YWCT
Custom Cooling Towers

Variable frequency cooling towers

General

VFD (Variable Frequency Drive) is a speed adjustment system for the revolutions of the electric motor by varying THE motor input frequency and voltage. This system can be used in a cooling tower to reduce the revolution speed of the fan when the cold-water temperature goes below that required by the user. In practice, a temperature sensor such as PT100 is installed at the outlet of the cooling tower (where cold water are exiting the cooling tower basin), and connect it to a variable frequency drive (VFD)installed on the tower's electricity and control board.

The VFD is programmed to adjust the fan motor's revolution speed according to the cold water temperature: When the water temperature dips below a threshold defined by the tower designer, the fan motor turns more and more slowly until it stops. When the water temperature rises above this threshold, the VFD increases the fan motor revolution speed, and so forth.

VFD advantages

4 main advantages of using a frequency monitor in a cooling tower:

- **Extends the life of the mechanical system –** On a motor startup, a very high current is produced, up to 10 times the design current. Installing a VFD reduces both the startup current and the startup surge, so that the motor's and the fan's startup is gradual. The result is reduction in mechanical load on the rotating system during startup and consequent extension of the mechanical system components (gear, motor, drive shaft and fan)..
- **Better monitoring and control over the process –** In many cases, it is important to the process that the cold-water temperature remains steady, i.e., not too high or too low (for example, industrial petrochemical processes, or wastewater cooling processes for biological treatment). In such cases, the VFD ensures that the water temperature does not go below that desired, and does not exceed a certain threshold.
- **Control over fan noise levels –** The noise made by the fan in a cooling tower is one of two main sources of cooling tower noise. Reducing the fan revolution speed in turn significantly reduces the noise therefrom. Because nighttime is on the one hand the period when noise is particularly an issue, and on the other hand it is when the wet bulb temperature drops, a VFD is effective in reducing noise without compromising output.
- **Saving electricity –** The outstanding advantage of installing a VFD is savings in electricity. While cooling towers are designed for harsh environmental conditions, most of the time they operate in milder conditions than those for which they are designed. As such, installing a VFD is particularly worthwhile.

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For example, in Ashdod (Israel), the design conditions for a cooling tower are wet bulb temperature of 26.5° C., yet 5,800 hours of the year – or 70% of the annual operating hours – the wet bulb temperature does not exceed 22° C. Therefore operating with a VFD and reducing the revolution speed of the fan during the lower-temperature hours leads to significant savings on electricity.

The significant electricity savings stem from this physical relationship: Reducing the fan revolution speed in turn reduces the air velocity in the cooling tower, which in turn decreases by a second degree (exponentiation) the resistance to the air flow in the cooling tower, resulting in a reduction by a third degree of the motor output. Thus, for example, reducing the frequency from 50 to 40 hz results in a nearly 50% reduction in energy consumption of the cooling tower.

Because, as aforementioned, the wet bulb temperature during most of the year is lower than the design temperature (nearly every day in winter and most of the summer), the VFD's being activated translates to savings of dozens of percents in annual energy expenditure for the cooling tower. This calculation is illustrated in the table below:

Basic data and working assumptions

Datum	**Figure**
Motor output in kilowatts	52KW
Cost per kilowatt-hour	0.11$
Average no. of hours of operation per day	24
Average days of operation per year	300
Average reduction in speed	30%
Average reduction in electricity consumption while controller is working	66%
Average no. of hours of operation at reduced speed (of operating hours per day)	18

	US $
Annual electricity expenditure without VFD	$41,184
Anticipated annual electricity expenditure with VFD	$20,891
Anticipated annual fan savings	**$20,293**

In our experience, the investment in installing a VFD repays itself in less than a year.

Practically speaking

In a multi-cell cooling tower, a number of configurations can be observed for installing a VFD (for example, installing one "skipping" VFD; installing one VFD that controls a total output of all of the motors together). The prevalent configuration is a separate VFD for each motor.

Yet even under this configuration, it is still recommended to run all of the motors as a single unit and activate them simultaneously at a slow speed that picks up as needed. As aforementioned, this is

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the optimum way to extend the life of the mechanical system components and save electricity. Installing a VFD for each motor reduces the risk of a system-wide breakdown in the event of a locale-specific malfunction in a VFD. The difference in price between this configuration and that of a single VFD for all of the motors is not large, and therefore recommend. The programming of the VFD should be performed as per a regime activation table such as the one shown below:

Hz	Cold water temp
50	Above 23°C
45	Below 23°C
40	wait 5 min
35	wait 5 min
30	wait 5 min
25	wait 5 min
20	

When installing a VFD in a cooling tower fitted with speed reducers, ensure that the revolution speed does not fall below the threshold recommended by the speed reducers manufacturer (usually 25 hz), due to the fact that reducing the speed below the threshold impedes the lubricant distribution.

Occasionally, the fan revolution speed at a certain point on the frequency scale matches the cooling tower's resonance frequency, causing the complete cooling tower to vibrate. This problem can be addressed simply by programming a secondary frequency monitor that simply "skips over" the problem point.

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