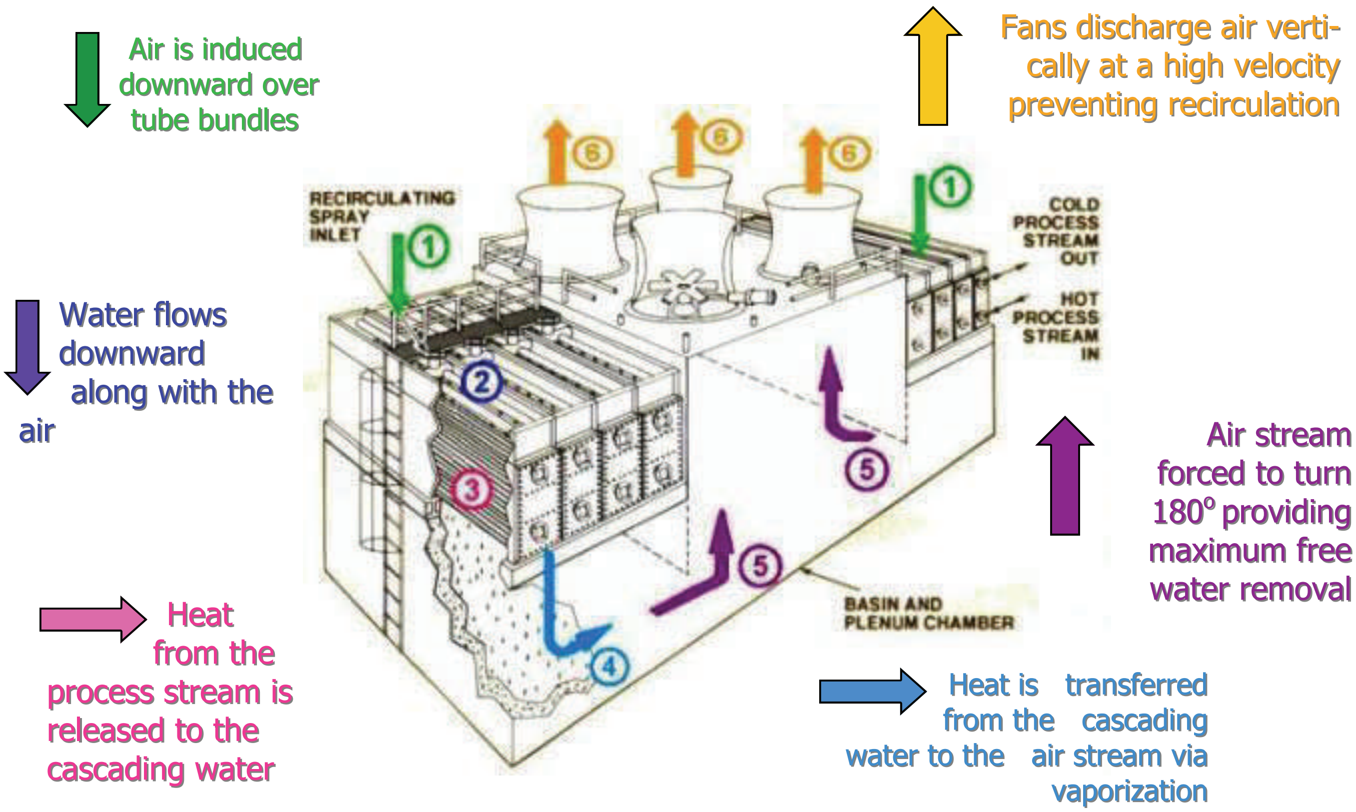
WATER CONSERVATION WITH CLOSED-LOOP, EVAPORATIVE COOLING FOR PROCESS, POWER APPLICATIONS

Water availability, restrictions and quality are increasingly important considerations in facility design and operation. Closed-loop, evaporative cooling is a cost-effective heat transfer technology that also optimizes scarce water resources.



Coolers, such as the Wet Surface Air Cooler (WSAC), are used in a variety of process, petrochemical and industrial facilities for fluid and gas cooling (water, water/glycol, oil, fuels, food ingredients) and vapor condensing (vacuum steam, hydrocarbons, refrigerants).

Principle of Operation

The basic operating principle of an evaporative cooler is heat is rejected by means of latent (evaporative) heat transfer. The fluid/vapor that needs to be cooled or condensed flows through tube bundles as part of a closed-loop system. A large quantity of water is pumped from the unit basin and sprayed downward over the tubes. Simultaneously, fans induce air over the bundles in a co-current direction. Evaporative cooling takes place at the exterior tube surface. The saturated air stream makes two 90° turns within the unit plenum and is discharged out through the fan stacks (see *Figure 1*). The co-current flow of air and water allows for an unobstructed spray system fully accessible for observation and maintenance, and protects the tubes from freezing. Co-current flow also ensures complete coverage of tube surfaces, sharply reducing fouling potential.

Alternative Technologies

There are two other cooling system configurations:

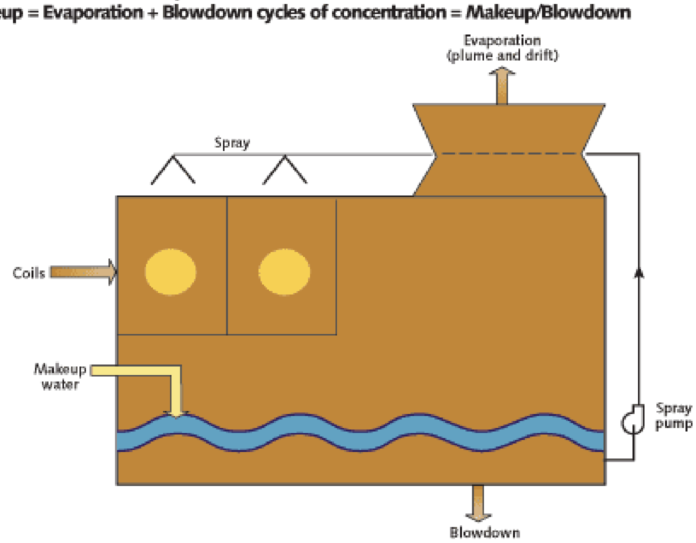
Open cooling tower/heat exchanger - where the process stream is cooled in a heat exchanger using tower water;

Dry, air-cooled systems - where the process stream is cooled inside a finned coil with air being passed over it.

In many applications, the evaporative cooler has distinct advantages as compared to these systems:

- Utilizes latent cooling (with an approach to wet bulb), which is far more efficient than sensible (dry) cooling (with an approach to dry bulb, which is higher).
- Smaller footprint than all dry systems.
- Provides the lowest process fluid outlet temperatures (within 5-10°F of wet bulb).
- Can be operated at higher concentration cycles (see Figure 2).
- Makeup water can come from almost any source (tower or boiler blowdown, RO and demineralizer effluent, neutralized plant discharge, produced water, wastewater treatment plant effluent, etc).
- Lower parasitic energy use (about 60% less than a dry cooler).

Figure 2. Water Issues: Evaporation (GPM) = Heat Load (BTU/hr) 500,000
Makeup = Evaporation + Blowdown cycles of concentration = Makeup/Blowdown

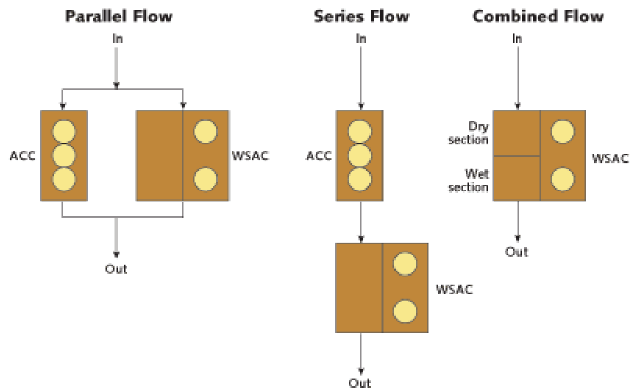


The WSAC system requires little maintenance. The spray system is accessible for inspection and maintenance without shutting down the unit or removing any obstructions such as tower fill.

General Specifications:

Tube bundles can be designed as straight-through cleanable or serpentine, and per ASME and TEMA standards. Tube material options include black or galvanized carbon steel, all types of stainless steel, admiralty brass, copper, titanium and others. Material choice is based on composition and pressure of the process stream (inside), and quality of the spray water (outside). Tube material, diameter, wall thickness, length, rows deep, tubes wide, etc., can be optimized to provide the most cost-effective sizing for any application.

Figure 3. Wet/Dry System Options For Water Limited Plants



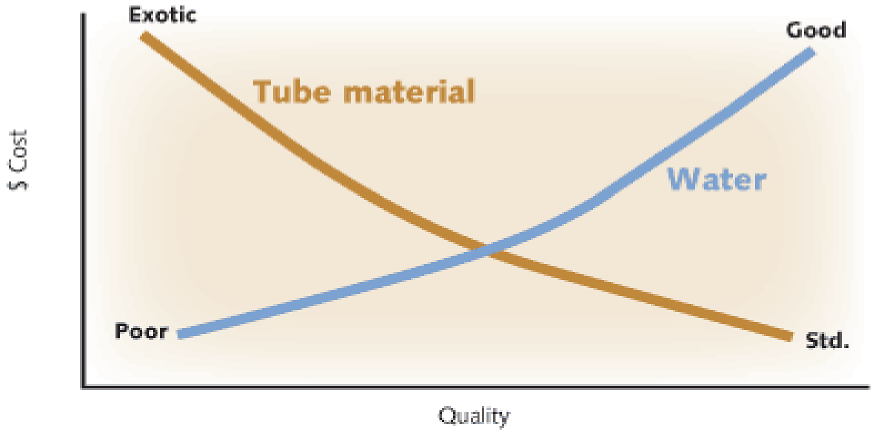
Metal basins are generally most economical for smaller (modular) units. They're generally constructed of prime carbon steel that's hot dipped galvanized after fabrication (H.D.G.A.F). Other material selections, including stainless steel, are available. In many areas, it's less expensive to use poured concrete for the basin and plenum, which is typical with larger (field-erected) unit sizes. Another alternative structure material is fiberglass reinforced plastic (FRP). In this scenario, about a 3 ft. high concrete "swimming pool" basin is poured to contain the spray water and support the structure, with the FRP used for the fan plenum and deck. FRP is much lighter, corrosion resistant and, in some instances, less expensive than concrete.

Water Issues

One of the most important features of evaporative coolers is their ability to use lower quality water as makeup (as described above). This is water that couldn't be used in cooling tower/heat exchanger systems due to high levels of suspended solids, or other contaminants. Using secondary source water reduces the plant's total amount of freshwater needed for cooling.

Evaporative coolers can be used as "first stage concentrators" in zero discharge plants. By being able to operate with higher cycles of concentration, the quantity of discharge water is reduced. This will reduce the installed and operating cost of downstream water treatment systems.

Figure 4. Cost Analysis Water Quality And Tube Material



Evaporative coolers are also used for adding capacity in "thermally challenged" plants. This allows for additional direct cooling without having to add tower capacity or buy additional makeup water.

Water Conservation

With water supply restrictions and the price of clean water increasing, many believe that a dry, air-cooled unit is the only option. This, however, may not be the case.

For water-limited applications, when not enough water is available for cooling the entire load, a hybrid unit incorporating a dry and wet section can be used (see *Figure 3*).

In addition to materials and water quality, there are many factors considered in the design optimization of evaporative systems including pressure drop, fouling factors, noise, footprint and horsepower. There are tradeoffs between tube material and water quality and treatment (see *Figure 4*). Consequently, a water treatment professional should be part of the design process.

Conclusion

Water (resource) issues will continue to have an increased impact on plant design and operation. Closed-loop, evaporative coolers can help maintain plant performance while utilizing water streams that are currently unusable with conventional towers and heat exchangers.

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