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INDUSTRIAL COOLING TOWERS AND PRESSURE TREATED WOOD

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This paper discusses the use of pressure treated lumber in the industrial cooling tower industry, its' origins, evolution and some of the challenges and issues we face today.

What is a cooling tower? A cooling tower is a mechanical device which, through the process of evaporation, extracts waste heat from a hot water stream and rejects it to the atmosphere.

All processes; thermal power plants, refineries, petrochemical plants, pulp mills and even commercial buildings require cooling systems to extract the low grade, unusable waste heat that's generated and ultimately transfer it to the atmosphere.

Cooling systems of significance fall into four general categories:

A. Once through cooling systems. Cool water from a river, lake, or even the ocean, is circulated to remove process heat and is then discharged back to that body of water. Clearly due to thermal pollution, this is not very environmental friendly. However, these systems are still widely used today by operating plants which were permitted decades ago.

B. Re-circulating systems using basin cooling and/or spray ponds. This basically involves man-made ponds/lakes to be used for surface cooling. If it's not big enough, spray systems are added to enhance the cooling rate. These require very large areas, and like once through systems disturb local ecosystems.

C. Re-circulating system using dry heat exchangers. These are closed systems very similar to the radiator in your car. Air is directed across metal finned tubes to cool the water circulating inside the tube bundles. For a power plant or refinery, these become very large, expensive radiators so they are only used where water conservation is paramount. Aside from that they are made of steel, not wood, so there really not very interesting to us here today!

That brings us back to our subject:

D. Re-circulating systems using evaporative cooling towers. This device rejects heat by mixing outdoor air with the heated cooling water; by evaporating a small portion of the water, the heat is transferred to the air steam. Warm, moist air is in turn discharged to the atmosphere and the cooled water is recycled back to the plant. Evaporation systems are much more efficient than dry because they can produce significantly lower operating temperatures. For example on a hot, dusty, 100°F day, the magic of evaporation can still

produce 80-85°F cooling water temperatures, whereas dry systems wouldn't get lower than 105°F.

Cooling towers first came into use in the early 1900's. However, it wasn't until the 1940/50's that their use became more prevalent and the functional form was really established. Since then there has been many advances in the science, materials and components, however the basic design concept is not much different than 50/60 years ago.

A cooling tower is comprised of these basic components:

1. Air movement system - fans, motors, gearboxes, stacks.
2. Water distribution systems
3. Fill media to mix the air and water streams
4. Drift eliminators to remove "mist" from the exit air.
5. Structure - to hold everything in place.

There is a large variety of applications for cooling towers, and the sizes and configurations range from small air conditioning towers handling water flow rates as low as 25 gallons per minute, up to large concrete cooling towers used in some nuclear power plants which cool waterflows in the millions of gallons per minute.

The hyperbolic cooling towers you see on the left, have the same basic components we discussed, however, the air movement system is the draft created by the large chimney rather than large diameter fans.

However, by far, the workhorses of the industry for the past 70 years, has been the wood framed crossflow and counterflow cooling towers. The cross and counter designations simply refer to air flow direction in relation to the waterflow direction.

To give you an idea of scale, the construction photos attached with this paper show a crossflow under construction, and a counterflow under construction. Both these towers are about twice the length of a football field and about half as wide.

As previously mentioned, these designs emerged in the mid-1900's.

At that time, untreated redwood was the predominant, if not exclusive, material used to manufacture evaporative cooling towers.

As redwood became more expensive and difficult to get due to pressures on logging the old growth forests, pressure treated Douglas fir began to gain acceptance in the industry –

- less cost

- more readily available
- rot was showing up in older untreated redwood cooling towers – overtime the natural protective resins had leached out. As a result pressure treating of redwood had been deemed necessary.

The most common preservative treatment for these wood towers is Chromated copper arsenate (CCA). Acid Copper Chromate (ACC) has also been used especially if arsenic is an issue.

The Cooling Tower Institute was formed in the late 1950's by representatives of manufacturers and end users. Its mandate was to document North American Standards for cooling tower design and manufacture. For pressure treated wood the applicable standards include:

CTI STD 112 Pressure Preservative Treatment of Lumber for Industrial Water Cooling Towers

CTI STD 103 For the Design of Cooling Towers with Pressure Treated Redwood Lumber

CTI STD 114 For the Design of Cooling Towers with Pressure Treated Douglas Fir Lumber

CTI STD 134 Plywood for Use in Cooling Towers

The standards require that all lumber to be pressure treated after fabrication. The manufactured components are then shipped to the job site for assembly like a big Mecca no set.

in the 1940's through 60's almost all components except the fans, gearboxes and motors, were manufactured from CCA or ACC pressure treated Douglas fir or redwood.

- wood fan stacks
- wood stave distribution pipe/systems
- fill - wood slats on racks
- drift eliminators - wood slats
- exterior enclosure - wood batten panels
- fan/water decks - tongue and groove 2' x 6' or plywood
- structure - 4 x 4, 4 x 6, 2 x 4, 2 x 6

Over the next few decades many tower components began to be replaced by plastics – the driving forces being efficiency, less cost and/or less labor to install.

Fan stacks: wood to fiberglass

Pipes: wood to FRP/steel

Fill: wood slats to PVC plastic

Drift eliminators: wood slats to PVC plastic

Exterior enclosure: wood battens to corrugated FRP

However, up until just 10 years ago, pressure treated fir or redwood was still the preferred material for the cooling tower structure, and for good reason.

- excellent durability
- readily available
- relatively low cost
- easily to work with
- 25 year service life – extendable to 40 or 50 years with maintenance

Pultruded fiberglass however was getting serious consideration as a viable alternative. Pultruded shapes, similar to structural steel shapes, could be substituted directly with wood counterparts – 3 ½” square tubes replace 4 x 4’s, 4” channels replaced 2 x 4’s, and so on. Existing cooling tower designs could be readily adapted to fiberglass structure.

However, most cooling tower purchasers were still unwilling to pay the premium for the “unproven” FRP framed cooling tower.

The FRP pultruded shapes are 3 to 5 times the cost of pressure treated fir or redwood. The premium on the fully assembled cooling tower is 15-25%. And with the 25-40 year service life provided by most wood towers, there was no real impetus to pay that premium.

A real game changer for wood structure cooling towers happened early in the new millennium and there were a number of catalysts.

1. CCA and ACC pressure treatment was banned from residential or commercial use in 2003. Although still allowed for industrial applications, public perception and misinformation regarding arsenic and hexavalent chromium have an impact on the permitting process and the willingness of cooling tower purchasers to consider pressure treated wood cooling towers.

2. ACQ - Copper quaternary treatments currently used for residential and commercial applications have not been generally accepted in the cooling tower industry due to concerns about the effectiveness, leaching and potential corrosion problems in cooling water systems.
3. Fire protection: Most wood framed cooling towers are required by insurance companies to have sprinkler systems
 - Additives can be added to fibreglass resins for fire resistance producing flame spread ratings of <25. In some cases, this can eliminate the fire protection system which reduces the overall cost premium for fiberglass towers.
4. In a world of material development using nanotechnology and composite, wood is often perceived as “low tech”. It’s a bad rap.
5. There were a few high profile collapses of wood frames towers in the early 2000’s – the root cause was poor to no maintenance of 35 year old towers and, in many cases, a design flaw.

The end result of these issues is that over the last decade, pultruded FRP has taken over as the dominant material for constructing new cooling towers.

So, where are we at today?

Well, the good news is that there are thousands of wood cooling towers still in service across North America with many very satisfied users. Many of these cooling towers have been in service for 20, 30, 40 years and, with routine maintenance, will continue to provide reliable operation for years to come. Wood continues to be used for repair/replacement and still retains some market share in the new cooling tower market.

There are still many believers in pressure treated wood cooling towers. The original benefits discussed earlier of durability, reliability, economics and so on are still valid, with the added catchwords of today being

- renewable resource
- zero carbon footprint

As well the rising cost of FRP may also eventually swing the pendulum back to wood’s favour.

At present, however for new cooling tower construction fibreglass pultrusion framed towers have the momentum in North America. The FRP advocates are quite vocal and it is a very good material for cooling towers, but then so is wood. There’s few, if any, actively promoting the merits or 70 year history of successful applications of pressure treated industrial cooling towers – it’s a story that should be told.