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The Benefits of VFDs on Cooling Towers

Variable-frequency drives can adjust fan speed, reverse fan rotation

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Used on large industrial projects, such as nuclear power plants, and countless HVAC applications ranging from 15 to 700,000 gpm, cooling towers are everywhere. Because of their increasing popularity and considerable number of applications, cooling towers are available in many different sizes and designs. This is especially true in the HVAC industry, in which the demand to increase efficiency and lower energy costs is great.

One of the most beneficial ways to increase efficiency and lower energy costs in a cooling-tower design is to utilize a variable-frequency drive (VFD). This article will discuss the different aspects of designs in which VFDs are used to improve performance and how this performance differs from conventional cooling-tower designs.

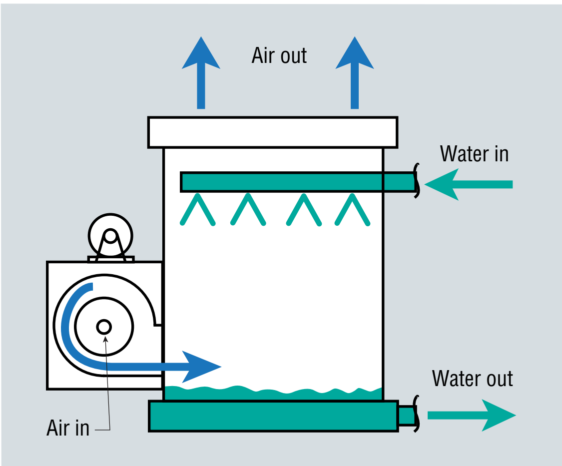

FIGURE 1. A mechanical forced-draft cooling tower.

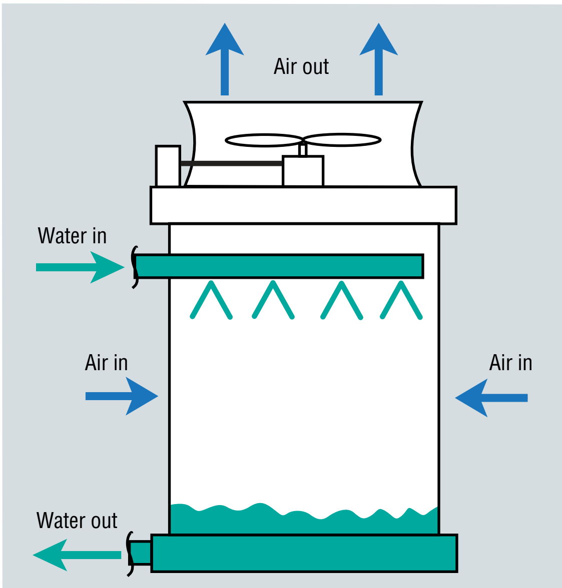

FIGURE 2. A mechanical induced-draft cooling tower.

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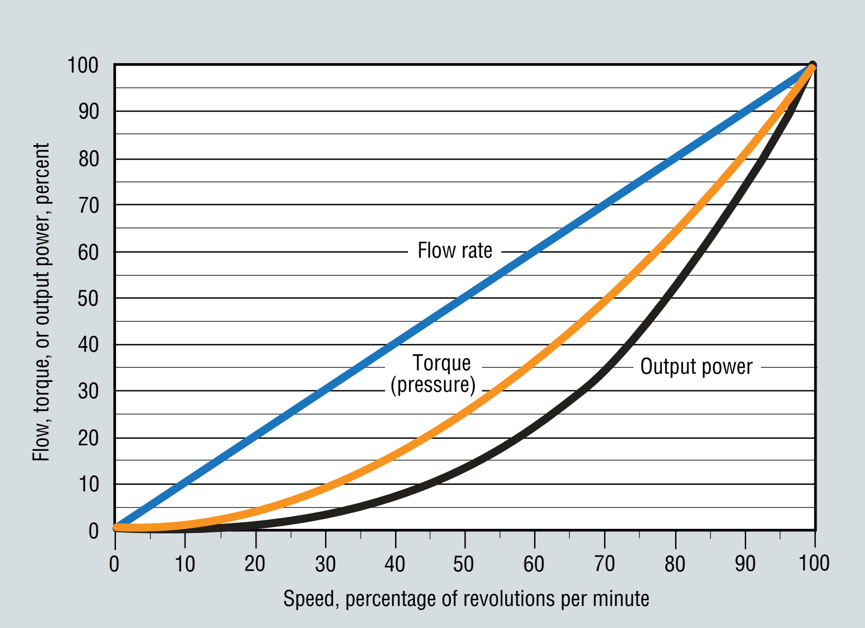

FIGURE 3. Affinity laws.

COOLING-TOWER TYPES

A mechanical-draft tower is a common type of cooling tower used in HVAC applications. Mechanical-draft towers can be broken into two main categories: forced draft and induced draft. A forced-draft tower has a fan mounted on its side, located in the path of entering ambient air (Figure 1). The fan draws ambient air in, pushing/forcing it through the tower and out of the top. Forced-draft towers generally have high air-entrance velocities and low air-exit velocities. An induced-draft tower has a fan mounted on its top, located in the path of exiting air (Figure 2). The fan draws ambient air in from the sides and blows it out of the top. Both designs use one or more fans to provide the flow required to extract heat from process cooling water. VFDs have proved to be beneficial on these fans.

VFD BENEFITS

Fans regulate airflow to compensate for changes in ambient air and load conditions. In the past, this was achieved by cycling fans on and off, manipulating fan capacity by varying the pitch of fan blades, or using two-speed motors. These methods can have considerable drawbacks and do not leave much room for error.

Across-the-line motor operation can be efficient if a system is designed for a fan to operate at full speed 100 percent of the time. However, that rarely is the case. As conditions change, flow needs to change as well. As a fan cycles on and off, its speed alters dramatically, causing leaving-water temperature to fluctuate, leading to inefficiency and control difficulty.

Fan speed. VFDs are able to adjust fan speed as conditions change while maintaining the exact flow required. They also are able to increase fan speed above 60 Hz to provide additional cooling capacity should the need arise. VFDs have built-in proportional-integral capabilities to automatically adjust fan speed to maintain a given set point, eliminating the need for an external set-point controller or variable-pitch fan. VFDs can reduce the energy consumed by a fan just by slowing the motor. As shown in Figure 3, a fan's power varies proportionally with the cube of its speed, so a small speed reduction causes a large power reduction. For example, if a fan motor runs at 80-percent speed, its energy consumption decreases by 50 percent.

Fan motors consume a large amount of energy because a high inrush of current is required to start the motor every time it is cycled. VFDs eliminate this problem by acting as soft starters, increasing/decreasing speed at a programmable rate. This feature reduces mechanical wear by eliminating stress on the power train caused by across-the-line motor starting. This can increase system life and save maintenance costs.

Fan rotation. VFDs not only save on energy and increase system efficiency, they perform numerous other functions that eliminate the need for additional equipment. For example, VFDs can sense fan rotation. If a fan is rotating in reverse because of windmilling, a VFD can catch it, slow it down, and ramp it back up in the correct rotation. A VFD's ability to reverse fan rotation can be beneficial in cold-weather conditions. Reversing a fan can cause warm air to be blown back into a tower, melting any ice that has developed. These VFD functions typically are performed using mechanical brakes or reversing contactors, which can increase costs and wear while adding mechanical components that can fail.

Automation and motor protection. Using a VFD on a cooling-tower fan also is valuable for automation and motor protection. VFDs have digital and analog inputs, outputs, programmable relays, and numerous serial-communication options that allow for flexibility in tower automation and performance monitoring.

Some utilities offer rebates for installing VFDs in new or retrofit work.

Retrofits. Although it is best to consider VFD capabilities during a tower's initial design, VFDs can be implemented into existing applications effectively. Many, if not all, of the benefits mentioned previously can be utilized; however, there are some considerations to note in retrofit applications. Because many parameters are fixed, there may be tower-design characteristics that need to be worked around rather than avoided completely.

For example, cooling towers have fixed locations, and fan motors may not include inverter-duty features. Depending on where a VFD can be mounted, long lead lengths can be a problem and could damage motor insulation. To protect the motor, an output load reactor or a dv/dt filter can be added to the VFD output. However, it may be more cost-effective to mount the VFD to the side of the cooling tower in an outdoor-duty enclosure. This can solve the long-lead-length issue, making it possible to use the existing motor for the remainder of its life.

Gearboxes also can be considered. Many times a gearbox requires a minimum speed to stay effectively lubricated. If this is the case, a VFD can be programmed with a minimum speed, thus protecting the gearbox.

Because these are just a few of the considerations that may arise in a typical retrofit application, it is best to consult the VFD manufacturer for assistance.

CONCLUSION

VFDs not only can save money, they can make money. Some utilities offer rebates for installing VFDs in new or retrofit work. In many cases, a VFD can pay for itself in less than a year. Upgrading with VFDs is a major part of the U.S. Environmental Protection Agency's effort to improve energy efficiency. Many resources offer comprehensive information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency. Whether in a new design or an existing application, VFDs offer numerous advantages when used on cooling towers.

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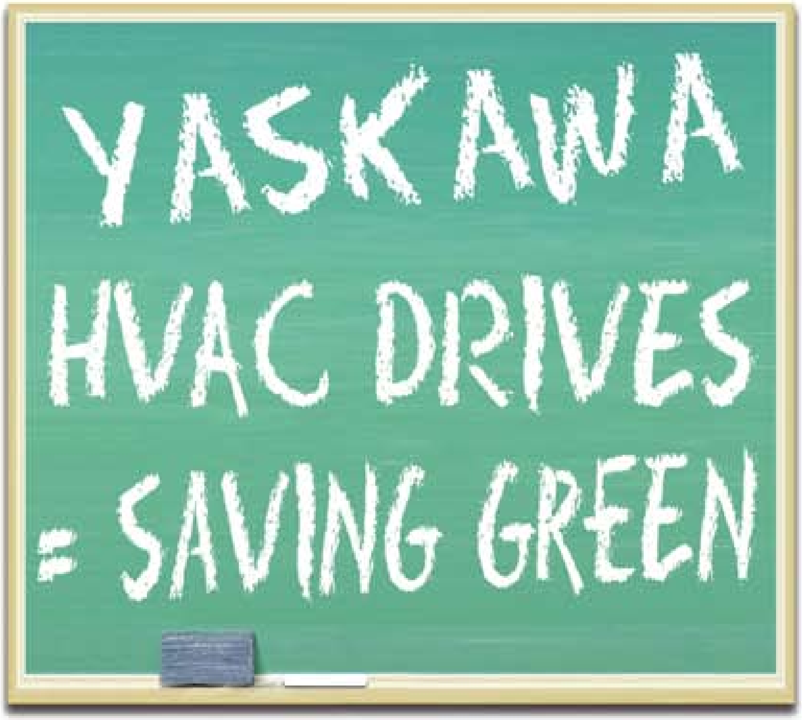

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