Column efficiency:

The number of ideal stages required for a desired separation may be calculated by one of the methods discussed previously, although in practice more trays are required than ideal stages. There are two types of efficiency usually used:

1. Overall column efficiency (E_c):

$$\text{overall column efficiency } (E_c) = \frac{\text{The theoritical number plates}}{\text{The actual number plates}} = \frac{N_{th}}{N_{act}}$$

$$E_c = \frac{N_{th}}{N_{act}}$$

Where: $N_{act} > N_{th}$

and: $N_{act} = N_{th}$ if $E_c = 100\%$

$$\mathbf{Z = N_{act} * \text{tray spacing}}$$

Where: $Z_{act} > Z_{th}$

2. Plate efficiency (E_m):

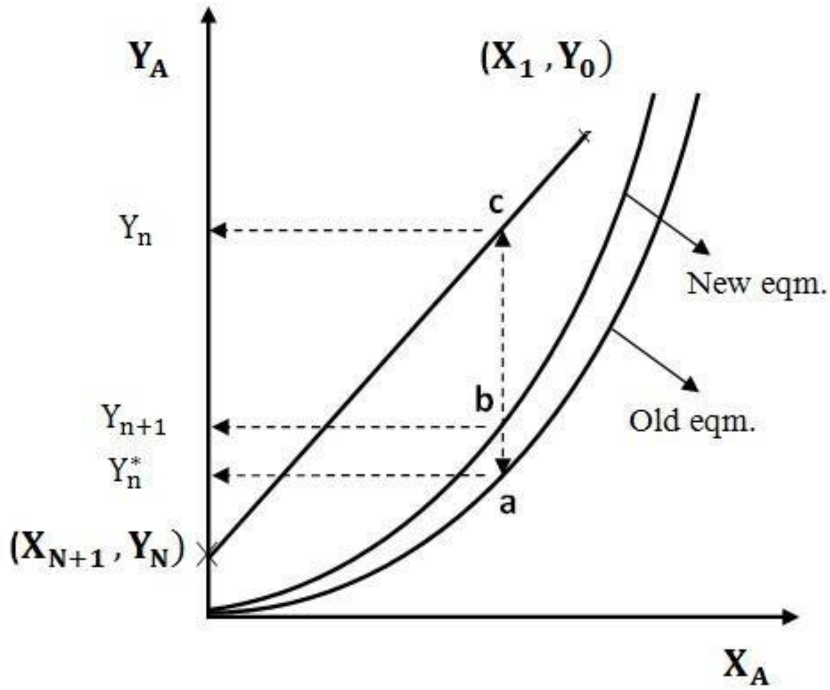
The proportion of liquid and vapour, and the physical properties of the mixtures on the trays, will vary up the column, and conditions on individual trays must be examined, as suggested by ***Murphree*** (1925). For a single ideal tray, the vapour leaving is in equilibrium with the liquid leaving, and the ratio of the actual change in composition achieved to that which would occur if equilibrium between $\mathbf{Y_n}$ and $\mathbf{X_n}$ were attained is known as the **Murphree plate efficiency (E_m)**. The plate efficiency can be expressed in terms of gas and liquid as given below:

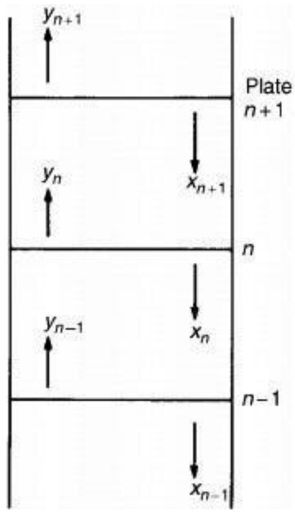
a. Plate efficiency based on gas phase (E_{mv}):

$$E_{mv} = \frac{Y_n - Y_{n+1}}{Y_n - Y_n^*} = \frac{\overline{bc}}{\overline{ac}}$$

Where:

Y_n^* : is the composition of the gas that would be in equilibrium with the liquid of composition $\mathbf{X_n}$ actually leaving the plate.



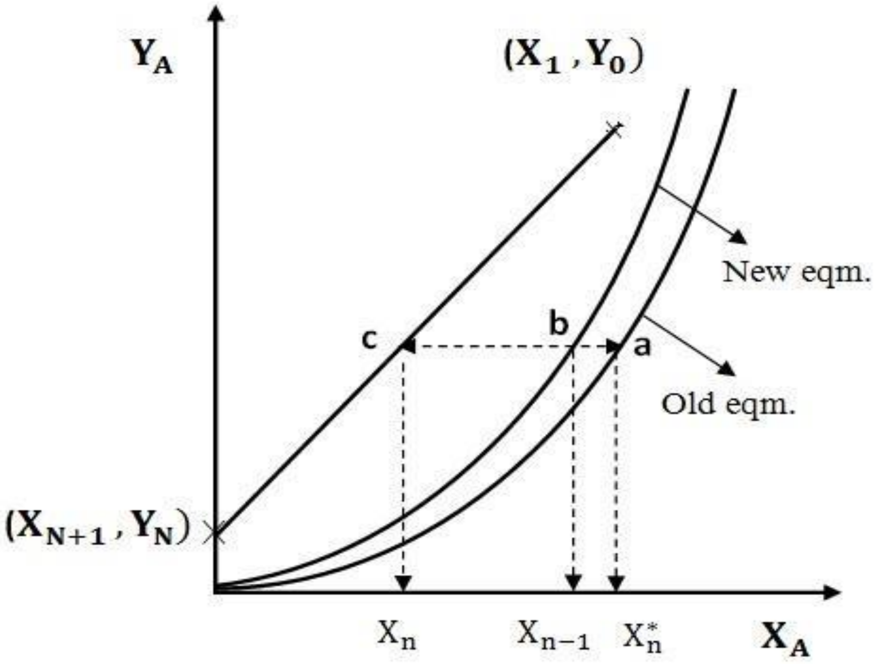


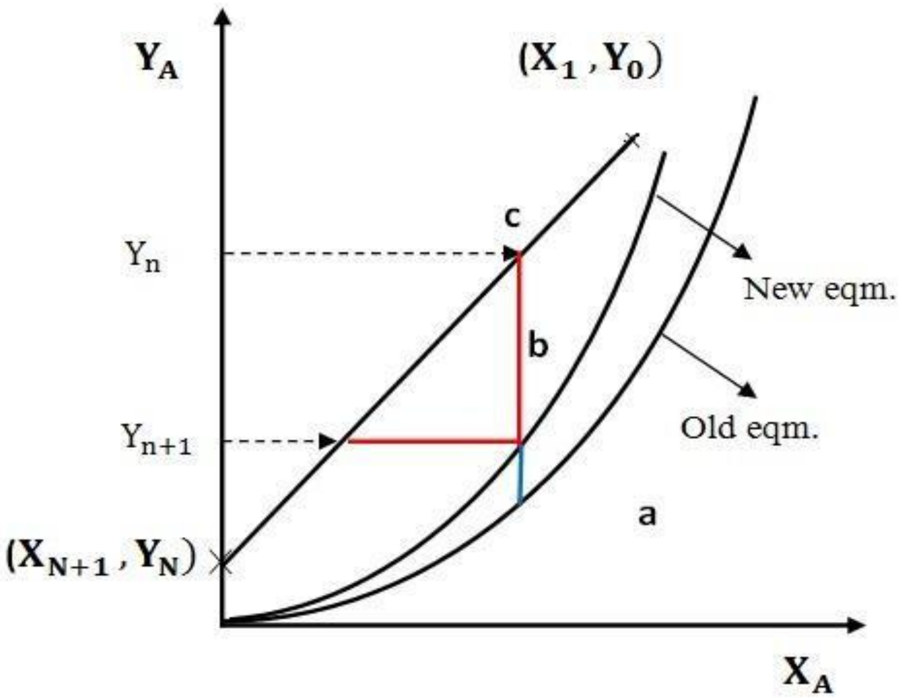
b. Plate efficiency based on liquid phase (E_{ml}):

$$E_{ml} = \frac{X_n - X_{n-1}}{X_n - X_n^*} = \frac{\overline{bc}}{\overline{ac}}$$

Where:

X_n^* : is the composition of the liquid that would be in equilibrium with the gas of composition $\mathbf{Y_n}$ actually leaving the plate.


Y_A
(X_1, Y_0)
New eqm.
c
b
a
Old eqm.
(X_{N+1}, Y_N)
X_n
X_{n-1}
X_n^*
X_A


Y_A
(X_1, Y_0)
c
Y_n
New eqm.
b
Y_{n+1}
Old eqm.
a
(X_{N+1}, Y_N)
X_A