5.5.3 The pumping head required for a splash fill tower is between 2 mWC and 4 mWC more than that with a film fill. This is a large increase in pumping energy resulting not only in increased operating costs but also increased carbon emissions. Hybrid fills may be considered in such cases as the height required for these fills will be comparable with that of film fills.

5.5.4 In most of the cases involving fresh or slightly brackish water applications, it may be possible to use film fills even with a necessity to replace fills once in 7 to 8 years because of fouling/scaling as the replacement costs will still be economical compared to the increase in energy costs with splash fill. A basic water treatment program will be required for both film and splash fill applications because the first zone that gets affected in any cooling tower because of poor water quality is the distribution system and the condenser tubing too gets fouled at the same time with poor quality water circulation.

5.5.5 Splash fills have either been completely eliminated or on the fast decline in many parts of the world due to the following reasons:

a) Requires higher pump head;

b) Takes longer to install;

c) Prevents easy access to fill level for maintenance of nozzles;

d) Certain types of splash fills with slotted surfaces cannot be cleaned once choked; and

e) Splash fills can sag with the passage of time affecting thermal performance.

5.5.6 The performance of all types of fills gets affected because of a poorly designed or performing distribution system, more so for a splash fill packing. Hence, the choice of fill shall be made by the designer and/or cooling tower owner weighing all the options as suggested.

5.5.7 Once the individual N_{VH} values (from air inlet through throat, where throat diameter is the same as exit diameter) are calculated as explained above, the total number of velocity heads for the NDCT is arrived at by summation,

$$N_{VH-Total} = N_{VH-ai} + N_{VH-RZ+SZ} + N_{VH-Fill} + N_{VH-C/B} + N_{VH-DE} + N_{VH-T}$$

where

$$\Delta p = N_{VH-Total} \times \rho_{avf} \times v_F^2/2g; \text{ and}$$
$$\Delta \rho = \rho_{avi} - \rho_{avo}.$$

Hence, the required draught height of the NDCT will be $H_d = \Delta p/\Delta\rho$ and the required total height of the NDCT will be $H_{Total} = H_d + FH/2$ + beam depth + H.

The above calculations can be repeated with different fill types, fill heights and spacing, air inlet heights and H_{Total}/Φ_B ratios for a techno-economic analysis of designs.

5.5.8 Chilton has defined Merkel number in 'the performance of natural draught water-cooling towers', which is $\alpha = 1/(KaV/L) + 1/2G$. This number is characteristic of the tower and can be used to calculate the tower performance coefficient as under:

$$C = \alpha\, G/L \times (N_{VH-Total})^{1/3}$$

It is seen that C is an indication of the efficiency of the fill used in design and hence, this value remains nearly constant independent of the NDCT size and varying (off-design) duty conditions.

5.5.9 The value of C is generally found to be between 3 and 4 for film fills (depending on their heat transfer surface and thermal efficiency) and between 4 and 5.5 for splash fills (sometimes higher for poorly performing splash fills). Values outside this range will result in uneconomical tower designs.

5.5.10 It is also possible to design a NDCT to achieve a specific value of C (within the range) depending on the type of fill chosen. Once the value of C is determined it is possible to arrive at a combination of NDCT dimensions in terms of Φ_B and H_{Total} using a parameter called duty coefficient (D_C). This coefficient is generally not used in thermic designs these days.

The duty coefficient is related to the performance coefficient in terms of the pond area at sill and height of the NDCT as under:

$$D_c = A \times \sqrt{H_{Total}/(C \times \sqrt{C})}$$

Replace it with $D_c = A\sqrt{H_{Total}} / C\sqrt{C}$

Many combinations of Φ_B and H_{Total} are possible for different H_{Total}/Φ_B ratios for a given fill configuration and pumping head limits.

5.6 Hydraulic Design

Hydraulic design involves sizing of the hot water header piping, riser piping, hot water channel/duct and distribution piping and the associated pressure drops.