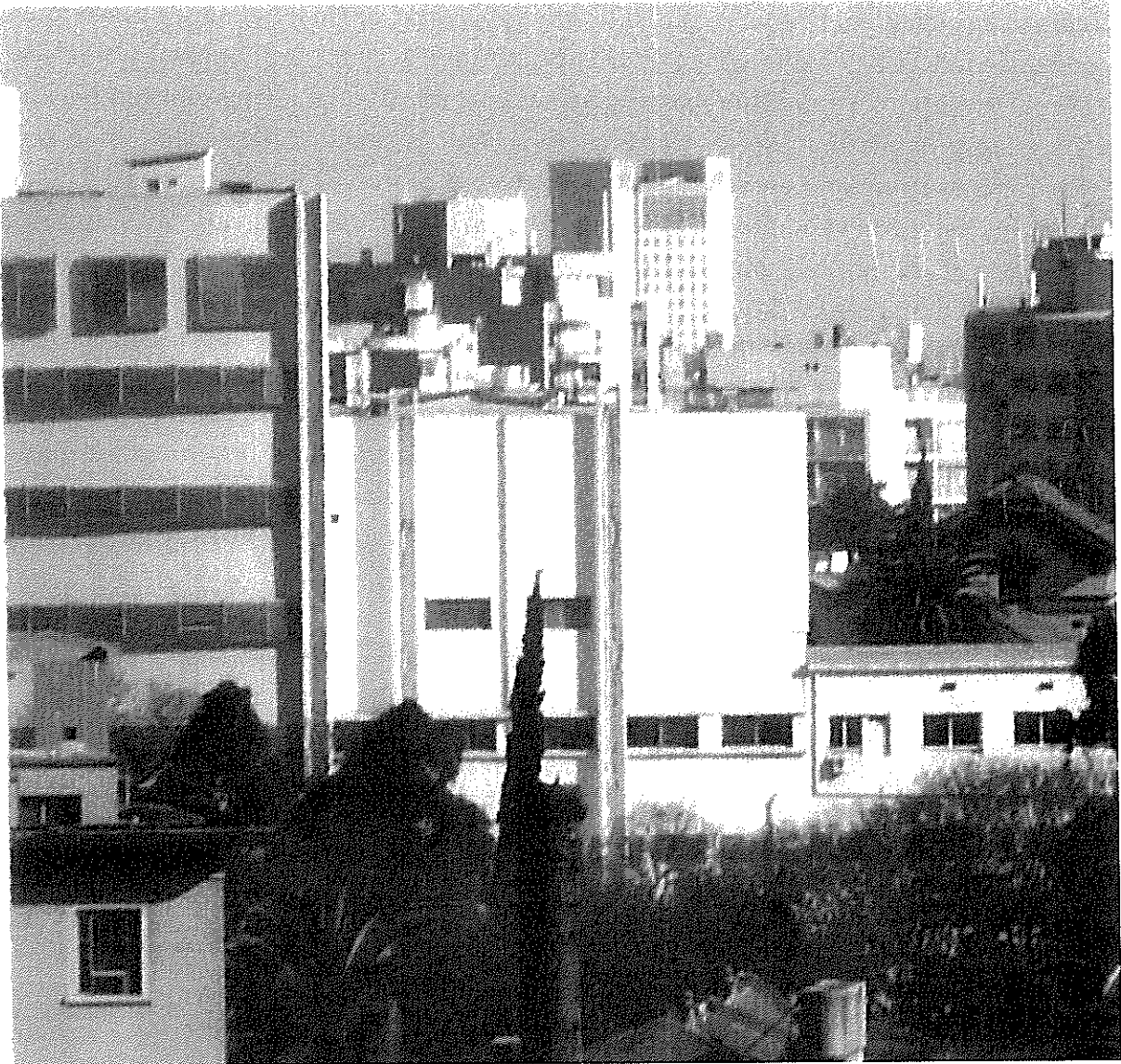


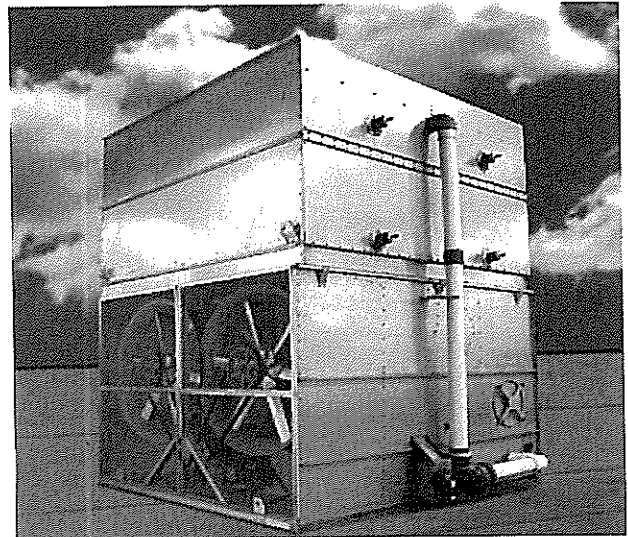
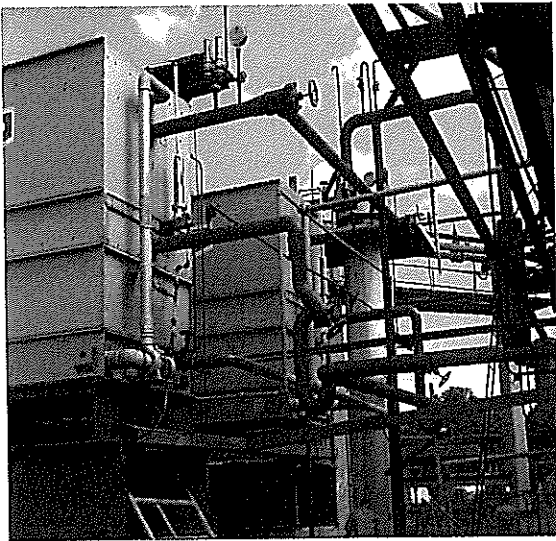
CTI Compañía Técnico Industrial S.A. Montevideo



Introduction

Evaporative condensers basically consist of some *enclosure* or shell housing a given amount of galvanized steel or copper coil. Water is doused all over the coil banks by nozzles. A fraction of the liquid evaporates removing *latent heat* released by refrigerant condensation. The remaining liquid flow keeps trickling down and is finally collected in some sort of bottom basin or sump and recirculated back to the top of the coil banks for another round. In properly designed evaporative condensers, the small fraction that evaporates during this brief passage is enough to achieve condensation targets. There is also a small sensible heat loss due to the temperature difference between incoming hot gas and air.

Evaporative condensers can be further classified as either *induced* or *forced draft* units. Induced draft units induce a negative pressure or vacuum right below the fan and pull in air from frequently louvered window sides. In forced draft units one or more fans are located at the air inlet as determined and essentially blow through required airflow. Forced draft condensers are usually made available with centrifugal as well as axial fan model configurations.



Induced draft designs insure an even, smooth air distribution over the unit's cross-section and if properly designed, e.g. larger diameter fans, can significantly lower required fan HP for a given thermal context. Forced-draft units risk significant thermal de-rating due to recirculation.

An incorrect wet bulb selection results in an extremely, non-linear underperformance of the unit. An EC selected to dissipate a certain amount of heat in an area with a wet bulb temperature of say 75 ° F, will thermally collapse in locations with significantly higher prevailing wet bulb, 78-80 ° F.

The selection of the heat transfer coefficient U must take into account the "de-rating" caused by unfavorable conditions in the field. The consequences of ignoring this item, unintentionally or maliciously, will gravely short-change the trusting end user.

Materials of Construction

Most common EC enclosure is hot-dip galvanized steel. Tube material can be galvanized steel or copper or other material depending on the application/refrigerant. Most common water distribution materials include plastic pipe and nozzles. PVC drift eliminators are frequently the standard.

Cooling towers

Basically consist of some *enclosure* or shell housing a given height of some suitable packing or fill media. Hot water is doused on top of this *packing* either by pressurized *nozzles* or gravity systems such as open troughs or trays. As a fraction evaporates, thus removing *latent heat*, the remaining flow trickles through the media and is finally collected in some sort of bottom basin or sump. In properly designed cooling towers, the small fraction that evaporates during this brief passage is enough to cool down the remanent flow to target temperature. There is also a small sensible heat loss due to the temperature difference between incoming hot water and air.

The interacting air stream can be arranged to meet said trickling liquid in either *counterflow*(countercurrent) or *crossflow* or sidewise fashion.

Mechanical-draft cooling towers can be further classified as either *induced* or *forced draft* units. Induced draft units induce a negative pressure or vacuum right below the fan and pull in air from frequently louvered window sides. In forced draft units one or more fans are located at the air inlet as determined and essentially blow through required airflow.

Induced draft designs insure an even, smooth air distribution over the tower's cross-section and if properly designed, e.g. larger diameter fans, can significantly lower required fan HP for a given thermal context. Forced-draft units risk significant thermal de-rating due to recirculation. In order to avoid this, some unfortunate forced-draft designs operate at the upper "thru fill" velocities, say 675 - 700 fpm only to find themselves requiring *twice* or *thrice* fan HP to load duty comparable, more engineered induced draft units specifically designed to operate at much lower "thru fill" velocity and selecting larger fan diameters.

In order to avoid this, some unfortunate forced-draft designs operate at the upper "thru tube" velocities, say 675 - 700 fpm only to find themselves requiring *twice* or *thrice* fan HP to load duty comparable, more engineered induced draft units specifically designed to operate at much lower "thru tube" velocity and selecting larger fan diameters. Centrifugal fan units characteristically require twice as much power as the same thermal capacity axial fan models.

Fundamentals

Evaporative condenser basic design and performance can be numerically examined using Newton's equation.

$$Q = U * A * \text{LMTD}$$

where

Q = heat reject, btu/hr

U = transfer coefficient

A = surface area, e.g. st.ft.

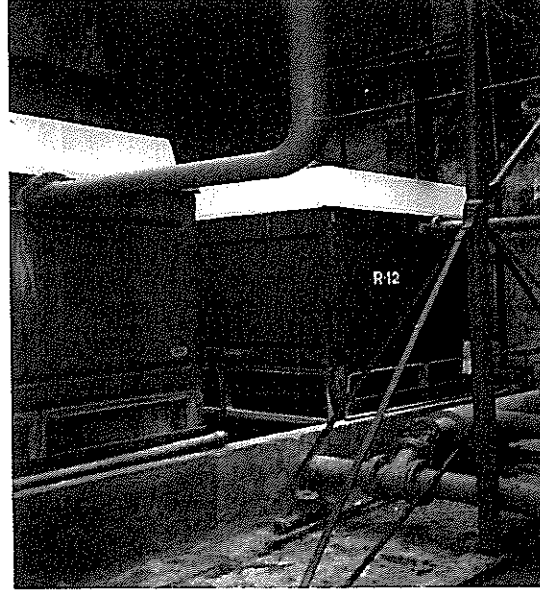
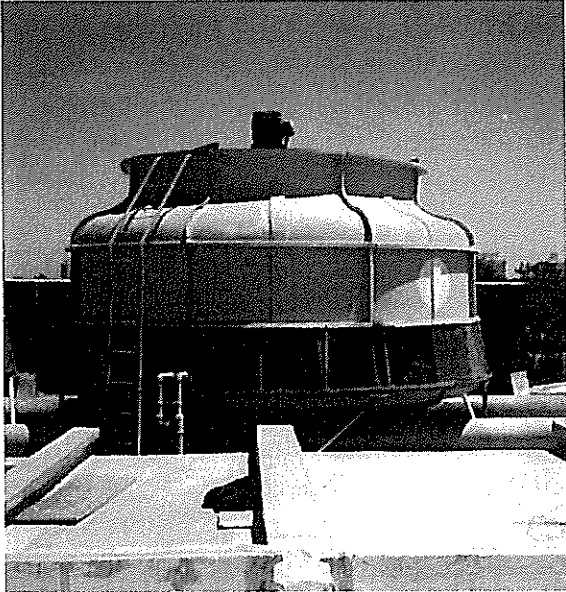
LMTD = mean logarithmic temperature

In our experience, this formula has proved successful enough in terms of interpretation of unit specifications, as supplied by each particular manufacturer. Unfortunately, not all industrial equipment suppliers choose to openly publish their specifications and actual performance data. Vendor catalogs and many engineering proposals often contain "inaccuracies" only to be noticed once the under-performing equipment becomes operative. While the model represents a significant simplification (basically assumes an air behavior following the saturation line, starting from a specific wet-bulb temperature and condensing temperature) it closely matches most available trade literature.

Standard evaporative condensers, unlike cooling towers, are almost always selected/ designed/ built with liquid-to-gas (L/G) ratios typically hovering 1.1 - 1.2, which obviously considerably limits its optimization. Any cooling tower designer can work with ratios L / G ranging between 0.6 and 2.2, which greatly allows job optimization and size to meet or accommodate a variety of criteria, e.g. lower fan HP, lower required area, direct drive fan restrictions. Selection by way of catalog further handicaps the final decision.

Blurred bid specifications only go against the future equipment owner. Calculation formulas and algorithms cannot be technically more honest than what participants are bent to install in reality no matter what.

Cooling towers can be constructed in groups of cells. Each independent partition or cell may have one or more fans and one or more distribution system. Cells can be shut down if cooling water demand drops or cycled as needed, say for individual maintenance.



Cooling towers

Fundamentals

Cooling Tower Film Media

Numberless structured packing variants have been used since the inception of tower-like, evaporative cooling constructs. Early arrangements included planks, boards, and bricks. At the risk of historical inaccuracy perhaps one can point to the 1936 ACB construct, basically assemblies of side-by-side, corrugated asbestos cement board (thus the name) plates, as breaking grounds as regards performance and somehow anticipating later field developments.

The '50s' and the '60s' saw probably the greater strides namely Carl Munters 1957 patent combining corrugated and flat plates, Kohl and Fuller's 1963 vertically corrugated pack patent and ultimately Bredberg's 1966 cross-fluted design patent which brought [successful] closure as it were to low-profile, highly efficient packing endeavors.

Cross-flute packing, noted for high efficiency and moderate pressure loss, has been used extensively. Illustrative media include Munters' CF-12060 and CF-19060, Brentwood's CF-1200 and CF-1900, and Marley's MC-67.

Offset-flute packing, developed much later splits and reunites gas and liquid streams along the vertical fill section profile. Typical media include Hamon's ANCS and Balcke-Durrs' FB-20.

Vertical-flute packing, also referred at times as vertical flow packing and a far more recent design, proffers the largest flute openings available for structured packing today. By permitting higher liquid trickle down rates vertical flute packing helps maintain the packing walls and paths cleaner of foreign, undesirable material such as biofilms or debris.

The beauty of cross-flute structured packing is its ability to inherently achieve, impart or impose a high degree of auto or self- liquid phase distribution even though the latter role is frequently played by/assigned to specialty trays, pressurized nozzles or open, gravity flow distributor channels or basins.

Structured packing is today widely available from a number of manufacturers. Typically the packing consists of assemblies or packs of individual corrugated, flat, or both type sheets bound together in some form, e.g. glued together. Plastic and metal are probably the most popular materials of construction employed.

Vendor catalogs frequently indicate *surface area*, (sq.ft./cu.ft.) and *void space*. In practice, the actual or effective surface area can be augmented by an aggregate of sprays, bubbling, dripping, droplet splash, among others. Effective or actual surface area can be as well diminished by fouling/plugging/blocking, and unused or idle sections.

Cooling Tower Splash Media

Typical splash type media include splash bars of various makes most frequently spaced in staggered arrangements held in place by grid hangers. Splash media is available in PVC, polypropylene, treated wood, aluminum and even stainless steel. Splash type media, whether in counterflow or crossflow configurations, is not conducive to fouling.

Transfer Rates

It is generally understood that greater surface areas promote greater transfer rates. However this will happen as long as whatever contemplated greater surface area is actually put to use, thus the actual or effective surface area nuance (versus geometric or catalog surface area). It is wise to scrutinize active to plain geometric surface area ratios.

It must be noted that all too dense, small flute media while proffering highest surface area per cu.ft. may incur so high pressure drops so as to render the media inapplicable. It may also give rise to exacerbated plugging.

Pressure Drop

Whatever the liquid gas stream arrangement - counterflow, crossflow, cocurrent - packing introduces a level of resistance to the passage of the fluid and pressure drops through the packing media should be appropriately accounted for. In general one would treasure packing proffering lowest pressure drops naturally assuming full performance can be delivered all other things considered equal.

In many applications, liquid side pressure drops can be overlooked as it's just some liquid, frequently water, trickling down/gravity flow.

Fouling

Fouling refers to the undue accumulation and plugging of the media. Not only will performance noticeably suffer but there can be structural problems, even media/bed collapse as well. Fouled packing can weight far more than first day, original media.

Gas and Liquid Distribution

Probably most if not all structured packing applications require uniform gas and liquid distribution within the unit. To a certain extent this can translate into a make it or break it situation. Aside from things like faulty liquid distributors or flow design, media related culprits may include instances of fouling and channeling/by-pass. Uneven "rain" zones, thermal gradients, dry spots, media holes all add up to under performing packing.

Wetting

As with most packings, structured media achieves optimum utilization when most if not all exposed surface area is thoroughly wetted. So-called wetting point is defined as the recommended or required minimum liquid loading so as to insure complete media surface "coating" thus permitting design mass transfer rates. Packings with lower wetting points would configure the more desirable designs.

Flooding

During operation most all packings hold up some given amount of the circulating liquid. When gas or air stream velocity is unduly high, liquid will not be able to trickle or flow through the packing bed at all, a situation called *flooding point*. It should be apparent that for certain applications one will want this value to be as high as possible - we would then able to move larger gas phase volumes through smaller face areas. It should be noted that pressure drops increase as operation, willingly or unwillingly, approaches flooding conditions.

Liquid Distribution

The even distribution over the fill packing is essential. This is usually achieved by means of a network of pipes, open troughs or trays. The various makes may include pressurized spray nozzles, overlapping spill designs or orifices punched on trays

Air Section

Most fans used in cooling tower applications are equipped with manually adjustable pitch blades. This permits to use basically the same fan over a range of horsepower requirements. Most common materials of construction include quality aluminum and fiberglass-reinforced plastic. .

Links:

Evaporative Cooling

www.CoolingTowerFundamentals.com

www.EvaporativeCondensers.com

www.StructuredPackings.com

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