University of Mosul
College of Petroleum & Mining Engineering

Fluid Flow II

Lecture (2)

Fluid Dynamic

Petroleum and Refining Engineering Department

Ass.P. Raqeeb Hummadi Rajab
Ass.L. Ghufran Faris Alrahhawi

Email: ghufranalrahhawi @uomosul.edu.iq

LECTURE CONTENTS

Euler’s Equation

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Fluid Dynamic

Conservation of Energy

The energy of the fluid flowing in any system remains constant, unless a certain amount of energy is added to or subtracted from the fluid. But the energy (or a part of it) can be changed from one form to another

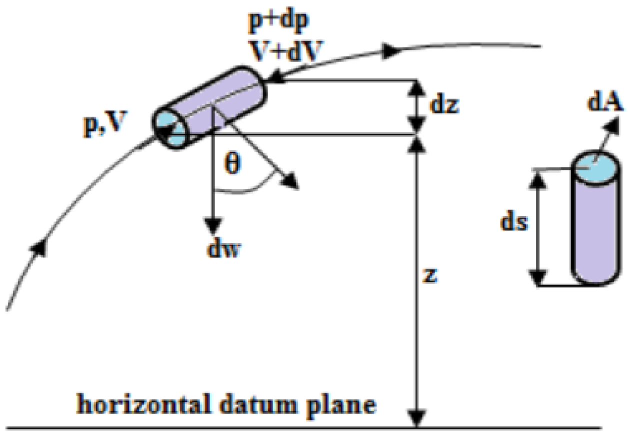
Flow of Steady Incompressible One-Dimension Ideal Flow

Euler's equation:

Consider a flow along the stream line 'S' and consider a cylindrical fluid element of length 'ds' and cross-sectional area 'dA'.

Appling Newton's 2nd law along the

streamline.



$\sum dF = dm.a$

$PdA - (P + dP)dA - dwsin\theta = dm.a$

$-dPdA - dwsin\theta = dm.a$ ....(1)

But $dm = d(\rho\forall) = \rho d\forall + \forall d\rho$

$\rho =$ const. $d\rho = 0$ Incompressible fluid

$dm = \rho d\forall = \rho dAds$ ....(2a)

$$dw = gdm = g\rho d\forall = g\rho dAds \qquad \times \quad sin\theta$$

$$dw\ sin\theta = g\rho dAds\ sin\theta = g\rho dAdz \qquad \text{.......................(2b)}$$

$$a = \frac{dV}{dt} = \frac{dV}{ds}\frac{ds}{dt} = V\frac{dV}{ds} \qquad \text{.........................(2c)}$$

Substituting equations 2a, 2b , and 2c, in eq. 1:

$$-dPdA - g\rho dAdz = \rho dAds\ V\frac{dV}{ds} \qquad \div \rho gdA$$

$$\frac{dP}{\gamma} + \frac{VdV}{g} + dz = 0 \qquad \text{By integrating}$$

For incompressible flow ρ = cons.

$$\boldsymbol{\frac{P}{\gamma} + \frac{V^2}{2g} + z = cons.} \qquad \text{Bernoulli's equation}$$

$$\boldsymbol{\frac{P_1}{\gamma} + \frac{{V_1}^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{{V_2}^2}{2g} + z_2}$$

Bernoulli's equation

It states as follow: in an ideal incompressible fluid when the flow is steady and continuous, the sum of pressure energy, kinetic energy and potential or (datum) energy is constant along a stream line where

$\frac{P}{\gamma}$ pressure energy or pressure head (m)

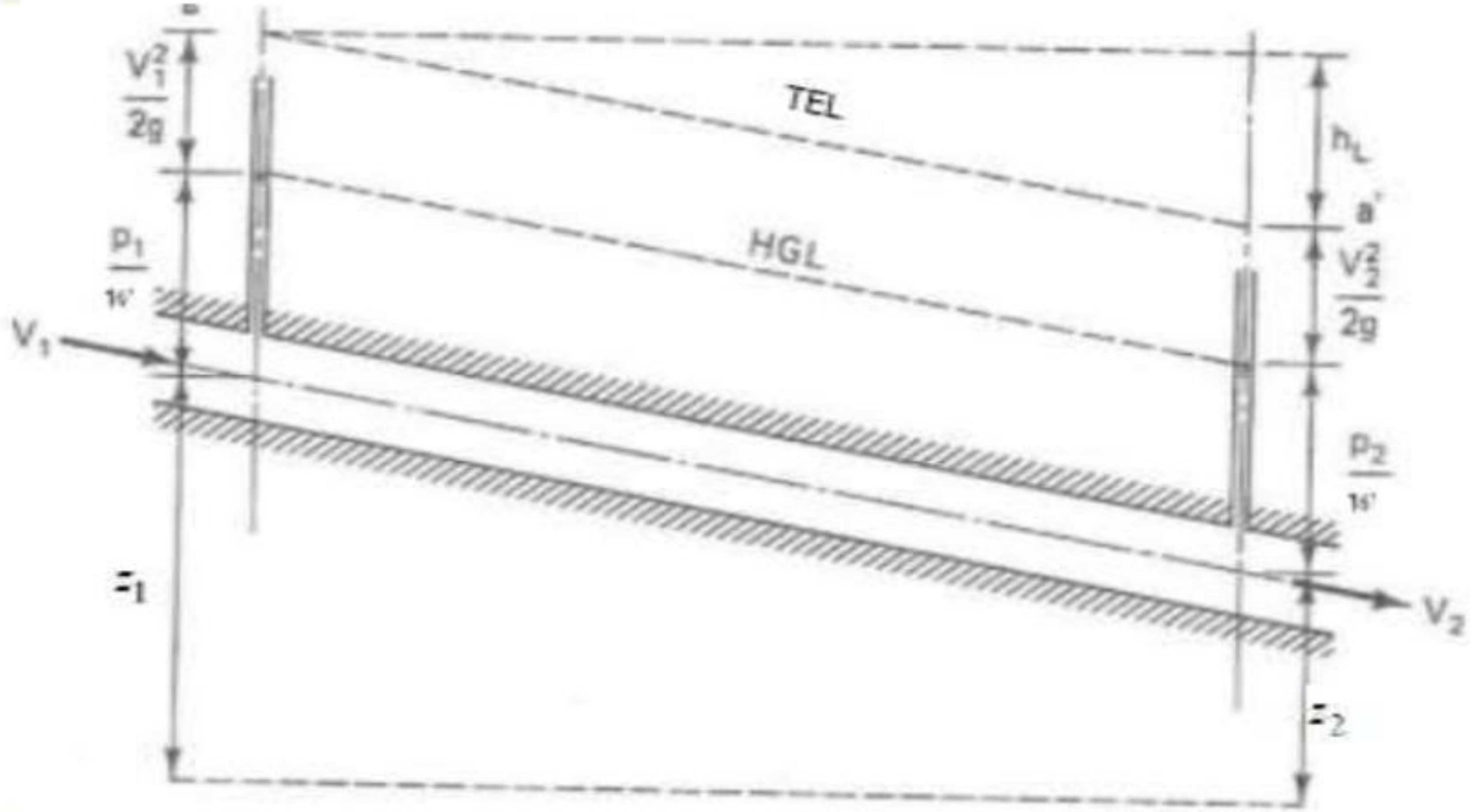
$\frac{V^2}{2g}$ Kinetic energy or velocity head (m)

z datum or elevation energy elevation head (m)

The elevation term, z, is related to the potential energy of the particle and is called the ***elevation head.*** The pressure term, is called the ***pressure head*** and represents the height of a column of the fluid that is needed to produce the **pressure** p. The velocity term, is the ***velocity head*** and represents the vertical distance needed for the fluid to fall freely (neglecting friction) if it is to reach **velocity** V from rest. The Bernoulli equation states that the sum of the pressure head, the velocity head, and the elevation head is constant along a streamline.

Bernoulli's equation states as follows

"In an ideal incompressible fluid when the flow is steady and continuous, the sum of pressure energy, kinetic energy and potential (or datum) energy is constant along a stream line."



$$\frac{P}{w} + \frac{V^2}{2g} + z = cons$$

Where

$\frac{P}{w}$ pressure energy.

$\frac{V^2}{2g}$ Kinetic energy

z datum or elevation energy.

Note: γ OR w

Total energy line **(T.E.L)** : Line represents the sum of pressure head, potential head , and velocity head.

$$z + \frac{V^2}{2g} + \frac{P}{w}$$

Hydraulic Grade Line **(H.G.L)** : Line represents the sum of pressure head and potential head.

$$\frac{P}{w} + z$$