Mass Transfer Coefficient

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General equation

$$N_A = \frac{N_A}{N_A + N_B}\frac{C\,D_{AB}}{z} Ln\left[\frac{N_A/(N_A+N_B) - C_{A_2}/C}{N_A/(N_A+N_B) - C_{A_1}/C}\right]$$

For liquid

$$x_A = \frac{C_A}{C}$$

For gas

$$y_A = \frac{C_A}{C} = \frac{P_A}{P_T}$$

$$N_A = \frac{N_A}{N_A + N_B} F\, Ln\left[\frac{N_A/(N_A+N_B) - C_{A_2}/C}{N_A/(N_A+N_B) - C_{A_1}/C}\right]$$

F : mass tranfer coefficient

Specific case
A diffusing B immobile

For gas

$$N_B = 0 \qquad\qquad \frac{N_A}{N_A + N_B} = 1$$

$$N_A = \frac{D_{AB}}{RTz}\frac{P_T}{\overline{P}_B}\left(P_{A1} - P_{A2}\right)$$

$$N_A = K_G\left(P_{A1} - P_{A2}\right)$$

Specific case
A diffusing B immobile

For gas

$$N_A = K_G\left(P_{A1} - P_{A2}\right)$$

$$N_A = K_y\left(y_{A1} - y_{A2}\right)$$

$$N_A = K_c\left(C_{A1} - C_{A2}\right)$$

Specific case
A diffusing B immobile

For liquid

$$N_A = K_L\left(C_{A1} - C_{A2}\right)$$

$$N_A = K_x\left(x_{A1} - x_{A2}\right)$$

Specific case
For gas

A diffusing
B diffusing at countercurrent equimolarly

$$N_A = -N_B$$

$$N_A = \frac{D_{AB}}{RTz}\left(P_{A1} - P_{A2}\right)$$

$$N_A = K_G^{'}\left(P_{A1} - P_{A2}\right)$$

Specific case

A diffusing
B diffusing at countercurrent equimolarly

For gas

$$N_A = K'_G (P_{A1} - P_{A2})$$

$$N_A = K'_y (y_{A1} - y_{A2})$$

$$N_A = K'_C (C_{A1} - C_{A2})$$

Specific case

A diffusing
B diffusing at countercurrent equimolarly

For liquid

$$N_A = K_L^{'}\left(C_{A1} - C_{A2}\right)$$

$$N_A = K_x^{'}\left(x_{A1} - x_{A2}\right)$$

Remark 1

Mass transfer $$N_A = K\left(C_{A1} - C_{A2}\right)$$

Heat transfer $$q = h\left(T_1 - T_2\right)$$

Remark 2

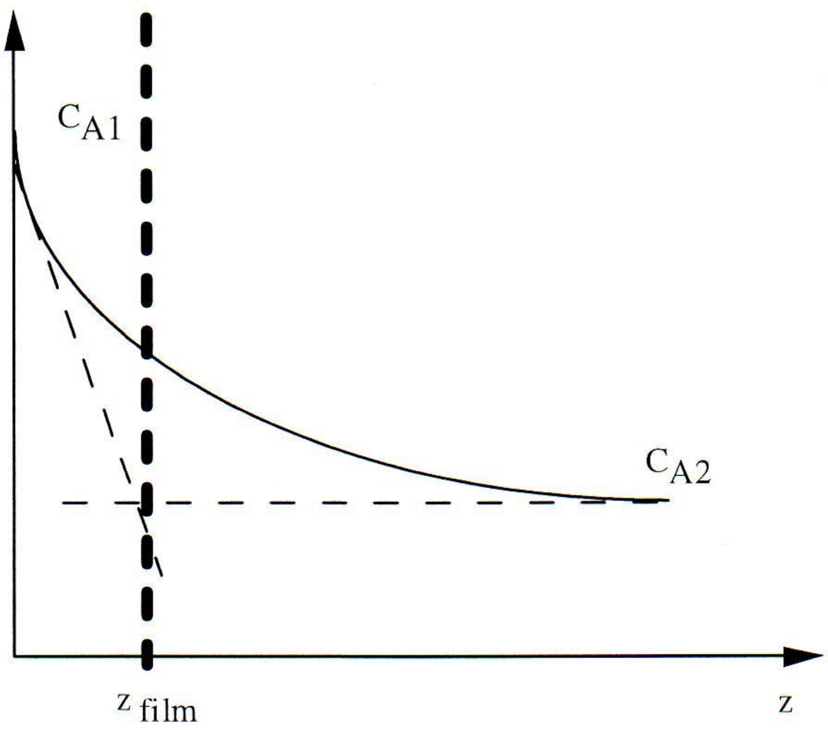
F is different as a function of the operating conditions

$$F = \frac{D_{AB}}{z}$$

$$F = \frac{D_{AB}P_T}{RTz}$$

$$F = \frac{D_{AB}P_T}{RTzP_B}$$

Film theory



$$N_A = K_L\left(C_{A1} - C_{A2}\right)$$

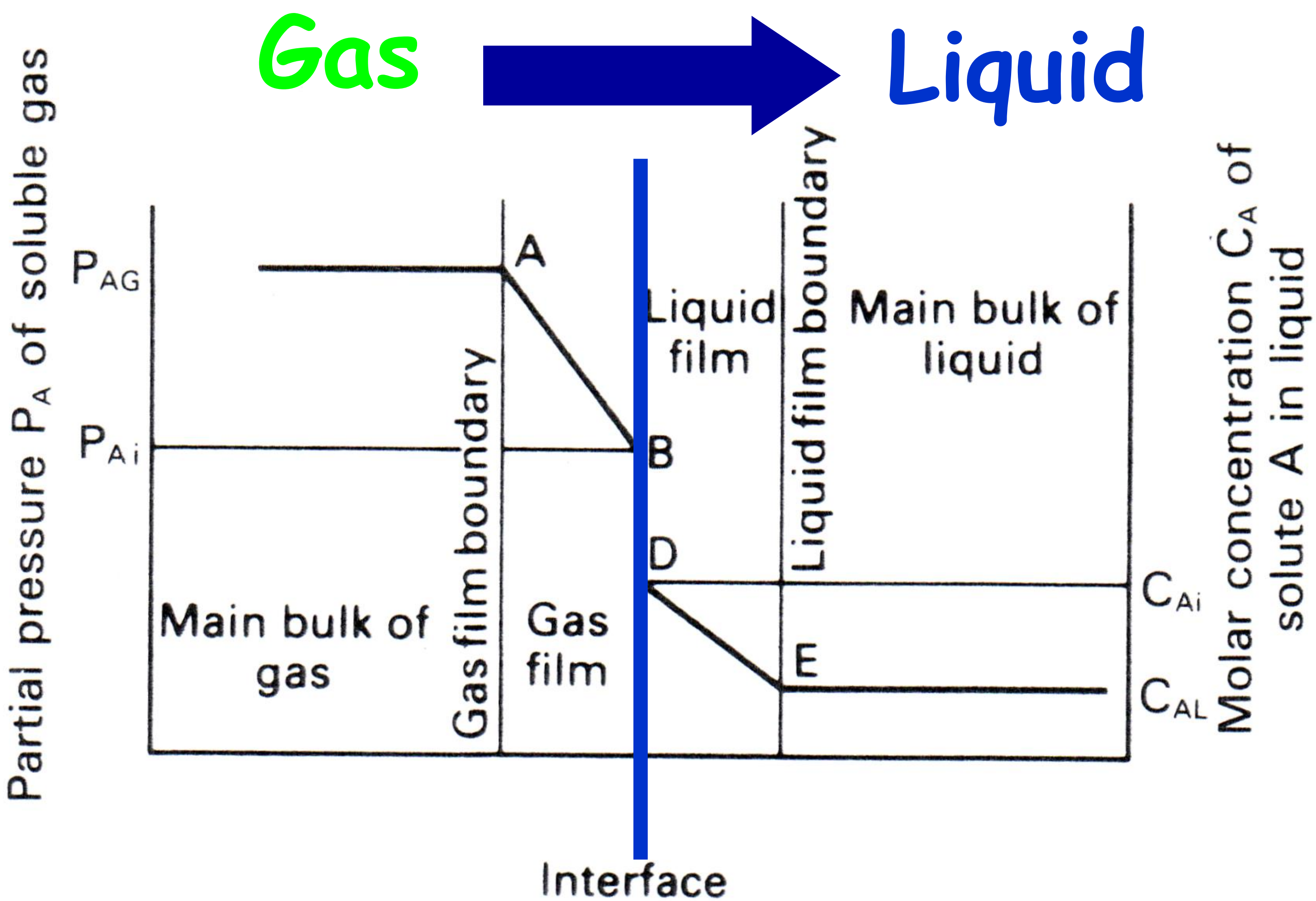
$$K_L = f(D^n)$$

$$K_L \approx 0.8 - 0.9$$

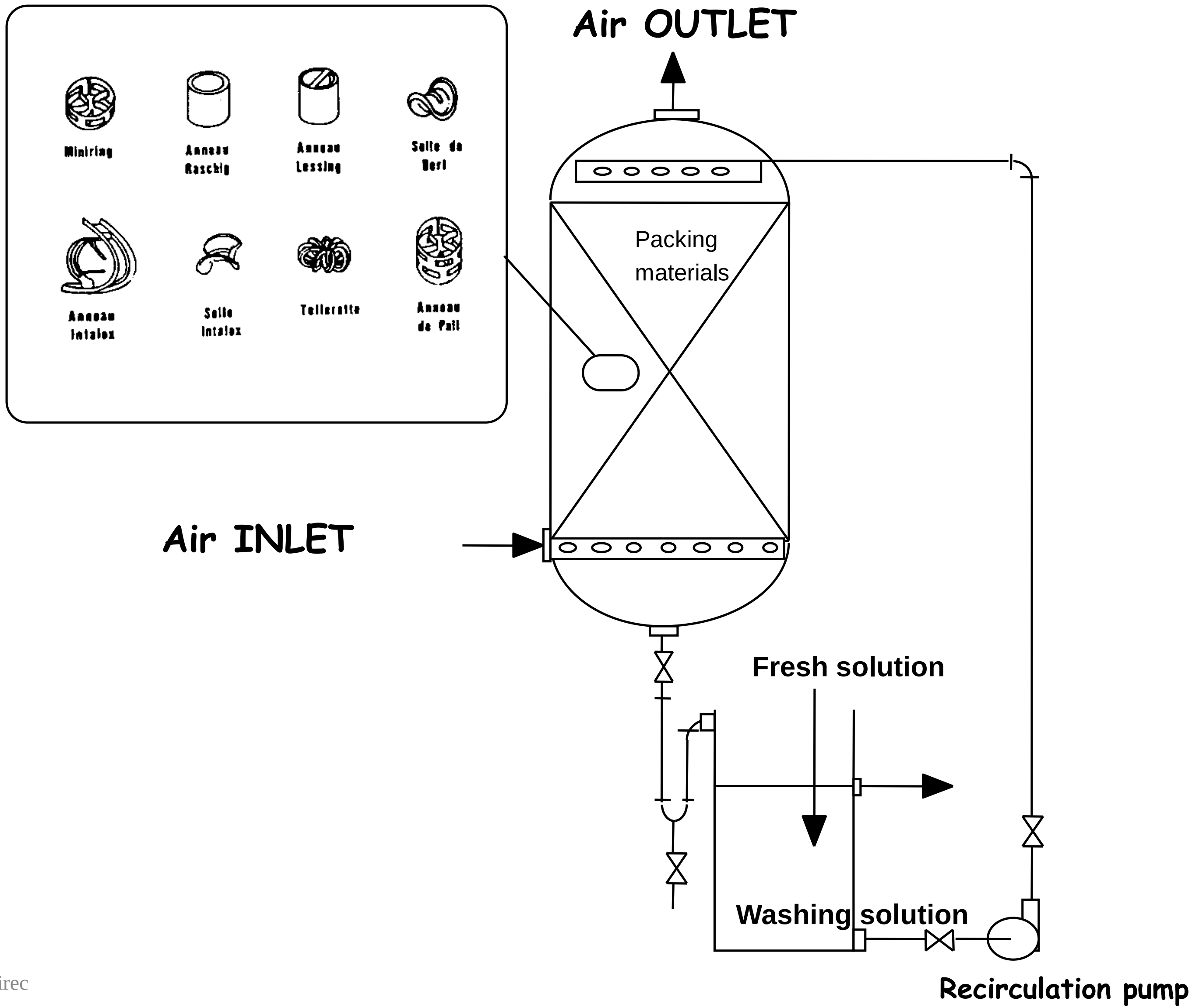
$$z \sim \frac{L}{\sqrt{\frac{V.L}{\nu}}} = \frac{L}{\sqrt{Re}}$$

Gas - Liquid transfer

Double Film Theory



Packed column



An industrial application

How to determine the mass transfer coefficients ?

1. To define adimensionnel number (operating conditions)

2. To determine empirical (statistical) relations between the adimensionnel numbers

To define adimensionnel number (operating conditions)

Reynolds $$Re = \frac{dU\rho}{\mu}$$

Sherwood $$Sh = \frac{K_x l}{D_{AB}}$$

Schmitt $$Sc = \frac{\mu}{\rho D_{AB}}$$

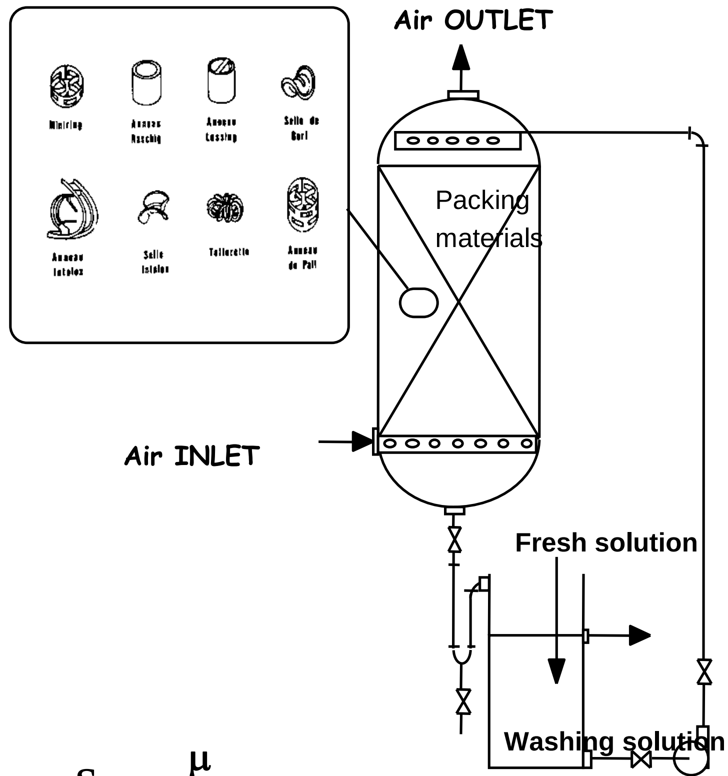
Stanton $$St = \frac{Sh}{ReSc}$$

J_D $$J_D = St(Sc)^{1/3}$$

To determine empirical (statistical) relations between the adimensionnel numbers

Example : Packed fixed bed

Re = 90 – 4 000 Sc = 0.6	$J_D = \frac{2.06}{\varepsilon} Re^{-0.575}$
Re = 5 000 – 10 300 Sc = 0.6	$J_D = \frac{20.4}{\varepsilon} Re^{-0.815}$
Re = 0.0016 - 55 Sc = 168 – 70 600	$J_D = \frac{1.09}{\varepsilon} Re^{-2/3}$
Re = 5 – 1 500 Sc = 168 – 70 600	$J_D = \frac{0.25}{\varepsilon} Re^{-0.31}$



$$J_D = St(Sc)^{2/3} \qquad Re = \frac{dU\rho}{\mu} \qquad Sh = \frac{K_x l}{D_{AB}} \qquad Sc = \frac{\mu}{\rho D_{AB}}$$

To determine empirical (statistical) relations between the adimensionnel numbers

Example : fluid and spherical particle

$$Sh = \left(4,0 + 1,21Pe^{2/3}\right)^{1/2}$$

$$Re = \frac{dU\rho}{\mu} \qquad Sc = \frac{\mu}{\rho D_{SL}} \qquad Sh = \frac{kd}{D_{SL}}$$

$$Pe = \frac{dU}{D_{SL}} = \frac{dU\rho}{\mu}\frac{\mu}{\rho D_{SL}} = Re\,Sc$$

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