The Criticality of Cooling

Utilities, power plants, and manufacturing facilities all make use of cooling towers for critical heat transfer needs. By cycling water through the manufacturing process, cooling towers transfer process heat so that it can be safely released into the atmosphere. To prevent the environmental, safety, and profitability impact of failure, the cooling tower systems must run continuously, without issue. Identifying and addressing common failure modes makes it possible to keep a plant operating at maximum capacity.

Knowing in advance that cooling tower equipment is facing an impending failure means having the time and resources on hand to resolve any issues before they bring production to a grinding halt. Proper condition monitoring of a cooling tower system can mean the difference between catastrophic failure and a planned shutdown, greatly reducing risk and saving a significant amount of money.

Mechanical Draft Towers

Different types of cooling towers exist to serve different heat transfer needs. Of the many types of towers in operation, the most common is the mechanical draft cooling tower.

Mechanical draft cooling towers are typically implemented in banks mounted on an elevated platform. The towers are commonly located at a significant distance from the rest of the plant, which adds an extra layer of complication when addressing faults, and also makes spurious trips more problematic.

Operation

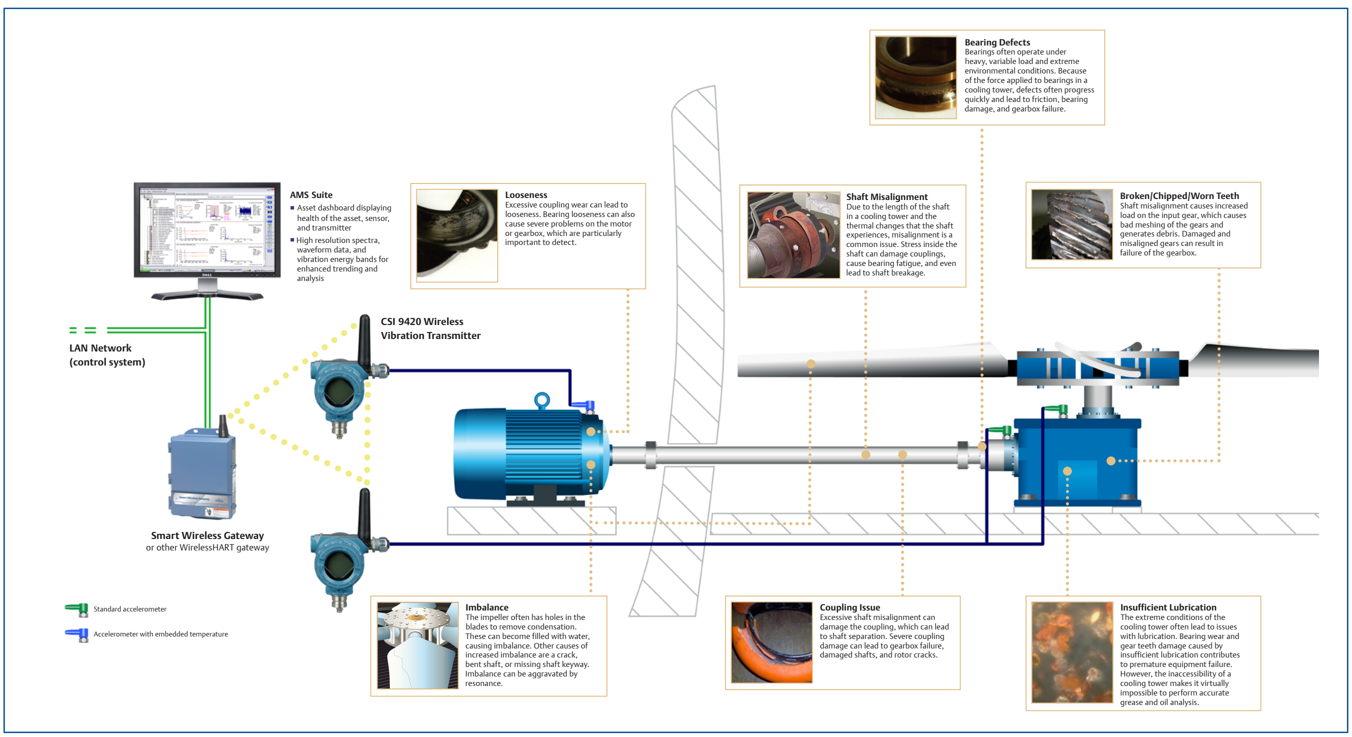
Each mechanical draft tower incorporates one or more cells, with the airflow driven by one or more fans. These fans may be propeller or centrifugal fans driven by motors via a right-angle gearbox.

Causes of failure

There are a number of common causes of failure in a mechanical draft tower:

- Prolonged exposure to moderate imbalance
- Exposure to extreme imbalance
- Coupling wear due to misalignment of the long shaft between the motor and gearbox (jackshaft)
- Broken, chipped, or worn gear teeth in the gearbox
- Defects in bearings in the gearbox

Of these issues, the gearbox issues are the most common reason for failure. The root cause of gearbox failures is frequently insufficient lubrication, a preventable issue that is nonetheless a serious risk.



A propeller fan, with its associated motor and gearbox, can be monitored remotely using wireless vibration transmitters and a gateway.

Risks of failure

Allowing a mechanical draft cooling tower to run to failure can be catastrophic. Though the fans have low rotational speeds, the structure of the fans and the gearbox itself cause inertia. When allowed to run to failure, the inertia of the fan is transformed into a destructive force that can not only bring down the tower, but even compromise the structural integrity of the entire cooling tower platform. Such a catastrophic failure could endanger personnel and result in an extended process shutdown or slowdown for all processes requiring heat transfer.

However, even if a fan's damaging inertia is mitigated and no physical damage is done to the tower shroud or platform, tower failure still has a significant impact on production. The internal components of cooling towers are often not easily accessible, resulting in the need for specialized maintenance crews and equipment to perform service. In addition, because of the location and size of the equipment and the tower, a crane is often necessary in order to perform any repairs.

Moreover, replacement components for cooling towers are specialized, and can have long lead-times for procurement. Because the parts are often too large or too costly to keep on hand for emergencies, an unexpected failure can leave sections of the plant down for long periods of time while maintenance is waiting on replacement equipment.

Monitoring cooling towers

Whether a cooling tower failure results in catastrophic damage or only costly downtime, the risks are too great to allow these essential pieces of equipment to run without advance warning of mechanical problems. To run a cooling tower safely and efficiently requires some type of monitoring system. The preferred solution for detecting failure modes is vibration monitoring.

Because many options exist for the monitoring of cooling tower health, it is important to consider the risks and rewards for each type of monitoring system in order to develop an ideal solution for each plant.

Periodic Monitoring

Though it is physically possible to monitor the vibration of components of a cooling tower by having trained personnel take periodic measurements with portable vibration analyzers, the towers are often difficult and dangerous to access. Cooling towers are typically located a significant distance from the main facilities of an operation, requiring added time and effort to reach the area.

In addition, the primary components (the jackshaft, gearbox, and fan) are all located inside the tower's shroud. Even if there were a safe way to access the components during operation, trying to take readings in such conditions would be like standing at the center of a storm.

The most effective, safe solution for monitoring is to use an automated monitoring solution.

Vibration Switches

The oldest and most basic form of vibration monitoring used in cooling towers is referred to as a vibration switch. An embedded sensor on the tower can detect excessive vibration and, in the case of a problem, can shut off the fan.

Though the vibration switch is a better solution than periodic monitoring or no monitoring at all, it comes with significant disadvantages. Vibration switches only detect lower frequency vibration. Because nearly all of the key failure modes for cooling towers (gear defects, bearing faults, and insufficient lubrication) generate higher frequency vibration, vibration switches are blind to nearly every failure mode that is likely to occur. The operator will only be notified of an issue after the cooling fan has tripped. A vibration switch may help the plant avoid a catastrophic failure, but it provides no advance notice or data to help the plant prepare for maintenance and minimize the impact of a problem.

Vibration switches initially have maintenance-free operation. Unfortunately, this benefit comes with a significant drawback. The harsh environment around the switch – wet with exposure to chemical vapors – can eventually cause corrosion on the switch. Because these switches are rarely monitored, the first sign that a vibration switch is not functional may come when the cooling tower's fan has run to failure.

Remote Monitoring

The most reliable way to monitor cooling towers is through remote monitoring. Installing a high quality vibration monitoring system will allow operators to detect the high frequency vibrations that signal the most common issues in a cooling tower's mechanical equipment.

The remote vibration monitoring system can send clear, precise alerts to the control room, allowing trained analysts to review the signals. Proper analysis of vibration signals can lead not only to the identification of problems, but also can alert the control room and maintenance team to the severity of any defects in the cooling tower. With all of this information at hand, maintenance teams have more flexibility in addressing problems on a schedule that allows for a minimum of downtime.

The primary drawback to a remote monitoring system is that the costs of running cabling to the sensors can be prohibitive, particularly because cooling towers are often remote from the control room at a plant. However, this cost concern can be mitigated or even eliminated with the implementation of wireless monitoring.

Wireless technology allows plants to take advantage of the benefits of remote vibration monitoring without the added expense of running wiring to the cooling towers. The miles of communication cables that used to be required to carry signals from the towers can now be replaced with wireless vibration transmitters and a gateway.

Because the wireless gateway can be placed near the control room, it requires only a single Ethernet cable to transmit frequent updates to operators on the health of the cooling tower, while also transmitting high quality diagnostic data to the reliability team for more detailed analysis.

Making Sense of the Data

Wireless transmitters send data to the control room that can be compared to pre-defined alert limits. In order to ensure that the transmitted data can be translated into meaningful, immediate action, a high quality vibration transmitter will publish at least two types of parameters:

- LOW FREQUENCY: a low frequency vibration parameter warns primarily about imbalance on the fan.
- HIGH FREQUENCY: a high frequency vibration parameter captures impacting signals generated by root cause problems such as bearing faults, gear defects, and under lubrication.

Of the two parameters, it is the high frequency parameter (measured in peak acceleration) that will generate the highest concern for the plant. This parameter represents the level of impacting occurring on the equipment.

A piece of equipment that is properly installed and well lubricated should have little to no impacting. The "Zero Principle" comes from this rule, meaning that the impacting on a good machine should be at or close to zero.

Conversely, when the level of impacting is in double digits, it can be deduced that a defect is developing on the machine. Each time the amplitude doubles, it reflects an escalation in the criticality of the defect. This leads to the "Rule of 10's," a set of rules which the control room operator can use to effectively monitor the health of a cooling tower:

Rule of 10's

Level of Impacting (g's Peak)	Interpretation	Action
10	Abnormal situation present	Alert maintenance team
20	Serious abnormal situation present	Define maintenance plan
40	Critical abnormal situation present	Implement maintenance plan

Conclusion

By using comprehensive wireless vibration monitoring on mechanical draft cooling towers and following a simple set of rules for analysis of vibration data, the control room can offer significant help to the maintenance team in developing an optimal maintenance plan to minimize risk and cost and to optimize any downtime. The end result of properly monitoring cooling towers is improved safety and production while lowering cost and unpredictability.

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