University of Mosul
College of Petroleum & Mining Engineering

Fluid Flow II

Lecture (4)

Fluid Dynamic

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Hydraulic Gradient Line and Energy Line

Examples

Hydraulic Gradient and Total Energy Line

The concept of hydraulic gradient line and total energy line is very useful in the study of flow fluids through pipes

- **Hydraulic gradient line**: The line which given the sum of pressure head $(\frac{P}{\gamma})$ and datum head (z) of a flowing fluid in a pipe with respect to some reference line. It is briefly written as H.G.L
- **Total energy line**: The line which gives the sum of pressure head $(\frac{P}{\gamma})$, kinetic head $(\frac{V^2}{2g})$ and datum head (z) of following fluid a pipe with respect to some reference line

Example (5)

Draw the hydraulic gradient line (H.G.L) and total energy line (T.E.L) for the system shown in the figure.

Solution

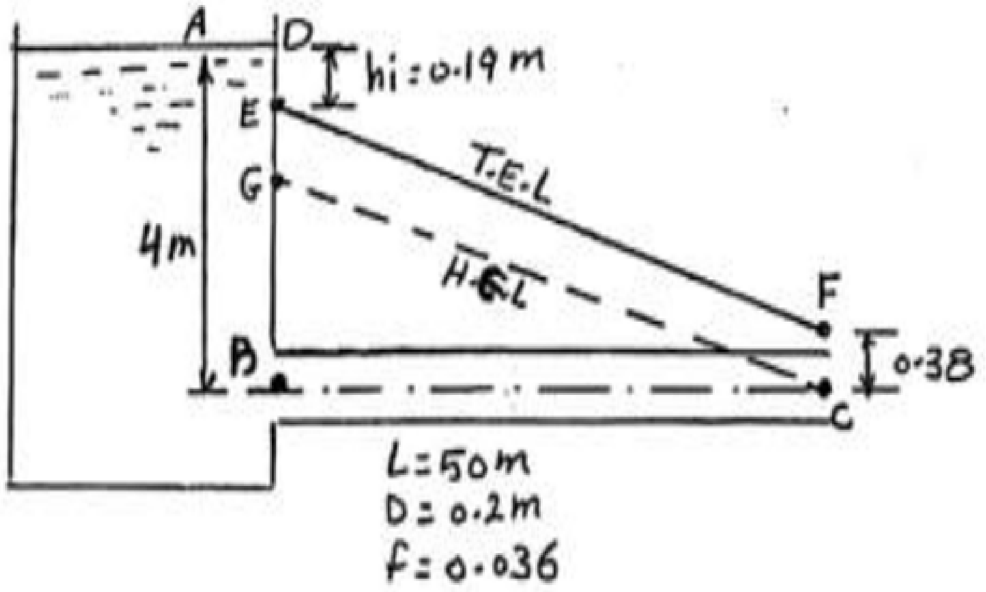
Consider the velocity was calculated in previous example and is equal to (2.734) m/s

h_i = Head loss at the entrance of the pipe

$$h_i = 0.5\frac{v_2^2}{2g} = \frac{0.5\times(2.734)^2}{2\times9.81} = 0.19 \text{ m}$$

$$h_f = f\frac{L}{D}\frac{v^2}{2g}$$ due to friction

$$h_f = 0.036\times\frac{50}{0.2}\times\frac{(2.734)^2}{2\times9.81} = 3.428$$



Total Energy Line (T.E.L)

1. Total energy line at point A = $\frac{P}{\gamma} + \frac{V^2}{2g} + z$ = 0+0+4= 4 m
2. Total energy line at point B = total energy at $A - h_i = 4 - 0.19 = 3.81$ m
3. Total energy line at point C = $\frac{P_C}{\gamma} + \frac{V_C^2}{2g} + z_c = 0 + \frac{V_C^2}{2g} + 0 = \frac{(2.734)^2}{2\times 9.81} = 0.38$ m

- Point D represents total energy at A
- $D_E = h_i$, represents total energy at pipe inlet (=0.19 m) at point F
- $C_F = 0.38$, represents total energy at pipe out point F

The **DEF** line represents the total energy line.

Hydraulic gradient line (H.G.L)

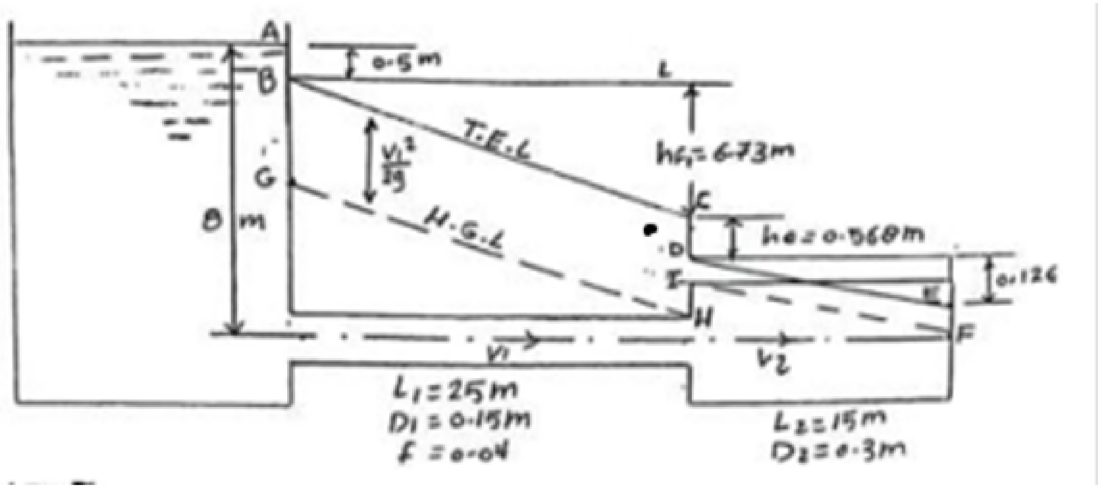
Hydraulic gradient line gives the sum $(\frac{P}{\gamma} + z)$ with reference to the datum line.

The hydraulic gradient line is obtained by subtracting $\frac{V^2}{2g}$ from the energy line (T.E.L), we shall get point C which lies on the center line of the pipe.

Draw the line **CG** parallel to the line **EF.** Then CG line represent the hydraulic gradient.

Example (6)

Draw total energy line (T.E.L) and the hydraulic gradient line (H.G.L) for the system shown in the figure.



Solution

From previous example

$V_2 = 1.113$ m/s

$V_1 = 4.452$ m/s

Various head losses :

Pipe entrance losses

$$h_i = 0.5\frac{v_1^2}{2g} = \frac{0.5\times(4.452)^2}{2\times9.81} = 0.51 \text{ m}$$

$$h_{f_1} = f\frac{L_1}{D}\frac{{v_1}^2}{2g} = 0.04\times\frac{25}{0.15}\times\frac{(4.452)^2}{2\times9.81} = 6.73\text{m}$$

$$h_e = \frac{(v_1-v_2)^2}{2g} = \frac{(4.452-1.113)^2}{2\times9.81} = 0.568 \text{ m}$$

$$h_{f_2} = f\frac{L_2}{D}\frac{{v_2}^2}{2g} = 0.04\times\frac{15}{0.3}\times\frac{(1.113)^2}{2\times9.81} = 0.126\text{m}$$

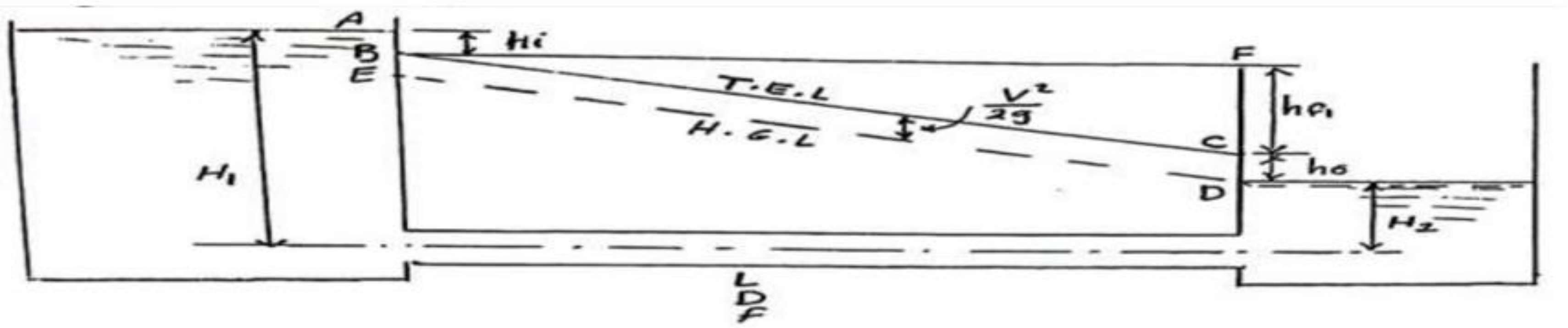
$$h_o = \frac{v_2^2}{2g} = \frac{(1.113)^2}{2\times9.81} = 0.063 \text{ m}$$

Total Energy Line (T.E.L) :ABCDE

Hydraulic gradient line (H.G.L):

From B, take BG = $\frac{v_1^2}{2g}$ =1.0 m

Hydraulic gradient line (H.G.L): GHIF



Total Energy Line (T.E.L): ABCD

$$\text{Hydraulic gradient line (H.G.L)} = \text{ED}$$

$$H_i = H_2 + losses$$

$$= H_2 + h_i + h_{f1} + h_e$$

$$h_i = 0.5\frac{v_1^2}{2g}$$

$$h_f = f\frac{L}{D}\frac{v^2}{2g}$$

$$h_o = \frac{v^2}{2g}$$