

# Prediction of Vapour Velocity in Bubble-cap Towers by Nomograph

-G.K.Roy\*

**B**ubble-cap towers are the oldest and the most versatile type of vapour — liquid contacting devices, used not only in distillation, but in gas absorption also when the relatively high resistance to gas flow is not a serious objection. Essential design features for a bubble-cap tower include the fixation of number of plates and diameter. Graphical representation of Gilliland's correlation<sup>(1)</sup> is a method for a quick estimate of number of theoretical plates in a bubble-cap tower. For calculating the tower diameter it is imperative to predict correctly the vapour velocity in a tower which depends on the tray dynamics and properties of the vapour-liquid system being handled. Souders and Brown<sup>(2)</sup> equation is widely used for this, which is given here under:

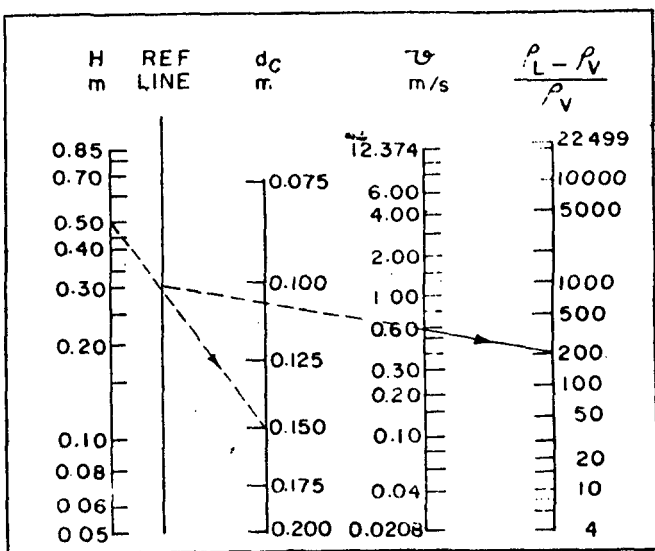
$$V = K_v \sqrt{\frac{\rho_L - \rho_v}{\rho_v}} \quad \dots\dots(1)$$

Where,  $V$  = Vapour velocity, ft per sec  
 $\rho_L$  = liquid density, lb per cu ft.  
 $\rho_v$  = vapour density, lb per cu ft.  
 $K_v$  = a factor depending on plate spacing and liquid seal

Kirschbaum (3) expressed  $K_v$  of equation-1 as:

$$K_v = 0.096 \sqrt{H/d_c^{2/3}} \quad \dots\dots(2)$$

FIGURE - 1



PREDICTION OF VAPOUR VELOCITY IN BUBBLE - CAP TOWERS

Where,  $H$  = distance from the top of the bubble to plate above, in inches  
 $d_c$  = diameter of bubble-cap, in inches.

A combination of equations 1 and 2 results in a final expression for the vapour velocity as —

$$V = 0.096 (H)^{0.500} (d_c)^{-0.667} \left(\frac{\rho_L - \rho_v}{\rho_v}\right)^{0.500} \dots (3)$$

Equation — 3 when written in the S.I. unit becomes,

$$V = 0.0159 (H)^{0.500} (d_c)^{-0.667} \left(\frac{\rho_L - \rho_v}{\rho_v}\right)^{0.500} \dots (4)$$

Where,  $V$  is in metres per sec.  
 $H, d_c$  are in metres  
 $\rho_L, \rho_v$  are in kg per cu. metre.

Based on equation — 4, a nomograph (Figure-1) has been prepared for a quick estimate of vapour velocity, which thereafter can fix up the diameter for a bubble-cap tower.

### RANGE OF APPLICABILITY

The range of applicability of the nomograph is presented in Table 1.

TABLE 1  
The Range of applicability of the nomograph.

S.No.	Variable	Unit	Range of applicability
1	$H$	m	0.050 - 0.850
2	$d_c$	m	0.075 - 0.200
3	$\rho_L$	$\frac{kg}{m^3}$	500 - 4500
4	$\rho_v$	$\frac{kg}{m^3}$	0.2 - 100

The ranges of variables cover the normal operating ranges for industrial bubble-cap towers.

### ACCURACY OF THE NOMOGRAPH

The values of vapour velocity obtained from nomograph have been found to agree well with their respective values obtained from equation — 3, e.g.

$H$  = 0.50 m  
 $d_c$  = 0.15 m  
 $\rho_L$  = 1005 kg per cu m.  
 $\rho_v$  = 5 kg per cu m.

Calculating and comparing the vapour velocity for the above case.

\* Dr. G.K. Roy is professor (Chemical Engineering) at the Regional Engineering College, Rourkela-769 008 (Orissa)

From equation — 3

$$V = 0.0159 (H)^{0.500} (d_c)^{-0.667} \left( \frac{P_1 - P_2}{P_2} \right)^{0.5}$$

$$= 0.0159 (0.5)^{0.5} (0.15)^{-0.667} \left( \frac{1005-5}{5} \right)^{0.5}$$

$$= 0.564 \text{ meter per sec.}$$

From nomograph (i.e. Figure-1),  
 $V = 0.59 \text{ m/s.}$

Percentage deviation of nomograph value from the corresponding calculated ones = 4.6%

#### REFERENCES

1. Gilliland, E.R., *Ind. Eng. Chem.*, 32, (1940), 1101, 1220.
2. Souders, M. and Brown, G.G., *Ind. Engg. Chem.*, 26 (1934), 98.
3. Kirschbaum, E., *Chem. Ing. Technik*, 28, (1956), 713.

Make habit of reading

**CEW**

India's foremost  
 technical journal for  
 Chemical & Processing  
 Industry



**This publication is available in microform.**

University Microfilms International reproduces this publication in microform: microfiche and 16mm or 35mm film. For information about this publication or any of the more than 13,000 titles we offer, complete and mail the coupon to: University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106. Call us toll-free for an immediate response: 800-521-3044. Or call collect in Michigan, Alaska and Hawaii: 313-761-4700.

Please send information about these titles:

Name \_\_\_\_\_

Company/Institution \_\_\_\_\_

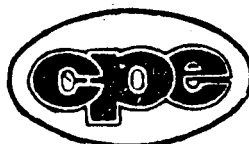
Address \_\_\_\_\_

City \_\_\_\_\_

State \_\_\_\_\_ Zip \_\_\_\_\_

Phone (\_\_\_\_) \_\_\_\_\_

**University  
Microfilms  
International**



Pioneers in Designing and Fabrication of Chemical Equipment such as Field Storage Tanks, Exhaust Systems, Scrubbers, Process Piping etc. of GRP, PVC-GRP, PP-GRP, PVDF-GRP, for Chemical and Allied Industries for over 22 years now offer PVC-GRP Electrostatic Precipitators, GRP Grating and Ladders.

## CHEMICAL PROCESS EQUIPMENTS PVT. LTD.,

Bhaktakavi Shivajibhai Devshi Marg,  
 (Govandi Station Road)  
 Chembur, Bombay-400 088.

Phones: 5513590 5514790 5514791 5518634

Gram: "CHEMPROCESS"  
 Telex: 11-72163 CPE IN

**"The Professional Corrosion Combators"**