MARLEY

applications engineering

Crossflow vs. Counterflow Cooling Towers

Crossflow and counterflow are two ways to describe how air moving through a cooling tower interacts with the process water being cooled and their fundamental differences. The focus is on factory-assembled induced-draft crossflow and counterflow cooling towers. For more information on other types of crossflow and counterflow towers, refer to the white paper "Classifying Cooling Towers" *AE-SK-19*.

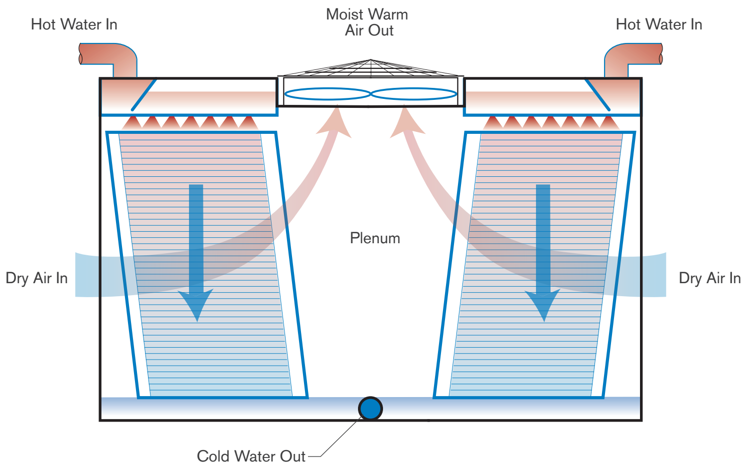

Figure 1 Crossflow cooling tower schematic

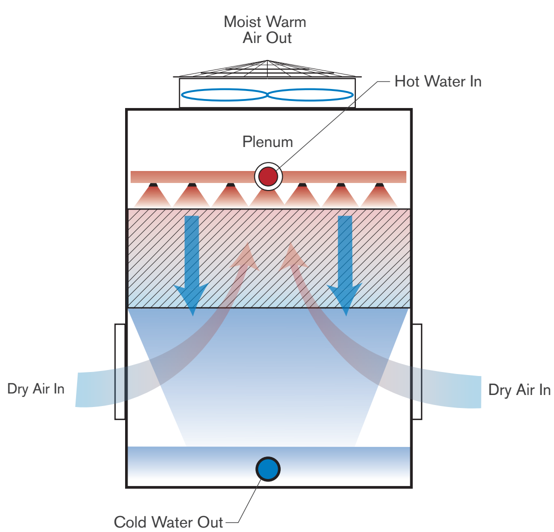

Figure 2 Counterflow cooling tower schematic

The fundamental difference between crossflow and counterflow cooling towers is how the air moving through the cooling tower interacts with the process water being cooled. In a crossflow tower, air travels horizontally across the direction of the falling water whereas in a counterflow tower air travels in the opposite direction (counter) to the direction of the falling water. See **Figure 1** and **Figure 2** for a visual explanation.

Space Requirements

The method by which air interacts with the process water creates two different styles of plenum areas as illustrated in **Figure 1** and **Figure 2**, which has a direct effect on the footprint of the cooling tower. Up to about 750 tons (3295 kW), a counterflow cooling tower requires less plan area than a crossflow cooling tower, which makes counterflow cooling towers advantageous in densely populated metro areas with limited space. At about the 750 ton mark, counterflow towers offer little to no advantage in footprint relative to a crossflow tower. Furthermore, it is critical to realize not all available real estate can be treated the same. Depending on the application, a crossflow cooling tower may require less total area than a counterflow tower even at heat loads less than 750 tons. This is because of the air inlets on each style of tower. A crossflow tower only has two air inlets compared to four on a counterflow cooling tower, see **Figure 3** and **Figure 4**.

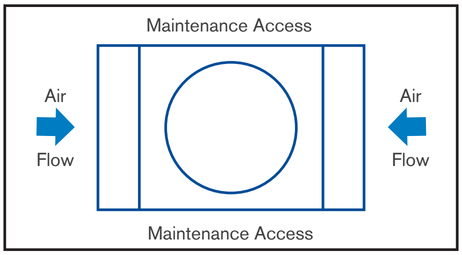

Figure 3 Crossflow effective footprint

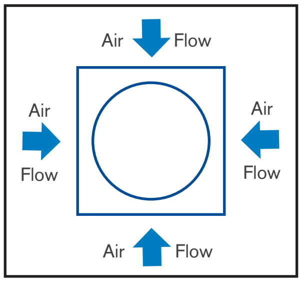

Figure 4 Counterflow effective footprint

Maintenance

Another direct consequence of the different plenum areas is maintenance access. As shown in **Figure 5** the large plenum area in the center of a crossflow tower is large enough to stand, making it very easy to access equipment for inspection and maintenance. A counterflow tower by nature has very limited space to access its components which makes maintenance and repair more complicated and time consuming. A cut-away of a counterflow tower in **Figure 6** shows the limited space available for maintenance.

Figure 5 Crossflow cutaway showing large plenum area for easy maintenance

Figure 6 Counterflow cutaway showing minimal working space for maintenance

Water Distribution

Another significant design difference between a crossflow and counterflow tower is the method by which water is distributed throughout the tower. In a crossflow tower, the process water is pumped to the top of the tower and discharges into a hot water basin with nozzles as shown in **Figure 7**. The nozzles are gravity fed with the height of the water above the nozzles being the driving force. When sizing a condenser water pump for a crossflow tower only the height from the pump to the top of the tower and the friction loss in the piping, including any flow control valves, need to be considered.

In a counterflow tower, the process water is pumped into a header box about three-fourths of the way up the tower. The header box then distributes the water into branch arms and nozzles. A pressurized water distribution system is created by the branch arms and nozzles fed by the header box as shown in **Figure 8**. When sizing a condenser water pump for a counterflow tower, the height from the pump to the header box, the friction loss in the supply piping, and the pressure drop through the branch arms and nozzles all need to be considered. The tower manufacturer will supply the total dynamic head through the tower at design flow, which makes pump sizing easier for the system designer.

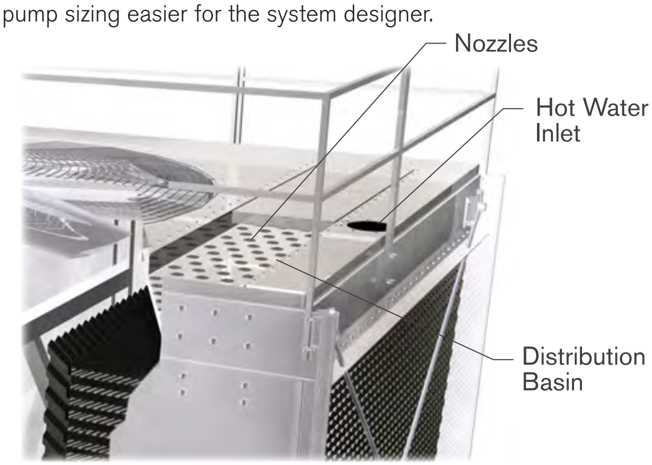

Figure 7 Crossflow distribution basin with gravity-fed nozzles

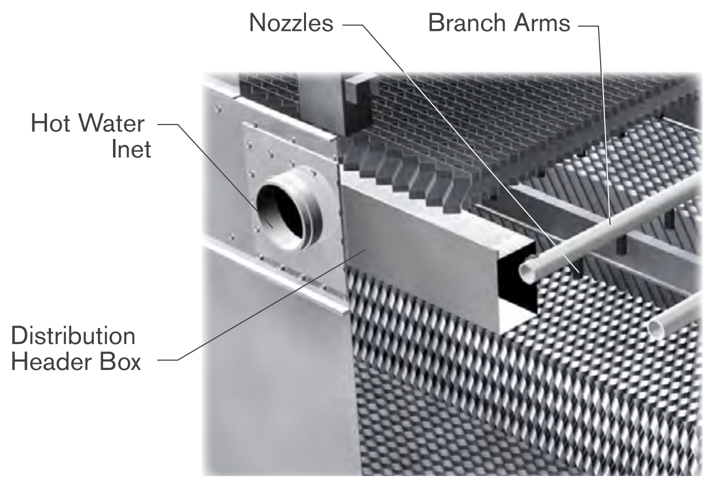

Figure 8 Counterflow distribution through header box to branch arms and nozzles

Variable Flow and Cold Weather Operation

Water distribution design has a direct effect on variable flow and cold weather operation. With the use of nozzle cups, a crossflow tower can utilize as little as 30% of design flow and maintain even water distribution across the fill as shown in **Figure 10**. An even pressure drop across the fill allows manufacturers to accurately predict the performance of the tower. Furthermore in cold weather operation, the use of nozzle cups on the inboard side keeps the heat load towards the side of the fill exposed to the elements.

At low-flow operation, counterflow cooling towers have less energy and nozzles to distribute water across the entire cross section of the fill, which limits low flow capability to about 70% of design flow. At flows under 70% of design water channeling begins to develop as shown in **Figure 12**. This channeling leads to unpredictable performance, scale build up, and icing during cold weather operations. Furthermore, the turbulent splashing water into the cold water basin can lead to non-visible ice accumulation on the inside louver faces during cold weather.

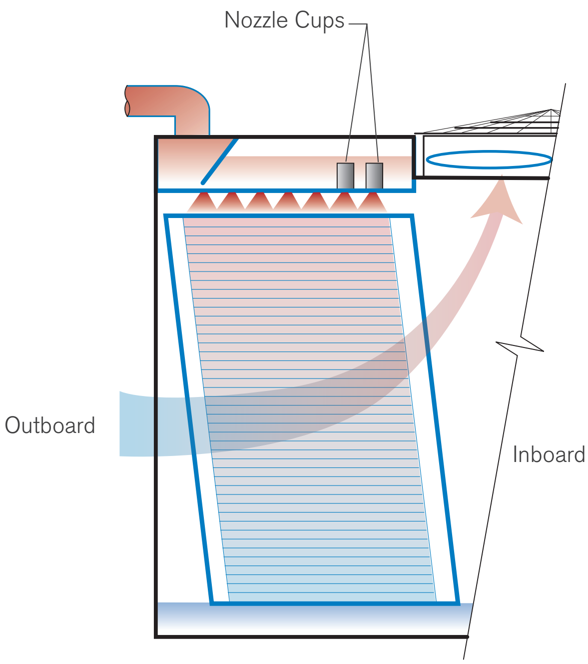

Figure 9 Crossflow water distribution over fill at full flow

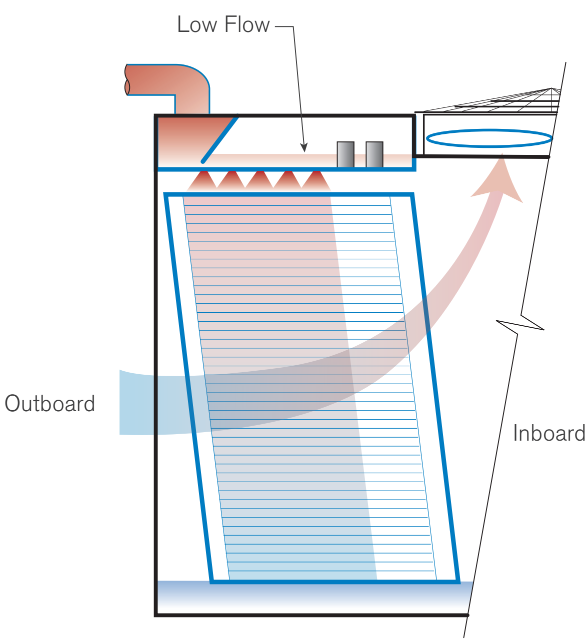

Figure 10 Crossflow water distribution over fill at low flow with the use of nozzle cups maintains even distribution

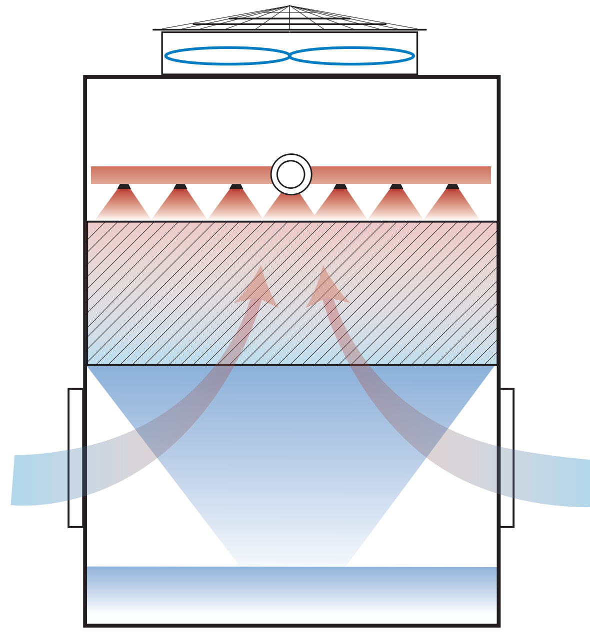

Figure 11 Counterflow water distribution over fill at full flow

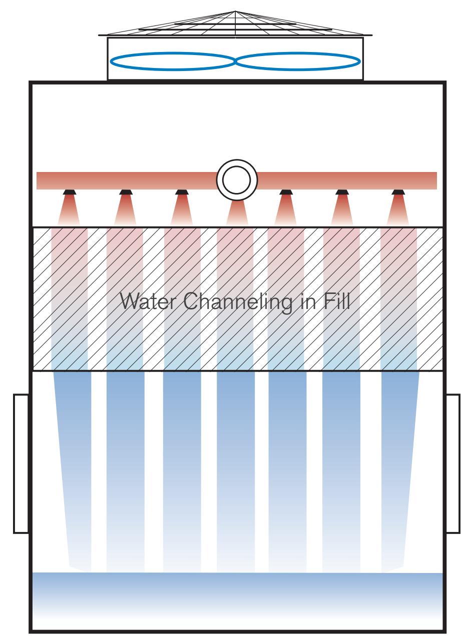

Figure 12 Counterflow water distribution over fill at low flow is channeling which can lead to scale and ice development and unpredictable performance

Summary

In conclusion, crossflow and counterflow are classifications of cooling tower—specifically the method in which the air contacts the water for heat transfer. Both crossflow and counterflow towers have their advantages and the application alone should dictate which type of tower should be used. Crossflow towers will serve better for maintenance access, variable flow, and cold weather operation. Counterflow towers may serve better in tight spaces under 750 tons, or in spaces where lower operating weight is required.

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