

8.WEEK

CHE 212 FLUID MECHANICS

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OVERALL ENERGY BALANCE

- Apart from mass and momentum balance the third property to be considered in flow systems is energy.
- The energy conservation equation is combined with the first law of thermodynamics to obtain the final overall energy-balance equation.

$$\Delta E = Q - W$$

where E: total energy per unit mass of fluid

Q: heat absorbed per unit mass of fluid

W: work of all kinds done per unit mass of fluid upon the surroundings.

OVERALL ENERGY BALANCE

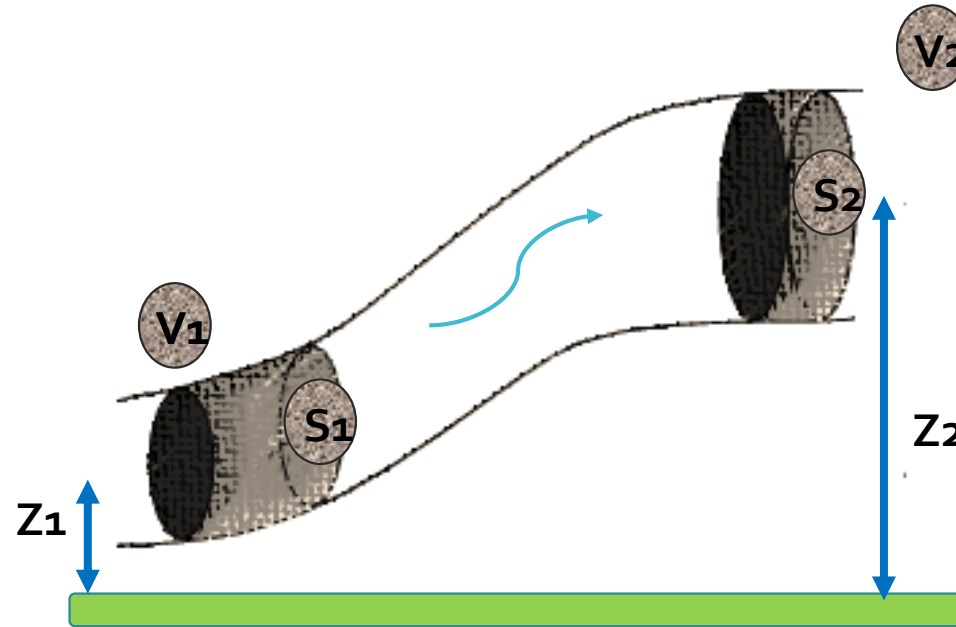
- Overall Energy Balance for Flow Systems;

$$\begin{array}{l} \text{Rate of energy entering the system} - \text{Rate of energy leaving the system} + \text{Rate of energy Produced/consumed the system} \\ = \\ \text{Rate of energy accumulation the system} \end{array}$$

$=0$
(no rxn in the system)

OVERALL ENERGY BALANCE

- BERNOULLI EQUATION is a particular form of a mechanical energy balance to describe the frictionless flow of an incompressible fluid along a streamline at steady state.



$$\frac{P_2}{\rho} + \frac{V_2^2}{2\alpha} + Z_2 g = \frac{P_1}{\rho} + \frac{V_1^2}{2\alpha} + Z_1 g$$

BERNOULLI EQUATION WITHOUT FRICTION

OVERALL ENERGY BALANCE

$$\bullet \frac{P_2}{\rho} + \frac{V_2^2}{2\alpha} + Z_2 g + W_s + h_f = \frac{P_1}{\rho} + \frac{V_1^2}{2\alpha} + Z_1 g$$

BERNOULLI EQUATION WITH FRICTION

Skin friction; is generated in unseparated boundary layers

Form friction; is generated when boundary layers separate and form wakes.

The term h_f includes both of them.

OVERALL ENERGY BALANCE

- FRICTION FROM CHANGES IN VELOCITY or DIRECTION
 - a. Friction loss from sudden contraction of cross section
 - b. Friction loss from sudden expansion of cross section
 - c. Effect of fittings and valves

OVERALL ENERGY BALANCE

- Total friction loss in mechanical energy balance:

Skin friction $4f \frac{L}{D} \frac{V^2}{2\alpha}$

Contraction loss $K_c \frac{V_b^2}{2\alpha}$

Expansion loss $K_e \frac{V_a^2}{2\alpha}$

Fitting loss $K_f \frac{V_a^2}{2\alpha}$