CHAPTER VI

EQUILIBRIUM - CONCENTRATION RELATIONSHIPS

The extraction process is designed to reduce the concentration of a component in one stream and to increase it in the other stream. In a series of contact stages, in which all of the components flow from one stage to another, mass balance can be written around any stages, or any number of stages. This enables equations to be set down to connect the flow rates and the compositions of the streams. See Figure 6-1.

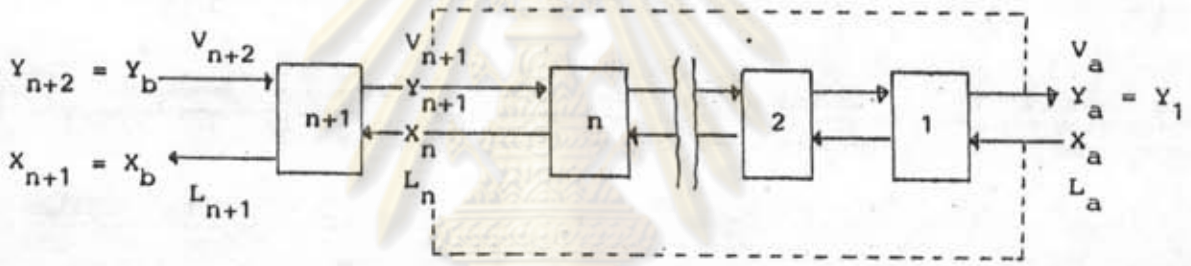

Figure 6-1 Contact equilibrium stages (Earle, 1966)

There is a stage contact process operating with a number of stages and two contacting streams. By convention, the flow of the light stream is denoted by V and the flow of the heavy stream by L. Taking a balance over the first n stages we can write, for the total flow,

$$V_{n+1} + L_a = L_n + V_a$$

and for the component being exchanged,

$$V_{n+1}Y_{n+1} + L_aX_a = L_nX_n + V_aY_a$$

Where V = flow rate of the light stream

L = flow rate of the heavy stream

y = concentration of the component being exchanged in the light stream.

x = concentration of the component being exchanged in the heavy stream.

Subscript n = condition at equilibrium in the nth stage.

n+1 = condition at equilibrium in the (n+1)th stage.

a = the conditions of the streams entering and leaving stage 1, one being raw material and one product.

Eliminating V_{n+1} between these equations, we have

$$V_{n+1} = L_n - L_a + V_a \qquad ...6.1$$

and so, $Y_{n+1}(L_n - L_a + V_a) = L_n X_n + V_a Y_a - L_a X_a$

$$Y_{n+1} = X_n \left[\frac{L_n}{L_n - L_a + V_a} \right] + \left[\frac{V_a Y_a - L_a X_a}{L_n - L_a + V_a} \right] \qquad ...6.2$$

This is an equation as it express the concentration in one stream in the (n+1)th stage in terms of the concentration in the other streams in the nth stage. In many practical cases, in which equal quantities or equal molar quantities of the carrying streams move from one stage to another, that is where the flow rates are the same in all contact stages, then $L_{n+1} = L_n = \ldots L_a$ and $V_{n+1} = V_n = V_a$. The simplified equation can be written

$$Y_{n+1} = X_n L/V + Y_a - X_a L/V \qquad ...6.3$$

Equation 6.2 or 6.3 is called the operating line, and used together with equilibrium line for determining the extraction stages in the process.