HIDROSTATIKA

Tekanan: Titik, Bidang, Segala Arah

Distribusi Tekanan

Tekanan Atmosfer, Relatif dan Absolut

Manometer

Gaya Tekan pada Bidang Terendem, Momen Inersia

Tekanan

- $p = \frac{F}{A}$

- Pada zat cair diam→ sama di setiap titik di segala arah
- Pada bidang cair diam → tekanan tegak lurus bidang

Distribusi tekanan

- $p = \gamma h = \rho g h \rightarrow h = \frac{p}{\gamma} = \frac{p}{\rho g}$

- p = tekanan hidrostatis
- γ = berat jenis zat cair
- ρ = rapat massa zat cair
- h = kedalaman titik yang ditinjau
- g = percepatan gravitasi

Tekanan Atmosfer, Relatif, dan Absolut

- Tek.atmosfer, p_a → berat udara di permukaan
- Pada permukaan air laut 1,03 kgf/cm^2, atau 10,3 m air, atau 76 cm air raksa (Hg)
- Tek.relatif, p_r → tek.terukur berdasarkan tek.atmosfer
- Tek. Absolut, p_{abs} = tek.atmosfer, p_a + tek.relatif, p_r

The relationship between them is

$$p_r = p_{abs} - p_a$$

The change of pressure within the fluid can be expressed as

$$dp = -\rho g dz$$

For a fluid with constant density, the differential formula can be integrated as

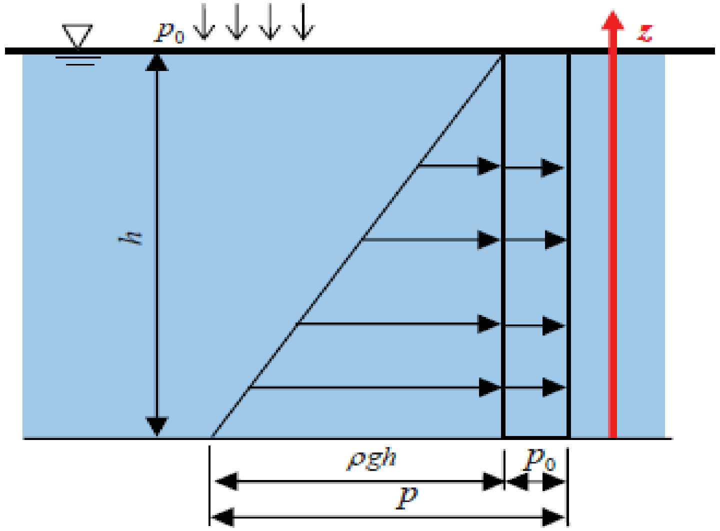
$$z + \frac{p}{\rho g} = C$$

where C is a constant that can be set from the boundary condition. If the top boundary pressure is p_0 and depth of the fluid is h, the bottom pressure can be derived as

$$p = \rho g h + p_0$$

For any two points in the same fluid, it can be derived

$$z_1 + \frac{p_1}{\rho g} = z_2 + \frac{p_2}{\rho g}$$



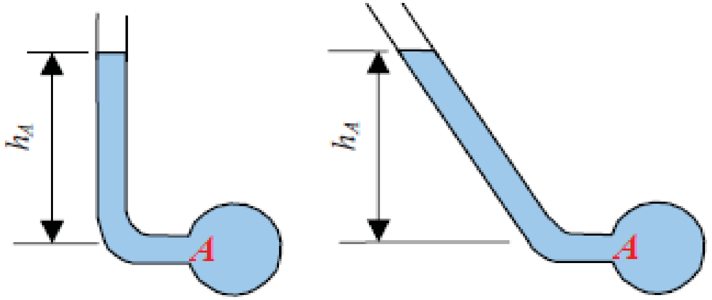
(Dawei Han, 2008)

Manometer

- Tekanan di setiap tempat pada bidang horizontal sama (zat cair homogen)

- Macam: piezometer, tabung U, manometer mikro, manometer diferential

A simple manometer is a tube with its one end attached to the fluid and the other one open to the atmosphere (also called *Piezometer*). The pressure at Point A can be derived from the height h_A in the tube.

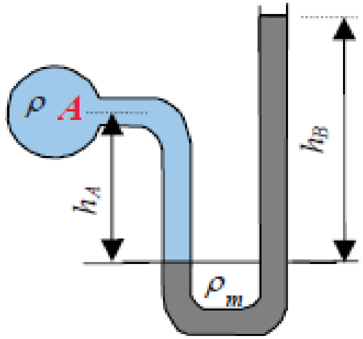


Simple manometers

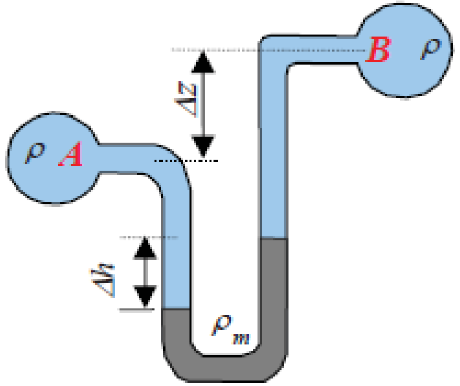
$$p_A = \rho g h_A$$

A more complicated manometer uses U-tube with a different fluid to the measured one. The pressure at Point *A* will be

$$p_A = \rho_m g h_B - \rho g h_A$$



U-tube manometer



Differential manometer

A differential manometer is used to measure the pressure difference between two points. A U-tube with mercury (or other fluids) is attached to two points whose pressures are to be measured. The pressure difference can be derived by measuring the elevation differences between Point *A* and Point *B* (i.e., Δz), and between the mercury levels (Δh).

Therefore

$$p_A - p_B = g[\rho_m - \rho)\Delta h + \rho \Delta z]$$

Gaya tekanan pada bidang terendam

- $F = A.p_0 = A\gamma h_0$

- F = gaya tekanan hidrostatis
- A = luas bidang tekanan
- p_0 = tek.hidrostatis pada pusat berat bidang
- h_0 = jarak vertical ant.pusat berat bidang dan permukaan zat cair

- $y_p = y_0 + \frac{I_0}{Ay_0}$

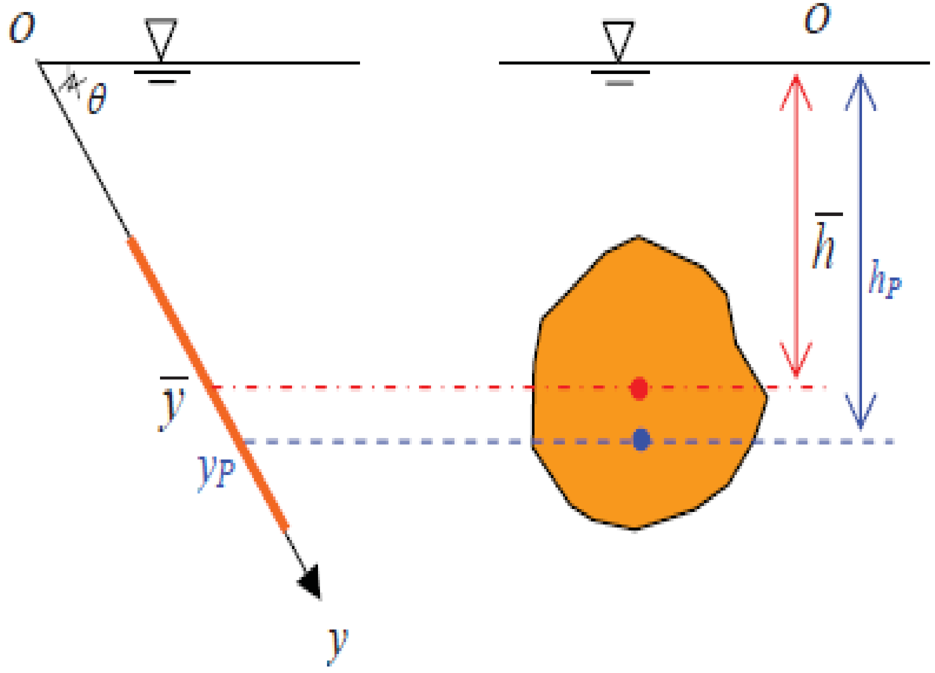
- y_p = jarak searah bidang, dari pusat tekanan thd. perm.zat cair
- y_0 = jarak searah bidang, dari pusat berat thd perm.zat cair

For a plane surface with area A, the total pressure force can be derived by the following integration formula:

$$F = \int_A p\,dA = \int_A \rho g h\,dA$$

where h is the depth of fluid from its surface.

If the centroid of the area is known, the pressure force can be derived as



$$F = \rho g \bar{h} A$$

where $\bar{h}$ is the depth of A's centroid.

The centre of pressure is the point through which the resultant pressure acts.

$$y_P = \frac{\int_A ypdA}{\int_A pdA} = \frac{\int_A y^2 dA}{\int_A ydA}$$

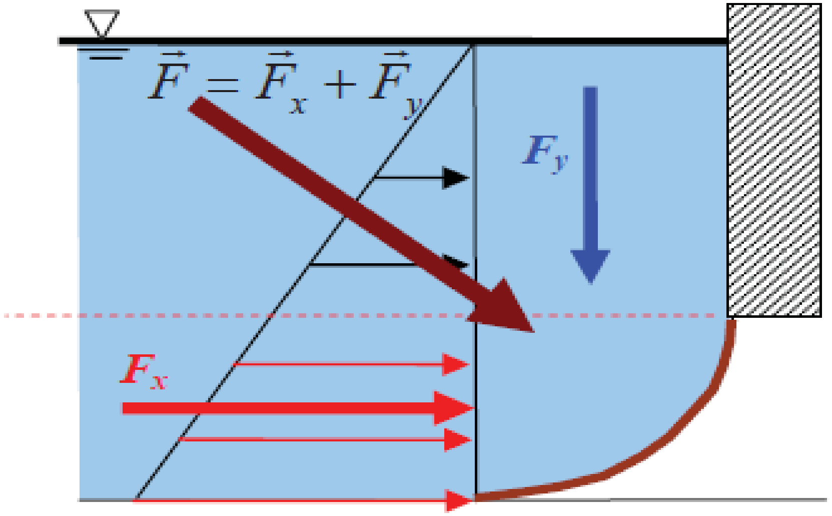
The numerator is the moment of inertia of the surface about the axis through *O,* and it equals to $I_x = I_C + \bar{y}^2 A$. Therefore

$$y_P = \bar{y} + \frac{I_C}{\bar{y}A}$$

For curved surfaces, the pressure force is divided into horizontal and vertical components. The vertical force F_y is the total weight of the fluid above the curved surface and its centre of pressure acts through its centre of gravity. The horizontal force F_x equals to the pressure force on a vertical plane surface projected by the curved surface. The resultant force is a triangular combination of the horizontal and vertical parts.

$F_y = \rho g V$ where V is the volume of the fluid above the curved surface.

$$F = \sqrt{F_x^2 + F_y^2}$$



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