Parallel Condensing Technology

Water Conserving Solutions for Power Plant Condensing Systems

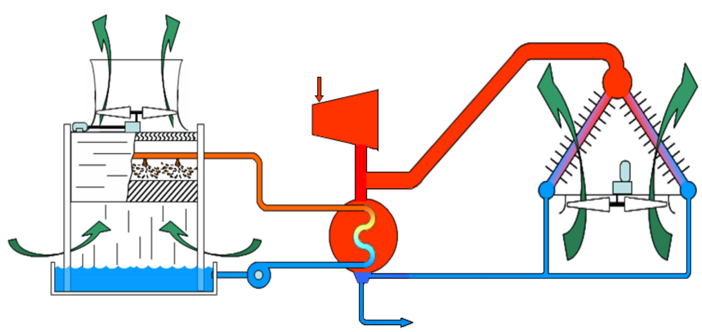
HOLTEC INTERNATIONAL

Introduction

For almost a century, wet evaporative cooling towers have been the predominant choice of heat rejection systems for power plants not situated on a large body of water. In 1939, the first air cooled condenser was placed into operation providing the power industry with a dry cooled solution. This was required for power plants located in arid areas or where sufficient quantities of make-up water were unavailable. From that point forward, if enough water was available, power plant developers installed wet cooled systems. Water availability at anything less than what was required for a 100% wet system, a 100% dry cooled system would be selected or another location for the power plant would be considered. The initial cost of a dry cooled system is 3 to 5 times greater than a wet cooled system. This, coupled with the fact that heat rejection performance during the summer months is reduced has maintained wet cooling as the preferred solution.

Conventional wisdom suggests that a power plant location requires access to a large body of water. If an adequate water source is missing, then the location would be abandoned unless the project's economic model could support a dry cooled option. Many good locations have been discarded simply due to minor shortfalls in water availability.

It wasn't until the early 1990's that consideration was given to combining wet and dry cooling technologies to provide an alternative water saving condensing solution for power plants. *Parallel condensing* represents a symbiosis (hybrid) of wet and dry cooling solutions. The hybrid configuration offers significant water savings over conventional wet cooling and substantial cost savings and performance benefits over 100% dry cooled systems.



Predominant Existing Solutions

Evaporative Wet Cooled Systems are generally comprised of: 1) a steam surface condenser, 2) a cooling tower (mechanical or natural draft), and 3) a circulating water system including make-up, blowdown, and water treatment sub-systems. This heat rejection solution is generally very efficient from a thermodynamic perspective since the performance of the evaporative cooling tower is primarily a function of the wet bulb temperature. Wet bulb temperatures are usually significantly lower than dry bulb temperatures. This provides the greatest temperature potential for rejecting waste heat to ambient air.

However, the issue of growing concern is water consumption. For every pound of turbine exhaust steam condensed, nearly the same mass of water is lost through evaporation alone. Couple this with the associated cooling tower blowdown and vast quantities of water are consumed. This is a consequence our society has grown accustomed to in order to feed our appetite for power. Now that water has become a scarcer resource, alternatives for reducing this consumption must be implemented.

Dry Cooled Systems are most commonly referred to as Air Cooled Condensers **(ACC)**. These systems are generally comprised of: 1) main steam ducting, 2) finned tube heat exchanger bundles on a supporting structure, and 3) an array of fans, motors and gears. This heat rejection process works by pumping large quantities of ambient air over finned tube heat exchangers. The steam turbine exhaust is condensed within the tubes. The thermodynamic disadvantage of this system is that it is based on sensible heat exchange on the ambient air side working against the dry bulb temperature instead of the wet bulb temperature. Because of this, dry cooled systems are always larger and more expensive than their wet cooled counterparts. However, there is absolutely no water consumption with this method.

An important aspect associated with dry cooling that is often overlooked is the fact that the dry bulb temperatures fluctuate considerably more than wet bulb temperatures. This occurs on a daily basis from day to night as well as seasonally. At lower ambient temperatures, the performance of a dry system will approach that of a wet system and the auxiliary loads often reduce to levels below that of conventional wet system. These are important factors to evaluate and leverage in developing a hybrid system presented in this bulletin.

The Challenge of Water Availability

The issue of water availability primarily affects new power plant development but can impact existing power plants as well. As local and regional governments are more protective of their diminishing water resources, obtaining a water permit for a new power plant has become a much more difficult process and adds valuable time to the development schedule.

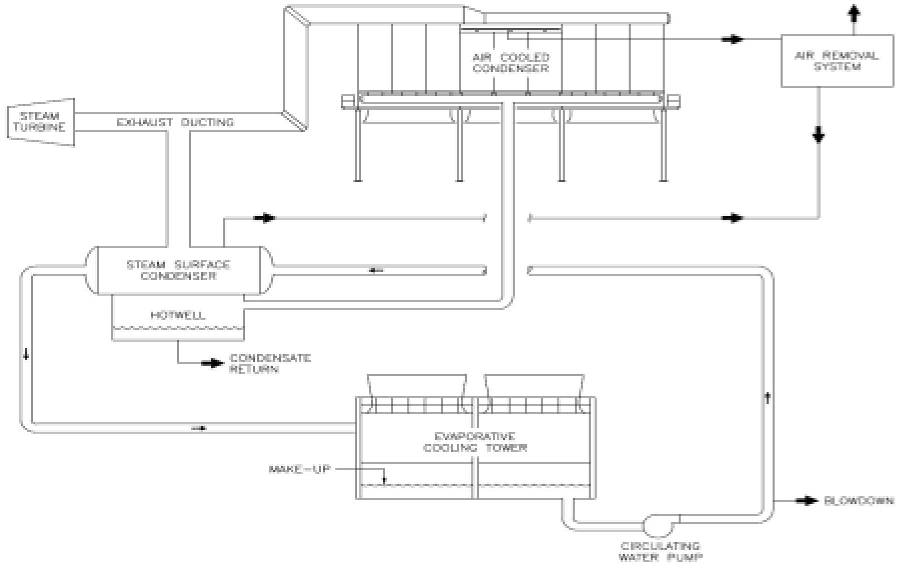
Evaporative wet cooled systems will consume essentially the same amount of water whether it is daytime, nighttime, summer or winter if the power plant is based loaded. However, the quantity of water available quite often varies and can cause shortages. These shortages must be overcome by either curtailing power generation or purchasing supplemental water. These are operational issues for existing power plants that can be relieved by *parallel condensing*. Operational concerns are not the only issues surrounding water consumption for existing power plants; administrative pressure from the local and state authorities on these plants to reduce their demand on water resources is playing a role as well.

Parallel Condensing

Parallel Condensing Systems were developed primarily for use in power plants where there is not enough water for a 100% wet cooled system. Essentially, it is based on a dry cooled system with supplemental capacity provided by a wet cooled system. Parallel condensers designed for 15 to 85% water savings over a conventional wet evaporative system have the following advantages:

1. Substantial water savings
2. Reduced overall cost as compared to a 100% dry cooling system
3. Improved performance as compared to a 100% dry cooling system
4. Reduction in the size of the plume from the Cooling Tower

The fundamental components that comprise a parallel condensing system are: 1) an ACC, 2) a steam surface condenser, 3) a cooling tower, and 4) a circulating water system with auxiliaries. The process flow diagram below illustrates the layout and arrangement of the fundamental components.



The turbine exhaust steam is conveyed through a large steam duct from the turbine exhaust to a steam surface condenser **(SSC)** **<u>and</u>** to the top of the air-cooled condenser **(ACC**). The exhaust steam is condensed simultaneously in both condensers at similar pressures. The quantity of steam condensed or the duty split between the SSC and ACC will be dependent upon the total heat rejection load, operator specified performance, available makeup water and the site's atmospheric conditions. For example, should the dry bulb temperature decrease at night, the capacity of the ACC would increase. Therefore, a portion of the thermal duty would shift from the SSC to the ACC causing a reduction in the makeup water required by the cooling tower. As the ambient and/or operating conditions vary, the steam flow will automatically adjust between the SSC and ACC without the need for internal flow control devices.

A control system operates the primary components such that the desired steam turbine backpressure is maintained within the allowable water consumption limitations. In this manner, water consumption is managed such that it is used most effectively. The control system also provides an automated means of exploiting the cyclic temperature profile at the power plant site to satisfy water restrictions on an annual, seasonal, or daily basis.

<u>Concluding Remarks:</u>

The ACC debuted in the North American market in 1968. In 2000, dry cooling was utilized on 10% of all new power generation and this number increased to 25% in 2007. This represents a growing acceptance of dry cooled technology and more importantly, recognition of the fact that water is becoming a more valued and scarce resource.

The adoption of parallel condensing, however, has been sluggish in the United States even though it is merely a hybrid of the well -established wet and dry technologies. There is nothing unique about Parallel Condensing: It is simply an intelligent integration of two well proven technologies providing enhanced operating flexibility and performance benefits that surpass either wet or dry stand-alone systems. Parallel Condensing has been used as a "water saver" on over a dozen power stations ranging from 13 MW cogeneration plants to 750 MW supercritical coal-fired power plants over the past 20 years.

One may rightfully characterize Parallel Condensing as an environment-friendly waste heat rejection solution for power plants.