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Prediction of Hydrostatic Head Effect in Process Plant Evaporators by Nomograph

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Evaporation in process plant evaporators is influenced by two common phenomena, viz. **Solute** effect and **Hydrostatic head effect,** which elevate the boiling point of the solution thereby reducing the available temperature difference driving force for boiling heat transfer and increasing the heat transfer area. Although literature provides information in the form of plots and nomographs[1,2] for a quick estimate of boiling point elevation for different solutes in their solutions, available information for the prediction of hydrostatic head effect is scanty[3]. The effect of hydrostatic head on the boiling heat transfer is quite appreciable in many situations and cannot be ignored especially for evaporators operating under moderate to high vacuum and when the liquid-level is fairly high above the tube bundle.

In this communication a nomograph has been prepared for the rapid estimation of the hydrostatic head effect with the help of the following equation:

$$\Delta t_h = 0.87 \frac{\nu_R T_R}{\lambda} \Delta P \quad \ldots\ldots(1)$$

Where, Δt_h = hydrostatic elevation of the boiling point, °C

T_R = Solution boiling temperature, °K

ν_R = specific volume of water vapour at T_R, $\frac{m^3}{kg}$

λ = latent heat of vaporisation corresponding to the saturation pressure, $\frac{Kcal}{kg}$

ΔP = hydrostatic head, metre (one-half of the indicated liquid level)

Equation (1) is a converted form of equation (14-7) given by Kern[3].

Figure-1 presents the nomograph for the direct prediction of the hydrostatic elevation of boiling point based on equation 1, Accuracy (valuation) of the nomograph:

The values obtained from nomograph coincide well with their respective values obtained from the equation 1.

EXAMPLE:

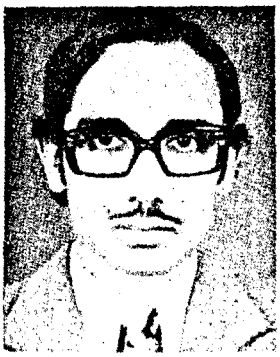
Solution boiling temperature: (T_R). 331.6°K

specific volume of water vapour at T_R (ν_R): 8.164 $\frac{m^2}{kg}$

latent heat of vaporisation corresponding to saturation pressure (λ): 564.03 $\frac{Kcal}{kg}$

hydrostatic head (ΔP): 1 meter

To calculate and compare the hydrostatic elevation of boiling point.



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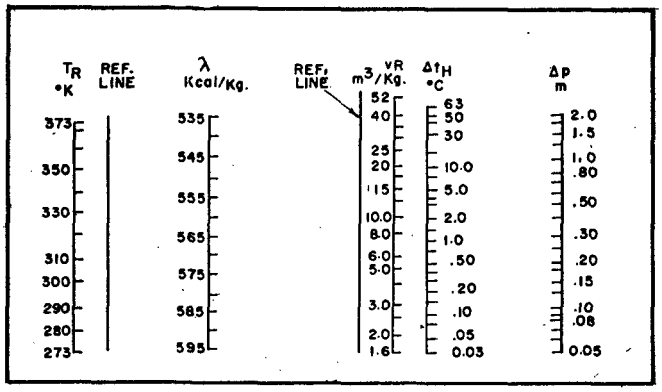

FIG. 1
PREDICTION OF HYDROSTATIC ELEVATION OF BOILING POINT.

SOLUTION

$$\Delta th = 0.87\ \nu_R\ T_R\ \Delta P$$

$$= \frac{0.87 \times 8.164 \times 331.6 \times 1}{564.03} = 4.18\ ^\circ C$$

from nomograph, $\Delta th = 4.0^\circ C$

Percentage deviation of nomograph value from the calculated ones = 4.3.

REFERENCES

1) Hougen O.A., Watson K.M.. and Ragatez R.A. Chemical Process Principles, Vol. I, 2nd edition, John Wiley & Sons Inc., P 81 & 104 (Fig. 17)
2) Perry J.H., Chemical Engineers' Hand book, Fourth edition, P 11 &30 (Fig.11 & 19)
3) Kern D.Q., Process Heat Transfer, McGraw Hill Book Co. Inc., P408.