As part of our firm's mission, Real Time Service's Advanced-Control Group offers its Water Cooling Tower Optimization System - a system that can achieve energy savings and reduce the environmental impact of your heat dissipation equipment.

**Cooling towers: your process cooling sources**

Industrial process and machines generate enormous amounts of heat, which must be dissipated continuously if these equipments are required to work in a proper, efficient fashion. Cooling towers allow the control of the cooling process by means of controlled evaporation, thus reducing the amount of water which is consumed. When the outer film of the water drops in contact with air is evaporated, it requires some heat absorption which comes from the water drops, and so the drops get cooler. Cooling is made by sensible heat, as well as by latent heat. So, the main goal pursued by the cooling tower is that the drops keep in contact with air as long as possible. This is achieved by placing obstacles and fillings which facilitate the cooling process even more.

As in any heat exchanger, a weather variation affects the tower performance. The most important variables are air temperature and air relative humidity. However, barometric pressure and wind velocity can cause strong effects. Both temperature and humidity have daily cycles due night and day, and seasonal cycles in the year. The effect of both variables is condensed in the **wet bulb temperature**, which is the dynamic equilibrium temperature achieved at the water surface when the heat flow transferred to the surface by convection equals the mass flow which exits the surface. Tower performance is affected by weather conditions, but there are more effects to overcome. Actually, the tower is part of an energy interchanging circuit, so whenever production levels are changed or new cooling services are enabled, hot water temperature will vary. Water quality is also a major issue, because heat exchange depends strongly on this value.

**An optimum solution for your plant**

Each plant has its own singularities regarding to instrumentation and automation level. That is why our solution is almost tailored-made. Depending on these singularities, the degree of automation wanted and the economical benefits that are expected to be attained, our customers may choose among the different proposed
systems. The main control goal is to meet the cooling demand from the plant. This demand may be expressed by the product of cold water temperature and flow, though many times only the cold water temperature is demanded. Various implementation solutions are given including different automation control system, instrumentation and final control elements.

**Control system**  
First, plants where no automation is present for its cooling towers are highly benefited when an automatic control is introduced either optimized or not. Automatic control systems are always more efficient than manual control operation. In this scheme, the single measurement of cold water temperature and comparing it to a given set point can decide if more or less air is needed in order to meet the actual cooling demand. Of course, the more efficient the control, the higher energy saving. The control strategy can be implemented at different layers, from a software advising the operator what to do, a PC-based control with OPC communication capabilities, in order to get data from the DCS, to a single PLC commanding the tower performance interacting with the DCS. Actually, as there may be several engines, a non-trivial decision has to be made about how many of them should be on or off, or what the speed should be. That is why the only way to improve the capability of a cooling tower control system is the implementation of a smart control algorithm with the ability to select the optimum speed for each fan.

Measurement of the more important disturbances leads to a control system with improved capacities for responding to cold water temperature deviations. An identification of the effects which the hot water temperature, the water flow, the wet bulb temperature, and the air flow have on the cold water temperature produced by the tower, it is possible to obtain a faster, more reliable control. Here we can apply the classical control technologies (PID, cascade, feed forward, lead-lag), as well as the most advanced multi-variable loop control (RGA, IMC, Robust Multi-variable Predictive Control Technologies, Fuzzy Logic and Neural Networks).

Finally, as there can be various final control outputs like fan motors and pumps, and many measurements, several possible solutions may arise. Then, an on-line optimization for the whole system may be viable, in order to make the control system capable of responding in the best way and attaining net energy savings.

As seen, the proposed architecture is very flexible, and it can adapt itself to any feature required in each particular plant.

**Instrumentation**  
The amount of information available about the process variables is strongly related to the degree of control effectiveness. Here, the degree of control effectiveness includes the concepts of efficacy, efficiency, quality, availability and safety. According to the improvement program, the instrumentation needed for facing a cooling water optimization may consist in just a measurement of the cold water temperature and a fan actuator mechanism. Of course, a great amount of added value can be attained with the complete measurement of all variables — hot and cold water temperatures, air wet bulb temperature or relative humidity, barometric pressure, inlet and outlet water flows, fan and pumps states, electrical power consumed in the engines, and so. Obviously, investments cost must be justified by the economical improvement expected. In most cases, the current tower instrumentation can be fully exploited, so the initial cost is greatly reduced. Anyway, any system claiming cooling tower optimization capabilities should have the following elements:

- ambient dry bulb temperature  
- inlet air wet bulb temperature  
- cold water flow  
- cold water temperature  
- fan actuators

**Final control elements**  
In cooling tower optimization, these are the main goals:

- minimization of cooling water
consumption

- minimization of electrical power consumption in fans
- minimization of electrical power consumption in water pumps

Each of these problems is related to the kind of control actuators. The control actions may be classified into two types:

**Actions regulating water flow:** Water flow circulation in the tower is determined by design constraints. An energy savings opportunity arises whenever the actual water flow can be less than the design flow, because the lower the amount of water to be cooled, the lower amount of fresh air needed and so the lower power consumption in the fans. If water flow must be sustained, a water bypass configuration can be implemented in order to reduce the amount of water passing through the tower. However, an optimization algorithm is needed in order to determine the operation point where actual savings occur.

**Actions regulating air flow:** Air flow is the more important manipulated variable. The tower has one or more cells containing electrical fans. The power consumption in these devices is the cause of energy costs. Different control alternatives are show below:

- **Single-speed engines:** Usually, air flow control is manual in these devices, and the operator sets them on or off depending on the cooling demand. Many cooling tower automation strategies are based on this method. However, there can be an intrinsic energy waste and too much cooling, since power consumption is not proportional to the demand compensation, but fixed — when a fan is running, it is consuming its maximum power.

- **Dampers:** The use of automatic dampers is a choice for modulating the air flow and thus the power consumed. In this case, there are energy savings but also an energy waste, because more pressure is needed for the air to flow through the system. Near the damper closure, fan gets stalled and the power consumption at the engine goes even higher, so special care should be taken to avoid this situation. Nevertheless, actual instantaneous savings can be as much as a 40%, when compared to the non-control, full-speed fan case.

- **IGV (Inlet Guide Vanes):** IGV (Inlet Guide Vanes) are accessories mounted at the fan air inlet. Essentially, they are a set of radial, mobile blades. Pressure needed to attain the air flow circulation is much lower than the pressure needed when using dampers, because the blades help air to rotate in the direction of the fan blades. The power consumed / air flow ratio is better than the dampers case, though the costs are similar.

- **Multi-speed engines:** Usually, the fans act like variable-torque loads, so the power consumption is proportional to the cube of fan speed. As this speed is proportional to the air flow, the best way to control power consumption is to control fan speed. Therefore, several cooling tower systems contain double- or multi-speed engines in order to control power consumption in a more efficient fashion. The most common engines are double-speed engines with 4/8 poles or 4/6 poles. Such engines are capable of operating at maximum or half velocity (4/8) or at maximum or two-thirds speed (6/8). This is a very effective control system for tower with three or more cells, and the maximum possible instantaneous savings are about a 70%, when compared to the non-control, full-speed fan case. In spite of this, a major level of intelligence at the control system is needed in order to explore the best savings opportunities while keeping the cooling demand satisfied.

- **Variable-speed engines:** As said, the most efficient way to obtain energy savings is to vary fan speed directly. This can be automatically adjusted using a variable frequency drive, which can convert power from 50 Hz (60 Hz)
to a 0 to 100 Hz frequency. By doing this, the synchronization speed of an induction engine is determined. This drives allow a soft start, by eliminating the power peaks during motor starts.

Get direct benefits...

Today, economical success for any business requires an efficient use of energy consumed in their respective processes. Energy conservation faces a strong incentive for examining common designing criteria and building and operation features. Energy savings are not only a strictly economic matter. Nowadays, energy as a scarce resource which must be conserved is becoming a popular concept, and this is reflected by several regulations around the world, and of course by energy prices. An optimized cooling tower system must meet this constraint. Energy savings needs not only a basic automation like turning fans on and off according water temperature, but also an effective control involving every variable of interest, each uncertainty source and an optimization system for getting the highest economical benefits, while taking care of the environment and keeping your plant as cool as it needs to be.

... And get additional advantages

Our cooling tower optimization system will also lead you to a series of additional advantages:

Environment Care: reduction of industrial waste water into natural watersheds.
Pouring industrial water into rivers or lakes may be cheap but it can lead to dangerous situations. Natural water temperature may grow, so the local flora and fauna will be exposed. More concerned to human life, water used in cooling circuits is usually fresh, drinkable water, which is perhaps the most important natural resource. An optimized cooling water system keeps an eye on the water consumed, so it can regulate the amount of water used for cooling the industrial processes in a smart, safe way.

Environment Care: reduction of water consumed by evaporative cooling.
Cooling water are evaporative cooling devices. Part of the hot water entering the tower gets evaporated and exits the tower with the air. This is a loss of water to the refrigerant system, so more water should be added in order to replace it. This amount of water must be minimized for economical and environmental reasons, but there are other effects that should be mentioned. Air exiting the tower is warm and very humid, and these characteristics are ideal for microorganisms to develop. These can affect vegetal, animal and human life by causing diseases. Our cooling tower optimization system is aware of this potential problem, and thus limits the amount of water evaporated.

Operation & Maintenance Improvement: Elimination of floods and blockages
One of the most common problems in cooling tower modulation is caused by the filling. If this filling is dirty, water circulation through the tower may be stopped, causing floods. When this occurs, air cannot move in the tower, so no cooling is produced. Additionally, as the fans are on, power consumed by them will actually grow, and there can be damages. Another problem is water blockage. This happens when water flow is very high, so the area where air can move through gets smaller and so the air flow is reduced. A different problem is air blockage. When air flow gets very high, water will not flow across the filling in a proper way, so the heat...
exchange is reduced strongly. There is a lack of diagnosis for these problems in common control systems. But in our system this situation is rapidly identified, corrected and reported before they have actual consequences in plant production.

**Operation & Maintenance Improvement: Reduction in Equipment Maintenance Tasks.**

A smart control system is a system that takes into account all the characteristics of its components. Most of the reactive maintenance tasks are produced by equipment faults due to operation at ranges outside the manufacturer specifications. Many maintenance engineers often say that it is not possible to keep in good condition something that cannot be seen. In a cooling tower system, equipment requiring maintenance is fans, pumps, engines, the water distribution system and so. It is true that inspection at operation condition of this equipment may be a complex task. However, a smart control system can realize when any of these elements is being used outside its specification range or when it is degrading. For instance, a reduction in the heat transfer coefficient, which can be estimated indirectly from measured variables at operation conditions, is a clear sign that the water distribution system is degrading by corrosion, scalding, or that filling is corrupted, or that there can be obstructions at the air inlet or outlet. The control system is not likely to overcome these problems by itself, but it can report this situation to the maintenance staff before the effects of this degrading affect plant production, telling what and where to find out. So, a reliability-centered maintenance policy can be implemented, reducing the reactive maintenance tasks.

**Operation & Maintenance Improvement: Reduction in Supervisory Tasks by effect of improved reliability**

Atmospheric variations make cooling tower performance change. In hot, humid days, operators must activate more fans than in cold, dry days. Also, at night there is always a decrement in temperature, so fewer fans are needed. On the other hand, changes in plant production can have impact in cooling water temperature, so it can be necessary to switch on or off some fans. There can be filtrations or leaks and water composition may change, leading to algae formation, scalding, corrosion or oxidation. This can lower remarkably the heat transfer in the tower and degrade the equipments. This is why cooling tower needs supervision. In a system without automation, operator learns to work with the cooling tower, activating or deactivating fans as the plant demands. Wet bulb temperature is neither measured nor considered in the control decision. Most automated system free the operator of control decision taking, but they do not consider the effect of wet bulb temperature either. As a result, automatic control may not work as expected, thus requiring some sort of supervision. Our optimized cooling tower system can take into account all variables involved in the cooling process, and take always the right decision, so reliability is better and supervisory actions are less frequent.

**Improved Quality**

If the area in charge of cooling tower management is engaged to its services quality, then a series of policies ensuring service uniformity should be implemented. Not only should cooling towers cool the plant water, but also should do it well. Quality is an inherent property of an optimized cooling tower system, because in each control decision, a major care is taken in order to meet all the requirements: plant cooling demands, tower's own constraints, and atmospheric conditions. In addition, all non-measured variables are indirectly monitored, and possible dangerous situations for equipments, environment and human life are discovered before they can affect them. This also prevents unwanted shutdowns in the cool water supply. The overall system then boosts improved quality.

As a result, control system robustness ensures stability of flows, temperatures and cooling water composition, while optimization techniques allow the choice of
the best control decision, involving both direct costs (electric power costs, production demand) and indirect costs (reactive maintenance, energetic demand penalties or environment penalties) and keeping your plant cooling demand always satisfied.

**Contact us...**

If you are interested in our Water Cooling Tower Optimization System, please do not hesitate to contact us.

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