



Two Phase Flows

(Section 4)

The Basic Model

By: Prof. M. H. Saidi

Center of Excellence in Energy Conversion
School of Mechanical Engineering
Sharif University of Technology

Energy Conservation



$$\frac{\partial}{\partial t} \left[a_k r_k \left(e_k + \frac{u_k^2}{2} \right) A dz \right] + W_k \left(e_k + \frac{u_k^2}{2} \right) dz - \left[W_k \left(e_k + \frac{u_k^2}{2} \right) - dz \frac{\partial}{\partial z} W_k \left(e_k + \frac{u_k^2}{2} \right) \right] \quad \mathbf{A}$$

rate of increase of total energy in the C.V

rate of entrance of energy within the control volume

e_k

Internal energy per unit mass

Rate of heat entrance to C.V of phase k

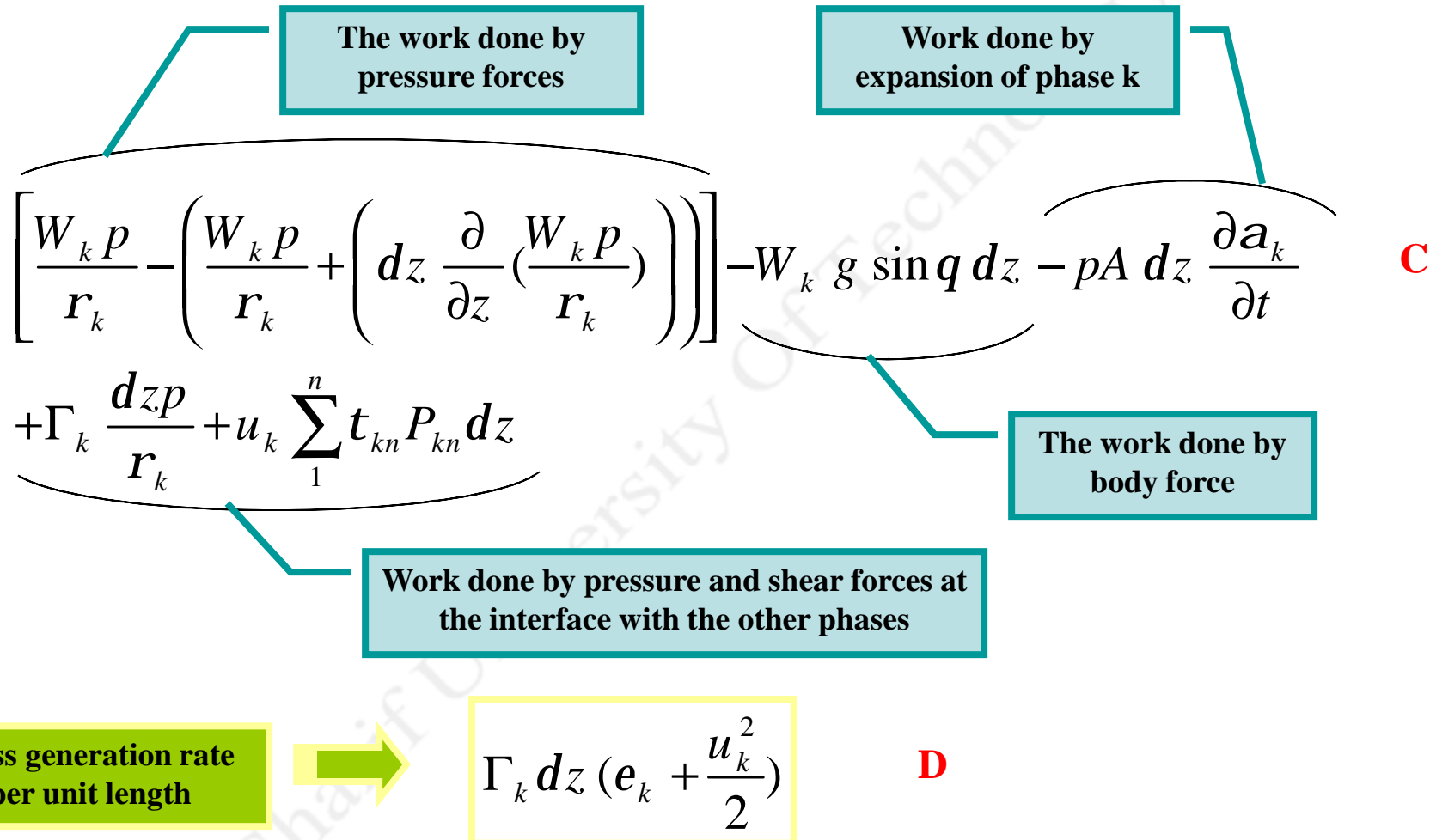
$$f_{kw} P_{kw} dz + \sum_1^n f_{kn} P_{kn} dz + f_k A a_k dz \quad \mathbf{B}$$

Heat flow from channel wall

H.V. via the various interfaces

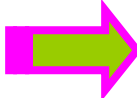
Internal heat generation within C.V

Energy Conservation



Energy Conservation

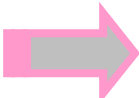
A=B+C+D



$$\frac{\partial}{\partial t} A a_k r_k \left(e_k + \frac{u_k^2}{2} \right) + \frac{\partial}{\partial z} W_k \left(i_k + \frac{u_k^2}{2} \right) = -W_k g \sin q + f_{wk} P_{wk}$$

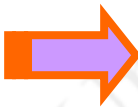
$$+ \sum_1^n f_{kn} P_{kn} + f_k A a_k - p A \frac{\partial a_k}{\partial t} + \Gamma_k \left(i_k + \frac{u_k^2}{2} \right) + u_k \sum_1^n t_{kn} P_{kn}$$

Enthalpy of phase k



$$i_k = u_k + \frac{p}{r_k}$$

For steady gas- liquid two phase flow in channel with constant area



$$d \left[W_g \left(i_g + \frac{u_g^2}{2} \right) \right] + W_g g \sin q dz =$$

$$f_{wg} P_{wg} dz + f_{gf} P_{gf} dz + u_g t_{gf} P_{gf} dz + \Gamma_g dz \left(i_g + \frac{u_g^2}{2} \right)$$

$$d \left[W_f \left(i_f + \frac{u_f^2}{2} \right) \right] + W_f g \sin q dz =$$

$$f_{wf} P_{wf} dz + f_{fg} P_{fg} dz + u_f t_{fg} P_{fg} dz + \Gamma_f dz \left(i_f + \frac{u_f^2}{2} \right)$$

†
†

Energy Conservation

Energy conservation at interface

$$f_{gf} P_{gf} + u_g t_{gf} P_{gf} dz + \Gamma_g (i_g + \frac{u_g^2}{2}) = f_{wf} P_{wf} dz + f_{fg} P_{fg} dz + u_f t_{fg} P_{fg} dz + \Gamma_f dz (i_f + \frac{u_f^2}{2}) \quad \text{†}$$

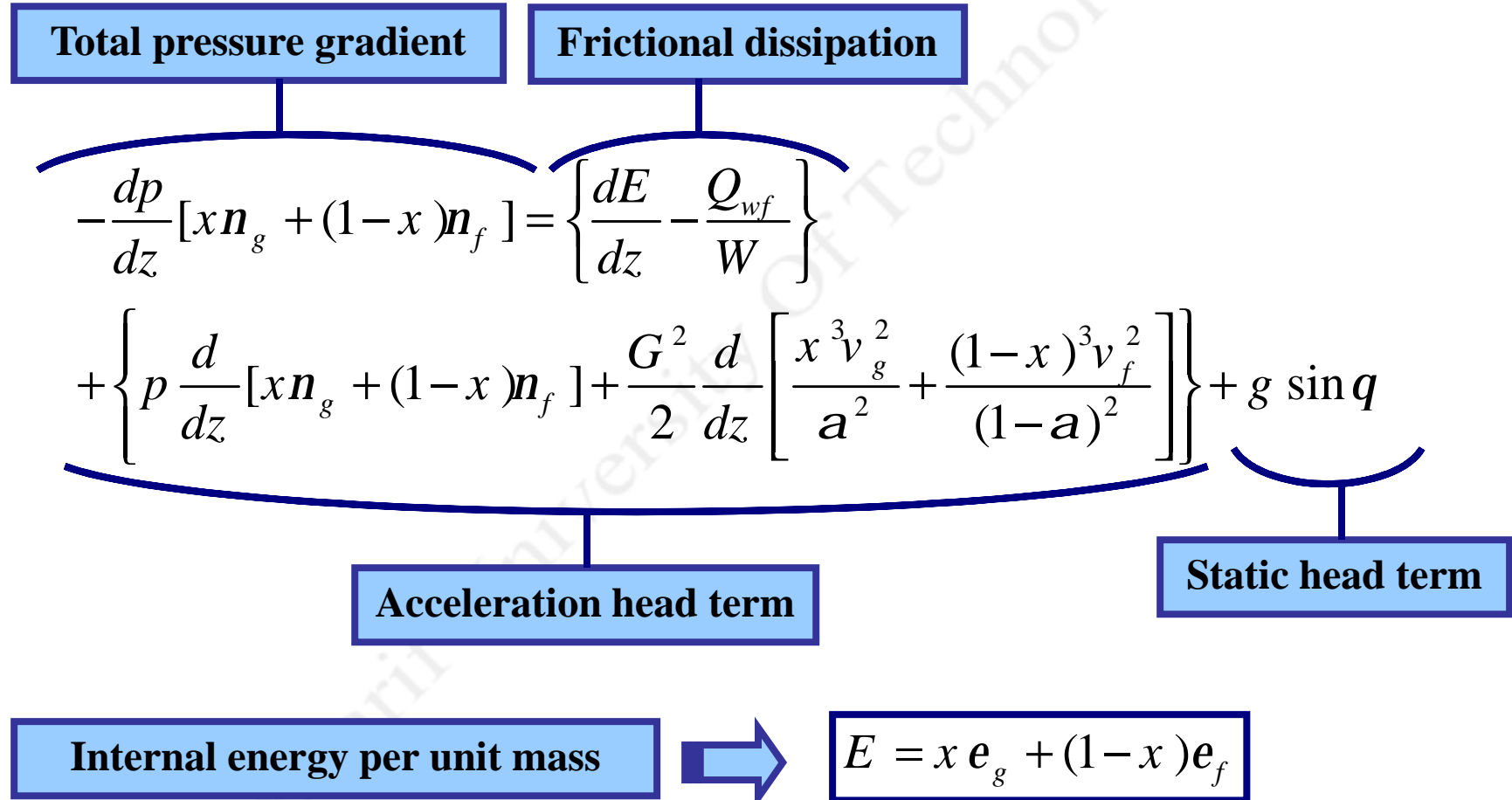
with regard the equations †, ‡ and †

$$\frac{d}{dz} [W_g i_g + W_f i_f] + \frac{d}{dz} \left[\frac{W_g u_g^2}{2} + \frac{W_f u_f^2}{2} \right] + (W_g + W_f) g \sin q = Q_{wl}$$

Heat transfer to the fluid across the channel wall per unit length

$$Q_{wl} (= f_{wf} p_{wf} + f_{wg} p_{wg})$$

Energy Conservation



Use of the momentum or energy equation to evaluate the pressure gradient



Using momentum equation

Using void fraction to calculate acceleration term from

$$-\left(\frac{dP}{dz} a\right) = \frac{1}{A} \frac{d}{dz} (W_g u_g + W_f u_f) = G^2 \frac{d}{dz} \left[\frac{x^2 n_g}{a} + \frac{(1-x)^2 n_f}{(1-a)} \right]$$

or static head term from

$$-\left(\frac{dP}{dz} z\right) = g \sin q \left[\frac{A_g}{A} r_g + \frac{A_f}{A} r_f \right] = g \sin q \left[a r_g + (1-a) r_f \right]$$

Then calculating friction pressure term from correlation equation in terms of independent variables.

Use of the momentum or energy equation to evaluate the pressure gradient



Using energy equation

- Calculation of pressure lost arising from variation of potential energy
- Calculation of pressure lost arising from variation of kinetic energy
- Calculate the friction pressure term from independent variables

Note: in two methods we need to the void fraction but the degree of importance in each method is not the same.

Sharif University Of Technology

Sharif University Of Technology

Sharif University Of Technology