CORRESPONDENCE

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"The development of a mechanical-draught water-cooling tower"†

by

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Mr H. E. Eduljee (Manager, National Peroxide Ltd, Bombay) observed that the data given in the Paper on the performance of 2-in. × 2-in. × ⅜-in. grid packing in industrial towers was very useful (see Table 1).

The "total-heat" method of designing cooling towers could be summarized by the equation:

$$c\int_{T_1}^{T_2}\frac{dT}{E_T - E_t} = \frac{K_a l}{L} = \text{N.T.U.} \quad . \ . \ . \ . \ . \ . \ . \quad (1)$$

where c denoted specific heat of water (= 1)
E_T ,, enthalpy of saturated air (B.Th.U/lb. of dry air) at water temperature T
E_t ,, enthalpy of air (B.Th.U./lb. of dry air) at air temperature t
T_1 and T_2 ,, inlet and outlet water temperatures respectively (°F)
K_a ,, volume coefficient of transfer: lb/(hr × cu. ft of packing volume), (lb/lb.)
l ,, height of packing (ft)
L ,, water rate: lb/(hr × sq. ft cross-sectional area of tower)

By analogy with other diffusional processes, $K_a l/L$ is called the number of transfer units (N.T.U.).

The height of the packing divided by the N.T.U. would give the height per transfer unit (H.T.U.)

$$l/\text{N.T.U.} = \text{H.T.U.}; \ \text{N.T.U.} \times \text{H.T.U.} = l \quad . \ . \ . \ . \ . \ . \quad (2)$$

Methods of integrating equation (1) had been discussed elsewhere[12] and it had also been shown that for film-type packings the H.T.U. could be correlated with the operating conditions by means of the equation:

$$\text{H.T.U.} = 0{\cdot}03(T_1 - 100) + m(L/G)^{0{\cdot}77} \quad . \ . \ . \ . \ . \ . \ . \quad (3)$$

Where G was the air rate, lb. of dry air/(hr × sq. ft cross-sectional area of tower), and m was a constant characteristic of the packing.

† Proc. Instn Civ. Engrs, Part I, vol. 5, p. 86 (Mar. 1956).

[12] H. E. Eduljee and B. V. Raman, "The Design of Mechanical Draft Counter-Flow Water-Cooling Towers—III". Trans Indian Inst. Chem. Engrs, vol. 4 (1952), p. 32.

The Authors' data on their packing allowed a test of equation (3). If the equation held then m should be a constant for all the runs (see Table 5).

TABLE 5

T_1: °F	T_2: °F	Wet-bulb temperature: °F	L/G	H.T.U.	m
68·0	60·3	49·9	0·96	4·28	5·40
80·0	70·8	61·8	0·96	4·52	5·30
81·3	71·0	61·5	0·872	4·55	5·66
72·5	62·1	53·0	0·685	3·86	6·26
75·5	57·6	41·3	0·680	3·98	6·35
96·4	73·7	50·5	1·138	7·23	6·64
80·6	65·1	43·1	1·123	4·89	5·02*
88·8	73·4	52·5	1·13	6·37	6·10
89·0	69·9	61·2	0·755	4·08	5·48
77·9	59·9	43·7	0·807	4·56	6·15
				Average	5·93

* Not included in average.

Equation (3) applied to that packing also, since the extreme values of m fell (with one exception) within 12% of the average value. The performance equation for the 2-in. × 2-in. × ⅜-in. grid packing was then:

$$\text{H.T.U.} = 0{\cdot}03(T_1 - 100) + 5{\cdot}93(L/G)^{0\cdot77} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Equation (4) was useful for three reasons:—

(*a*) The performance of the packing over a wide range of operating conditions could be expressed by a single equation.

(*b*) A preliminary calculation of the height of packing could be carried out rapidly; since equation (4) was based on actual test data the answer obtained would be reasonably correct. As an example, it was desired to cool water from 86·7 to 73·4°F with $L/G = 0{\cdot}868$ and a wet-bulb temperature of 62·8°F. The N.T.U. for those conditions was 1·375, and from equation (4) the H.T.U. was 4·95. The required height was therefore 1·375 × 4·95 = 6·8 ft; the Authors had actually used 6·0 ft of packing.

(*c*) When a new tower was tested, the test conditions seldom agreed closely with the design conditions. The problem then was to decide from the test data whether the tower would in fact work under design conditions. For the design data given in (*b*) above, the test data was: water cooled from 68·0 to 60·3°F with $L/G = 0{\cdot}96$ and a wet-bulb temperature of 49·9°F. From the test data the N.T.U. was 1·40 and the H.T.U. would be 6·0/1·4 = 5·24. Substituting that value of H.T.U., with $T_1 = 68{\cdot}0$ and $L/G = 0{\cdot}96$ in equation (3) gave $m = 5{\cdot}40$. The test equation for the packing was therefore:

$$\text{H.T.U.} = 0{\cdot}03(T_1 - 100) + 5{\cdot}4(L/G)^{0\cdot77}$$

For the design condition the N.T.U. was 1·375 and the H.T.U., calculated from the test equation, was 4·42. The height of packing required to carry out the design duty was therefore 1·375 × 4·42 = 6·08 ft. Since the actual packed height was 6·00 ft, the tower would carry out the design duty.

The value of m was also indicative of the efficiency of the packing—the smaller the value, the more efficient the packing as a transfer medium. For a complete evaluation of the packing its pressure-drop characteristics must, of course, also be taken into account.

The Authors, in reply, agreed that the "transfer unit" method of correlation reduced the work involved in preliminary design calculations. Mr Eduljee had presented a more refined version of the ordinary method, which improved accuracy. However, the Authors found that most tower designers evolved quick simple methods, and they would hesitate to advocate superiority for any particular method.