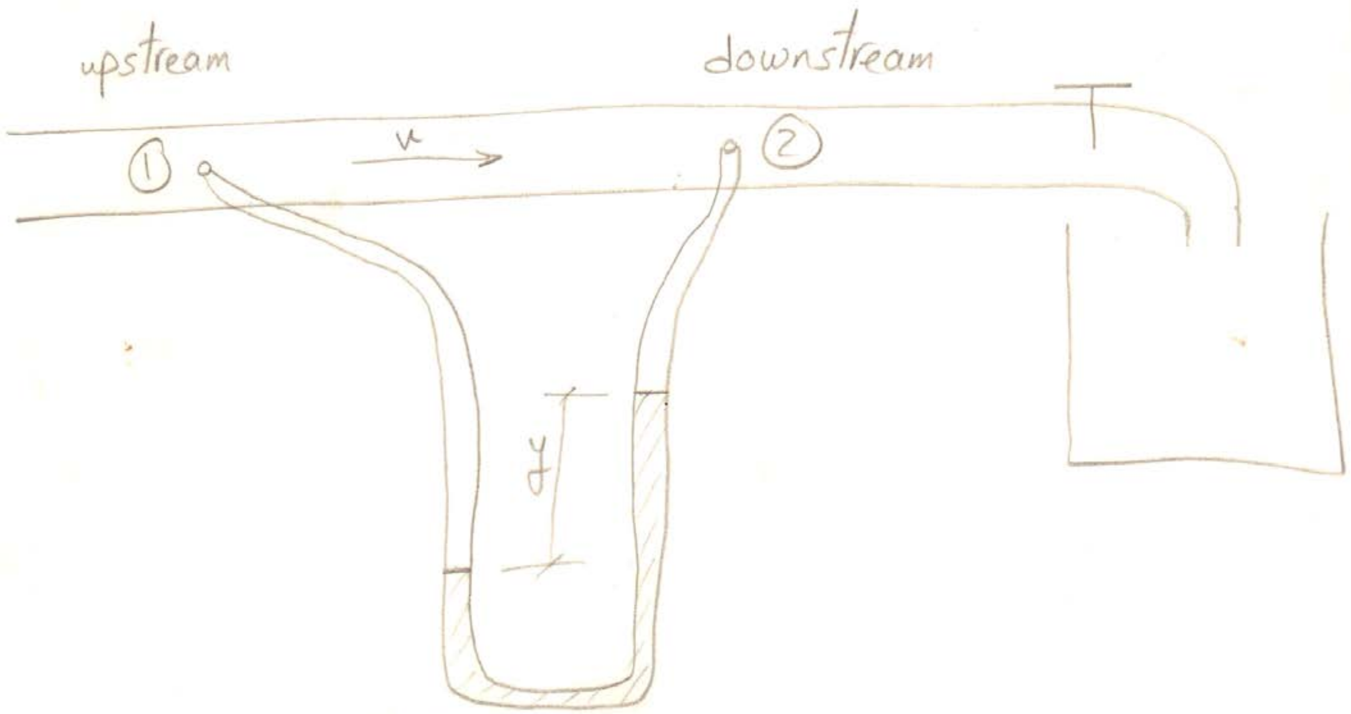
1 – Friction losses :

This type of losses exists for any flow as a result of fluid viscosity and velocity difference between fluid layers. As a result of friction, part of the fluid's mechanical energy is converted into heat energy (dissipated into atmosphere) and is considered as an energy loss.

2 – Eddy losses :

This type of losses occurs due to any change in the velocity vector (magnitude or direction). This change causes some of energy to be transferred from main flow to eddies formed at corners. This part of energy is considered as energy losses.

*** Friction losses** ماسورة ليس بها تغيير بالمساحة لحساب



$$E_1 = E_2 + h_{loss1to2}$$

$$\frac{P_1}{\rho g} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{v_2^2}{2g} + h_{loss1to2}$$

$$\frac{P_1}{\rho g} = \frac{P_2}{\rho g} + h_{loss1to2}$$

$$h_{f.l.} = \frac{P_1 - P_2}{\rho g} \quad \text{---} \quad (1)$$

تم تسميتها $h_{f.l.}$ لانها كلها friction losses وليس بها eddy losses

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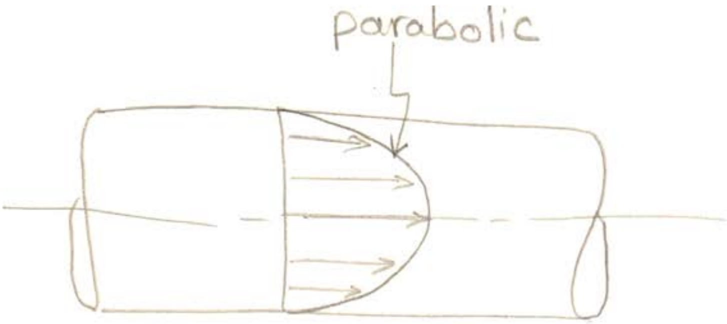
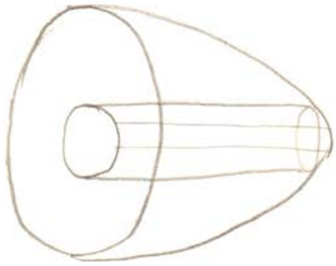
*** Friction losses in laminar flow   Re < 2000**





Velocity distribution for laminar flow

$$F_{vis} = \mu \; A \; \frac{du}{dy} \quad \text{---} \quad (2)$$

From (1) & (2)

$$\boxed{h_{f.l.} = \frac{32 \mu \; v \; L}{\rho \; g \; d^2}}$$

Where L is the pipe length

$h_{f.l.} \; \alpha \; v$ (linear)

$$h_{f.l} = 32 * \frac{\mu v L}{\rho g d^2} * \frac{v}{v} * \frac{2}{2}$$

$$= 32 * 2 * \frac{\mu}{\rho v d} * \frac{L}{d} \frac{v^2}{2g}$$

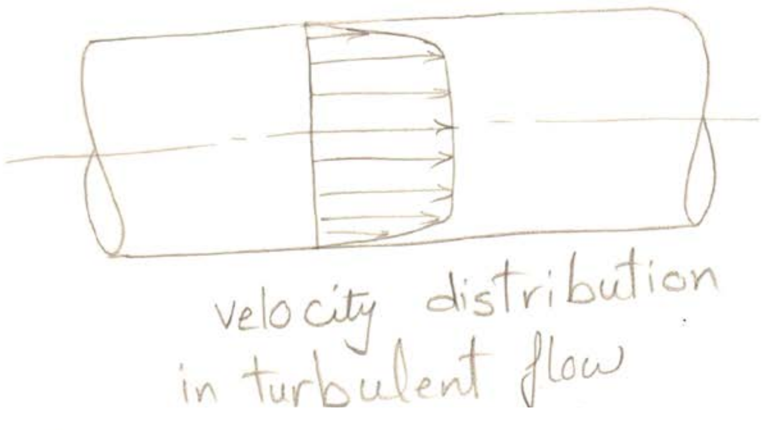
$$= \frac{64}{R_e} * \frac{L}{d} \frac{v^2}{2g}$$

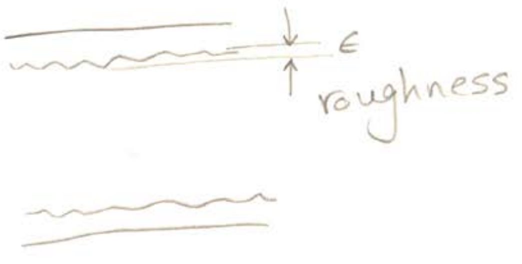
$$\boxed{h_{f.L} = f \frac{L}{d} \frac{v^2}{2g} \rightarrow}$$

Another from $f = \frac{64}{R_e}$ where f : coefficient of friction

Note :
for laminar flow , the pipe roughness has no effect on friction losses because the velocity of the fluid layer beside the pipe wall is very small and almost stationary.

B – friction losses in turbulent flow Re > 4000



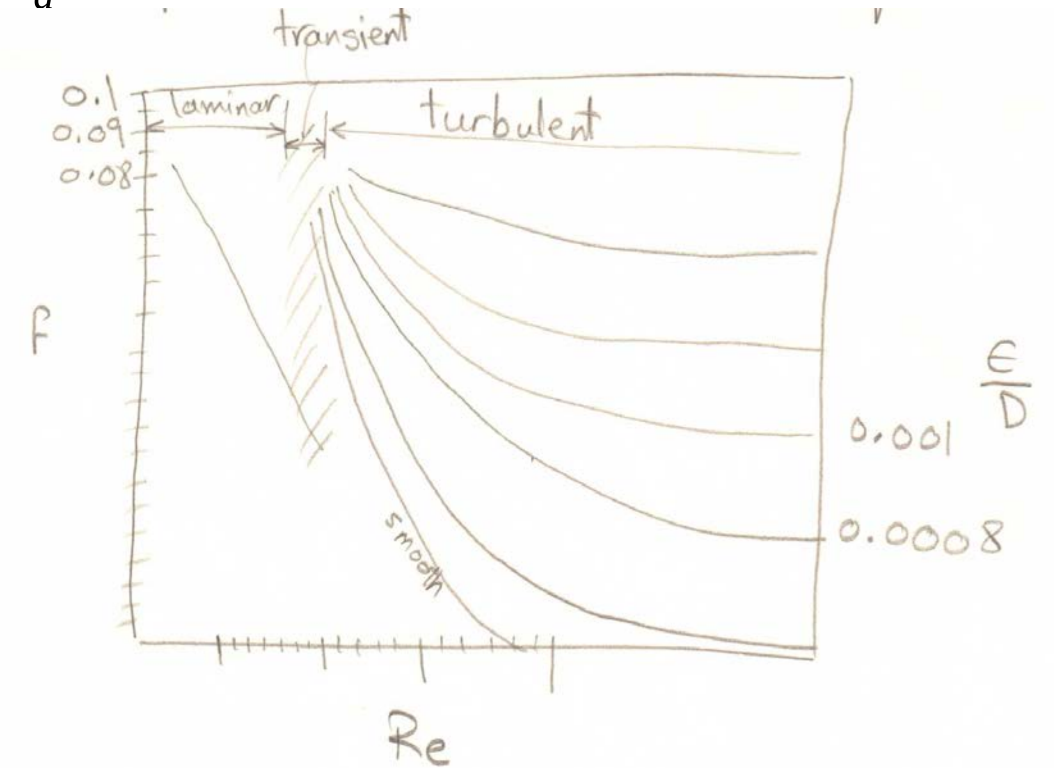


* All the following results are experimental results written as empirical formula

$$h_{f.l.} = f \frac{L}{d} \frac{v^2}{2g}$$

$$h_{f.l.} \ \alpha \ v^2$$

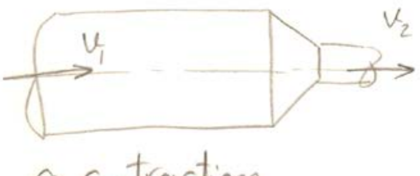
$$F \begin{cases} Re = \dfrac{\rho\ v\ d}{\mu} \\ \dfrac{\varepsilon}{d} \end{cases}$$

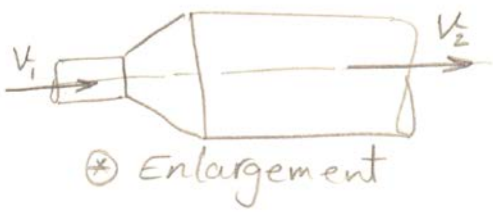


***Eddy losses :** اي تغيير في السرعة مقدار او اتجاه

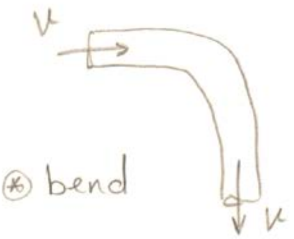
All eddy losses depend only on kinetic energy ($\frac{v^2}{2g}$) of flow (not type of flow).

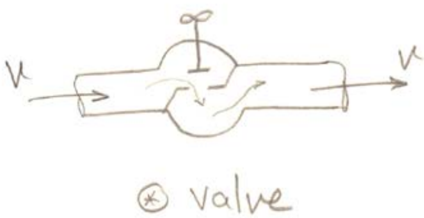
I – change in magnitude

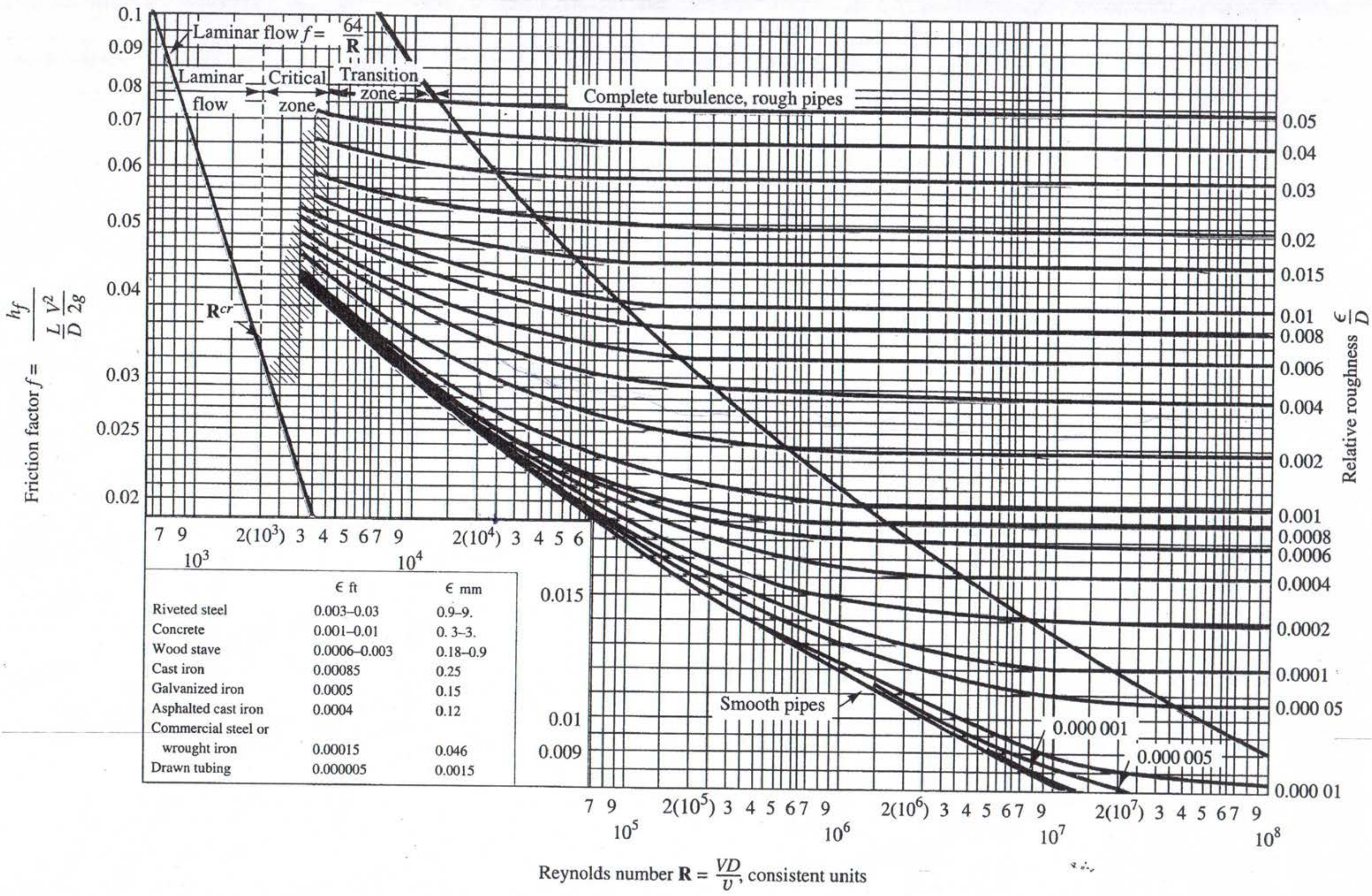




II – change in direction

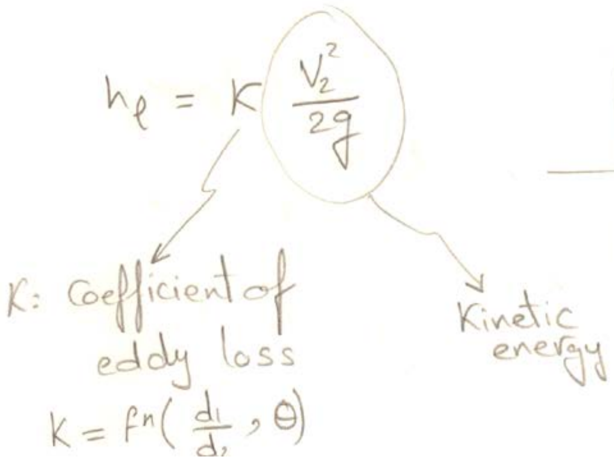


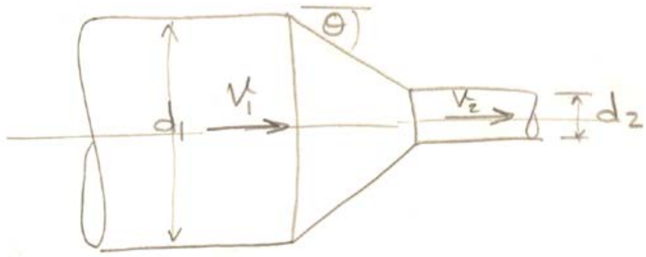




	ϵ ft	ϵ mm
Riveted steel	0.003–0.03	0.9–9.
Concrete	0.001–0.01	0. 3–3.
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.25
Galvanized iron	0.0005	0.15
Asphalted cast iron	0.0004	0.12
Commercial steel or wrought iron	0.00015	0.046
Drawn tubing	0.000005	0.0015

*** contraction**

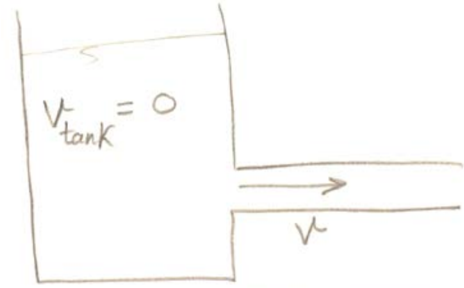


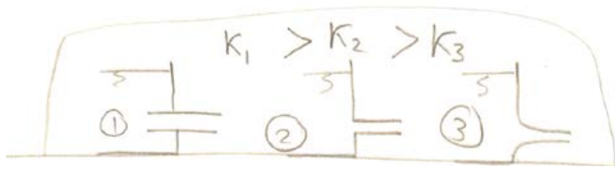


$$at \ \ \frac{d_1}{d_2} = \infty \quad \& \quad \theta = 90^o$$

$$k_{max} = 0.5$$

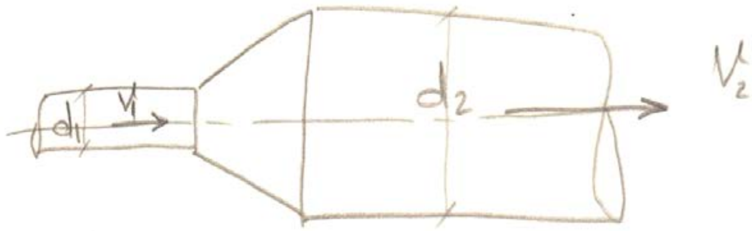
$$h_l = 0.5 \ \frac{v^2}{2g}$$





*** Enlargement**

$$h_\ell = k \ \frac{(v_1 - v_2)^2}{2g}$$



k = fn (θ) The effect of $\frac{d_2}{d_1}$ is presented in $(v_1 - v_2)$

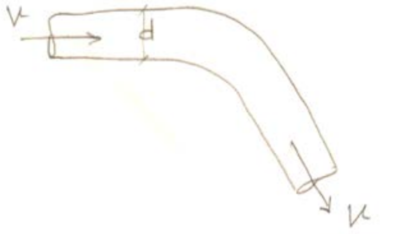
k_{max} For enlargement at $\theta = 90^\circ$

(sudden enlargement)

$$k_{max} = 1$$

$$h_\ell = \frac{(v_1 - v_2)^2}{2g}$$

* Bend or Elbow



$$h_\ell = k\,\frac{v^2}{2g}$$

k = fn (θ, d, type of bend)

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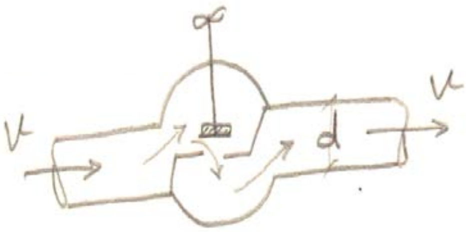
* valves

Globe valve



$$h_\ell = k\,\frac{v^2}{2g}$$

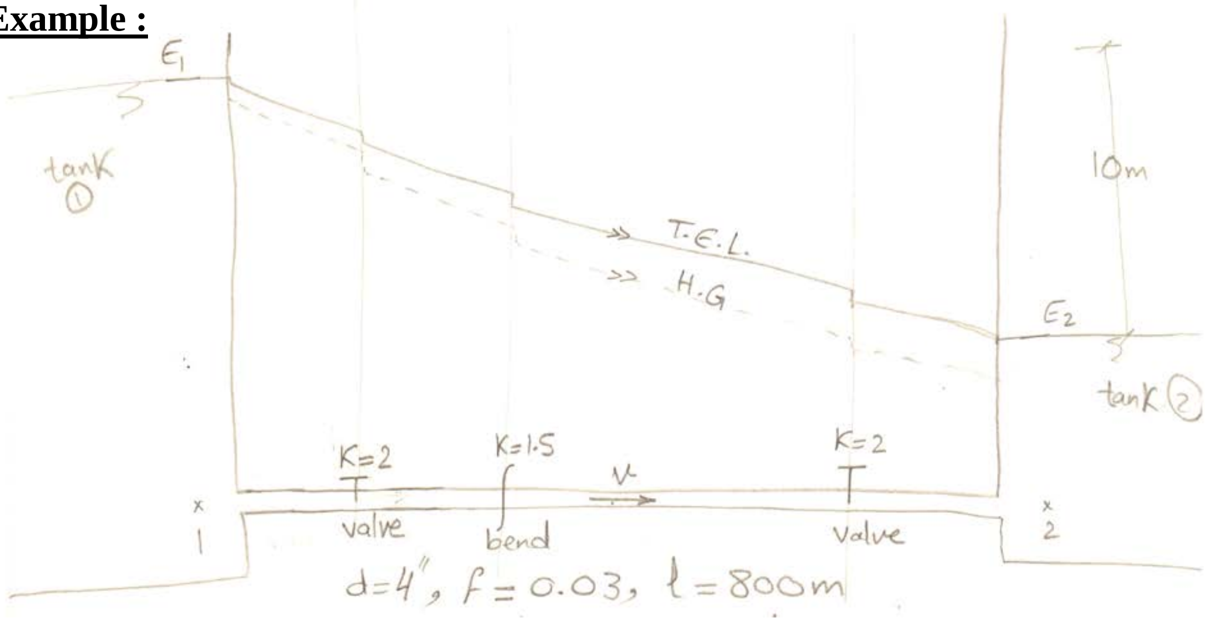
k = fn (d, type of valve)

Only for fully opened valves

-عند غلق المحابس نصف يكون هناك فاقد اكبر في الطاقة

-لذلك الاستخدام الامثل لها ان تكون مفتوحة بالكامل او مغلقة بالكامل

Example :



a) Calculate the discharge between the tanks.
b) One of valves is partially closed. The discharge reduced by 50 % .calculate the losses in the value in this case.

a) $d = \frac{4*2.54}{100} = 0.1m$

$$Q = AV$$

$$E_1 = E_2 + h_{loss}$$

$$10 = f\ \frac{\ell}{d}\frac{v^2}{2g} + k_{ent}\ \frac{v^2}{2g} + K_v\ \frac{v^2}{2g} + K_b\ \frac{v^2}{2g} + K_v\ \frac{v^2}{2g} + K_{ent}\ \frac{(v-o)^2}{2g}$$

$$10 = \frac{v^2}{2*9.8}(0.03*\frac{800}{0.1} + 0.5 + 2 + 1.5 + 2 + 1)$$

$$V = 0.89 m/s$$

Q = 7 x 10^{-3} m^3/s

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b)

$$Q = 0.5Q = Av^1$$

$$\therefore 10^{-3} * 3.5 = \frac{\pi}{4}(0.1)^2 V_1$$

$$V_1 = 0.445 m/s$$

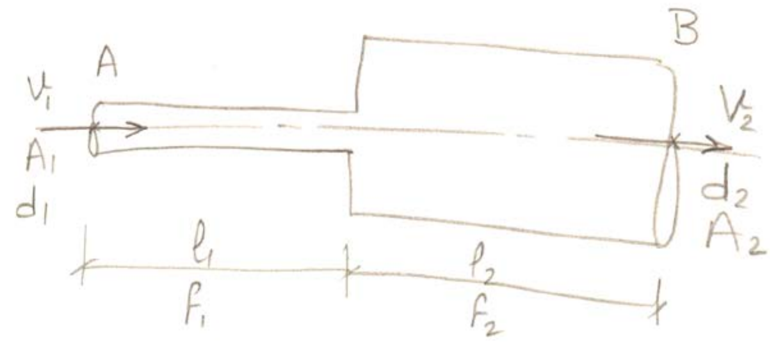
$$E_1 - E_2 = h_{loss} = 10$$

$$10 = f\ \frac{\ell}{d}\frac{v_1^2}{2g} + k_{ent}\ \frac{v_1^2}{2g} + h_{loss} + K_b\ \frac{v_1^2}{2g} + K_v\ \frac{v_1^2}{2g} + K_{\max}\ \frac{v_1^2}{2g}$$

$$10 = 0.03*\frac{800}{0.1} + \frac{(0.445)^2}{2*9.8} 0.5 \frac{(0.445)^2}{2*9.8} + h_{loss}\ 2 + 1.5 + \frac{(0.445)^2}{2*9.8} + 2 + \frac{(0.445)^2}{2*9.8} + \frac{1*(0.445-o)^2}{2*9.8}$$

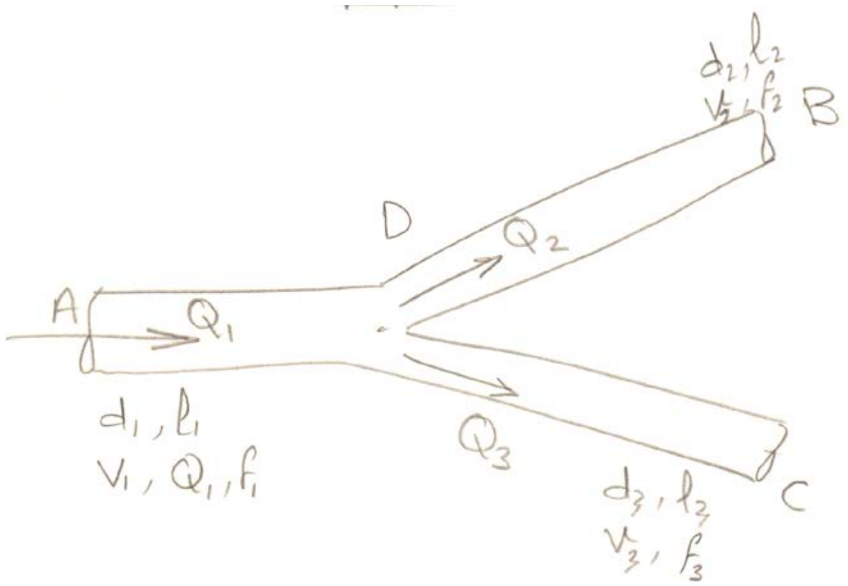
H_{loss} = 7.5 m of liquid

*** losses in series pipes :**



$$h_\ell = f_1 \frac{\ell_1}{d_1}\frac{v_1^2}{2g} + \frac{K(v_1 - v_2)^2}{2g} + f_2 \frac{\ell_2}{d_2}\frac{v_2^2}{2g}$$

*** losses in parallel pipes**



$$h_{\ell_{A\to B}} = f_1 \frac{\ell_1}{d_1}\frac{v_1^2}{2g} + h\ell_{branching} + f_2 \frac{\ell_2}{d_2}\frac{v_2^2}{2g}$$

$$h_{\ell_{A\to C}} = f_1 \frac{\ell_1}{d_1}\frac{v_1^2}{2g} + h\ell_{branching} + f_3 \frac{\ell_3}{d_3}\frac{v_3^2}{2g}$$

$$Q_1 = Q_2 + Q_3$$

$$A_1 V_1 = A_2 V_2 + A_3 V_3$$