Separation Science and Technology
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713708471

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To cite this Article Abdel-aal, H. K.(1995) 'A Straight-Line Equation Replaces Gilliland Plot', Separation Science and Technology, 30: 2, 313 — 316
To link to this Article: DOI: 10.1080/01496399508015841
URL: http://dx.doi.org/10.1080/01496399508015841

SEPARATION SCIENCE AND TECHNOLOGY, **30**(2), pp. 313–316, 1995

TECHNICAL NOTE

A Straight-Line Equation Replaces Gilliland Plot

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INTRODUCTION

A number of methods have been presented in the literature for approximating the relationship between the theoretical number of stages and the reflux ratio for distillation columns. Basically, an empirical correlation of the following form is assumed:

$$N = f(N_{\min}, R_{\min}, R)$$

The most widely accepted correlation is the one reported by Gilliland (1), in which the classical graphical plot X–Y is made as shown in Fig. 1. The values of X and Y are defined by:

$$X = \frac{R - R_m}{R + 1}, \qquad Y = \frac{N - N_m}{N + 1}$$

where R: the reflux ratio = L/D
N: the total number of theoretical plates (stages) including the reboiler and condenser
m: the subscript indicating minimum values at minimum conditions

Eduljee (2) found that the best equation for a Gilliland plot is represented by the following relationship:

$$Y = 0.75[1 - X^{0.5668}] \tag{1}$$

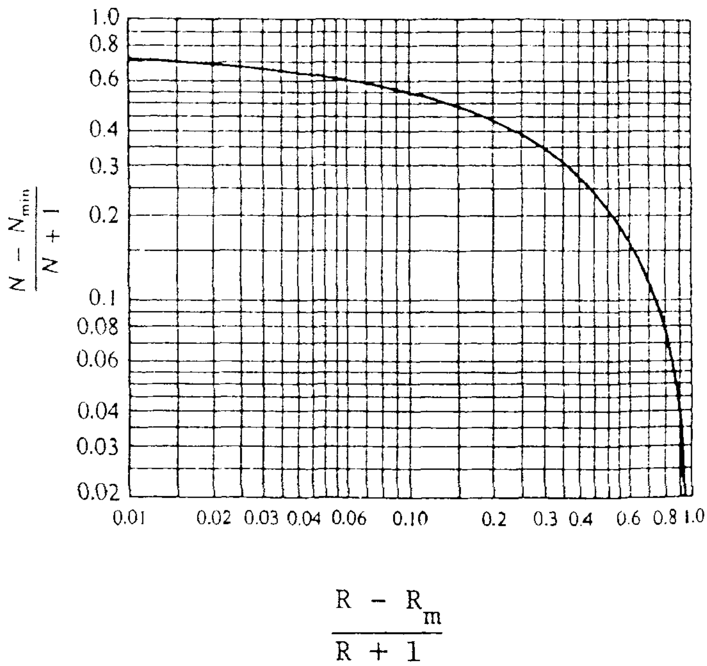

FIG. 1 Gilliland correlation.

As far as the reflux ratio is concerned, it was found from the studies by Fair and Bolles (3) that the optimum value of R/R_m is approximately 1.05. However near-optimal conditions extend over a relatively broad range of mainly larger values of R/R_{min}. In practice, superfractionators requiring a large number of stages are frequently designed for a value of R/R_{min} of approximately 1.10, while separations requiring a small number of stages are designed for a value of R/R_{min} of approximately 1.5. For intermediate cases, a commonly used rule of thumb is R/R_m equal to 1.30.

PROPOSED APPROACH

In this paper it is proposed to relate R to R_m using a simple relation of the following form:

$$R = AR_m \tag{2}$$

where A is a constant and its value ranges between 1.1 and 1.5.

The value of X defined above is rewritten accordingly as

$$X = \frac{A - 1}{A + 1/R_m} \tag{3}$$

Now if R_m is calculated and the value of A is selected for a given fractionator, N is related to N_m as follows.

Equation (1) is rewritten in term of Eq. (3):

$$Y = 0.75\left[1 - \left(\frac{A - 1}{A + 1/R_m}\right)^{0.5668}\right] \tag{4}$$

If A and R_m are specified for a given separation, then $[(A - 1)/(A + 1/R_m)]^{0.5668}$ is set equal to the same content, say C_1. Hence Eq. (4) is rewritten in the following form:

$$Y = 0.75(1 - C_1) \tag{5}$$

Setting $0.75(1 - C_1) = C_2$, another constant, the value of Y is presented in the following form:

$$Y = C_2$$

or

$$\frac{N - N_m}{N + 1} = C_2 \tag{6}$$

Solving Eq. (6), the value of N is computed directly using the simple straight-line relationship given by Eq. (7):

$$N = SN_m + I \tag{7}$$

where S = the slope of the straight line

$= \dfrac{1}{1 - C_2}$

I = intercept of the straight line

$= \dfrac{C_2}{1 - C_2}$

CONCLUSIONS

One can summarize as follows with respect to the above procedure.

- For a given separation, where the values of N_m, R_m, and A are deter-

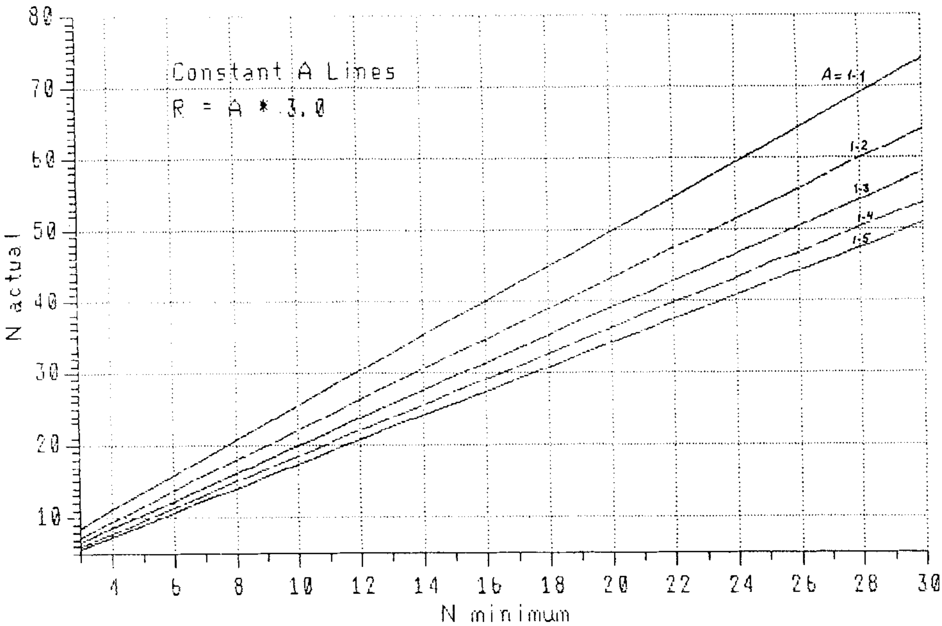

FIG. 2 Straight-line equation for Gilliland correlation.

mined, a straight-line equation relates the theoretical number of trays, N, to the minimum number of trays, N_m, as reported by Eq. (7).

- The proposed relationship is independent of the value of R, the operating reflux ratio.
- A graphical plot is provided in Fig. 2 to illustrate the concepts underlying the proposed procedure. N is calculated as a function of N_m for different values of A, as a parameter.

REFERENCES

1. E. R. Gilliland, *Ind. Eng. Chem.*, *32*, 1220 (1940).
2. H. E. Eduljee, *Hydrocarbon Processing*, pp. 120–122 (September 1975).
3. J. R. Fair and W. L. Bolles, *Chem. Eng.*, *75*(9), 156–178 (April 1968).

Received by editor April 11, 1994