The case for crossflow

Cooling towers had a lot of bad press some years ago and no wonder with all the outbreaks of legionnaires' disease. There have been all sorts of arguments and theories about the reasons for these outbreaks and as a result new regulations have been brought to bear and new water treatment systems have come onto the market to improve cooling tower water quality. *Steve Teleki reports..**

Sure, all these recent fixes have made a difference, but they are all add-on solutions, i.e. accessories to the cooling tower, rather than any major changes to the cooling tower itself.

History

Let's go back in time to pinpoint exactly when it was cooling towers lost public favour.

How many legionnaires' disease outbreaks in Victoria were attributable to crossflow towers in the last 15 years? Statistical data on this subject is not available, however, my limited observation of reported outbreaks indicate that very few were caused by crossflow towers. The main offenders appear to be counterflow towers. There are also different types of counterflow towers; induced draft, forced draft, etc, and some types may be safer than others. However, the induced draft type has had the greatest proliferation in recent years.

Crossflow cooling tower

It is important to note that I am referring to legionnaires' disease, not Legionella detected in cooling tower basins. There is a difference between detection within a tower and the microorganism escaping from the tower. If it can't escape, then its presence is harmless.

Operational influences and market forces have caused cooling tower design to evolve and this paper compares the two different configurations, both of which utilise modern, PVC, film fill.

Principles of operation

The basic difference between crossflow and counterflow is the contact angle of the air and water mixture at the point of primary heat exchange, the fill surface.

Crossflow cooling towers have a 90˚C contact angle of air and water mixture. Air is drawn horizontally across a fill pack while water flows down vertically from the top.

Counterflow cooling towers have a 180˚C contact angle of air and water mixture. Air moves up vertically through the fill pack while water flows down vertically in the opposite direction.

Counterflow design

Induced draft counterflow towers have gained immense popularity since the early 1990s in the race for lower pricing as their design and construction is generally lower in cost to crossflows. New tower installations became dominated by counterflow and many older style, crossflow tower configurations were converted to counterflow when replaced. This trend still continues today.

The counterflow's smaller plan area is favoured by consulting engineers and architects as it saves on valuable building space. However, the race to provide a lower priced product in a smaller package may have come at a cost to the community with the increase in the incidences of legionnaires' disease, peaking around the late 1990s, early 2000s. New regulations have since reduced this incidence.

Along with the induced draft counterflow tower revolution came higher pressure sprays. These, by nature, create aerosols via more efficient atomisation of the inlet water; higher internal air velocities; are more efficient at dragging smaller water droplets off the fill, off the sprays and through the eliminators; water distribution systems that are directly in the air stream; nozzles located closer to the eliminators due to a more compact design; crossfluted fill sheets which have many intersections that can retain more dirt and bacteria in the fill pack and let's not forget another area of drift creation, the splash or rain zone under the fill.

Windage

The rain zone is where the water falls out of the fill, which is suspended above the water line and then splashes into the basin below. This splashing creates aerosols which can be blown out through the louvres and carried away by prevailing winds in outdoor towers. This kind of drift is known as windage. It is interesting to note that counterflow towers are not required to have drift eliminators fitted at this location. Recent improvements by some manufacturers have seen double thickness louvre grilles fitted, however most are thin grilles or open-type louvres.

Tower Thermal applications engineer Steve Teleki

Water consumption

Water consumption is a topical issue at the moment and windage can add to the overall water lost from a counterflow tower. Look for a wet area around the tower. The larger the tower, the worse the condition can be, especially on large industrial 'louvreless' designs.

Noise

Another undesirable by-product of the rain zone is additional ground-based noise (waterfall effect). On large industrial counterflow towers, this high frequency nuisance noise can be heard over the fan noise at close proximity and continues when the fan cycles off, thereby diminishing noise savings via use of VSD's.

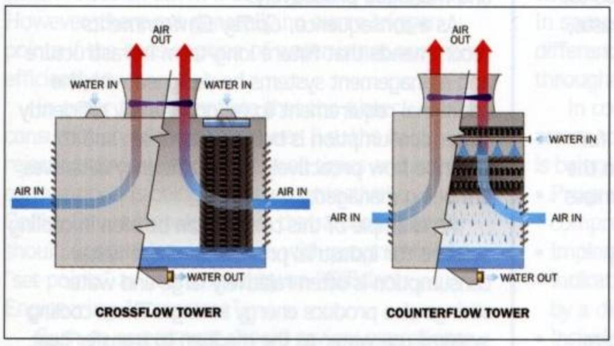
Power consumption

Generally, packaged cooling towers used for HVAC applications are about equal in fan power requirements regardless of the configuration. However, there can be a difference when it comes to pump head as the counterflow tower requires pressure to operate its nozzles, therefore consuming pump power to achieve this.

When it comes to large industrial cooling towers, the gap widens as the trend in crossflow towers is for lower, wider towers with large fans. Generally, a modern, crossflow tower of latest design will have lower fan power and lower pump power due to lower static lift and lower dynamic inlet pressures.

Operation and maintenance

The counterflow design raises issues with difficulty of access to some major components. Blocked nozzles can't be serviced without shutting down the tower or cell. This is a particularly big problem with large industrial towers which can suffer from pipe scale blockages and blown out nozzle diffuser plates. This reduces performance and plant production and leads to a premature plant shutdown while the tower nozzles are cleaned. Cleaning requires confined space access and crawling on the top of the fill, potentially damaging it without placement of protective boards.



Towers Crossflow & Counterflow

It is arguable whether multi-layered, crossflute structured counterflow fill can be properly cleaned without removal. Even so, it is certainly fully encased in the tower, making access rather difficult and cumbersome. Similarly for the drift eliminators.

Crossflow design

By comparison, a properly designed, modern crossflow tower with PVC film fill does not share these similar traits. Water is distributed via covered, hot water basins with gravity flow nozzles where water is broken up, but not sprayed. Air velocities across the fill are generally lower and have less effect on the water because the water distribution system is not in the air stream. Other features of the crossflow tower are nozzles are further away from the eliminators; fill sheets are in a parallel path with a continuous vertical void space; minimal snag points for dirt build-up; fill extends all the way into the water line so there is a gentle transition of water into the basin; no violent splashing or water noise; and air plenums are wide – governed normally by the fan diameter and requiring drift droplets to travel further to escape the tower.

Nozzles can be accessed and cleaned by lifting the hot water basin covers so that stopping the tower is not necessary. No confined space access is required.

Fill can be cleaned in-situ as the front and rear of the pack is openly accessible without removal. This is made easier with a vertical void space fill that can be accessed or spray cleaned between sheets.

Modern crossflows are fitted with internal walkways allowing walk-in entry and easy access to drift eliminators.

Drift

AS 3666 specifies a maximum drift rate of 0.002 per cent of flowrate. This is a volumetric measurement, but it is not specific to droplet size, so it can be deceiving. Smaller droplets pose a greater threat than larger droplets as they can travel further in the atmosphere and can be inhaled easier. So two cooling towers, both offering less than 0.002 per cent drift rate, may appear of equal specification, but be very different in the creation of droplet size and numbers and hence the level of risk to the community.

Well-designed large, industrial class counterflow towers have working air plenums (the gap between the eliminators and the fan deck) which are typically around 2m in height. Smaller, packaged, HVAC counterflows have virtually no air plenum. A cost-saving no doubt, but at the expense of air distribution resulting in increased "coring" potential at the eliminators – where air velocity is higher in the centre than at the perimeter of the eliminators. While "coring" may not affect the overall drift rate of a tower, it may have a greater influence on the smaller micronage droplets in the areas of higher air velocity by entraining more of this size in the discharge air.

Conclusion

Crossflow towers may be a safer and more environmentally friendly alternative, although more studies still need to be done to prove this theory.

Like it or not, Legionella has always lived in cooling towers at some time or another, but these days we may be doing a better job of expelling it rather than confining it to just the tower. There are certainly many other contributing factors that lead to incidences of legionnaires' disease and this paper is an attempt to explore just one of the many possible scenarios.

With the recent addition of new environmental considerations of water, power and noise, cooling tower designers may need to smarten up their act or market pressure will prevail upon new evidence and cooling tower design will be forced to evolve yet again.

The comments provided herein are theories and opinions of the author and may vary to actual, individual situations.

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