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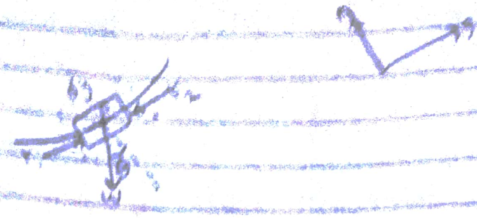
CHEMICAL ENGINEERING



$\Sigma F_s = ma$

Using the following assumptions
1. Inviscid liquid
2. Incompressible
3. Steady

$\partial F_s = ma$	i.e acceleration, a -
$= \rho\, \partial s \partial n \partial y \cdot v \frac{\partial s}{\partial v}$	$a = \frac{dv}{dt}$
	$= \frac{\partial v}{\partial s} \cdot \frac{ds}{dt}$
The component of weight force in direction of streamline	$= \frac{\partial v}{\partial s} \cdot v$
$\partial W_s = -\partial W \sin\theta = -\gamma \partial v \sin\theta$

1st-order Taylor series expansion for the pressure field

$$\partial P_s = \frac{\partial P}{\partial s} \cdot \frac{\partial s}{2}$$

$\therefore$ net pressure force in streamline direction

$$\partial F_{ps} = (P - \partial P_s)\partial n \partial y - (P + \partial P_s)\partial n \partial y$$

$$= 2\partial P_s \partial n \partial y$$

$$= -\frac{\partial P}{\partial s} \partial s \partial n \partial y$$

$$= -\frac{\partial P}{\partial s} \partial v$$

Hence, net force acting in streamline direction s

$$\Sigma dF_s = \partial W_s + \partial F_{ps}$$

$$= \left(-\gamma \sin\theta - \frac{\partial p}{\partial s}\right) \partial v \quad -\gamma \sin\theta - \frac{\partial p}{\partial s} \quad ---- (*)$$

$$= \rho v \frac{\partial v}{\partial s}$$

$$= \rho a_s.$$

Since $\sin\theta = \frac{dz}{ds}$ and $v \frac{\partial v}{\partial s} = \frac{1}{2} \frac{\partial v^2}{\partial s}$

By rearranging and integrating (*)

$$-\gamma \frac{dz}{ds} - \frac{dp}{ds} = \frac{1}{2} \rho \frac{dv^2}{ds}$$

$$dp + \frac{1}{2} \rho d(v^2) + \gamma dz = 0 \quad \text{[along a streamline]}$$

For constant acceleration of gravity:

$$\int \frac{dp}{\rho} + \frac{1}{2} v^2 + gz = C$$

For steady, inviscid and incompressible flow:

$$p + \frac{1}{2} \rho v^2 + \gamma z = C$$