MARLEY®

thermal science

Vibration Management

FOR COOLING TOWER COMPONENTS

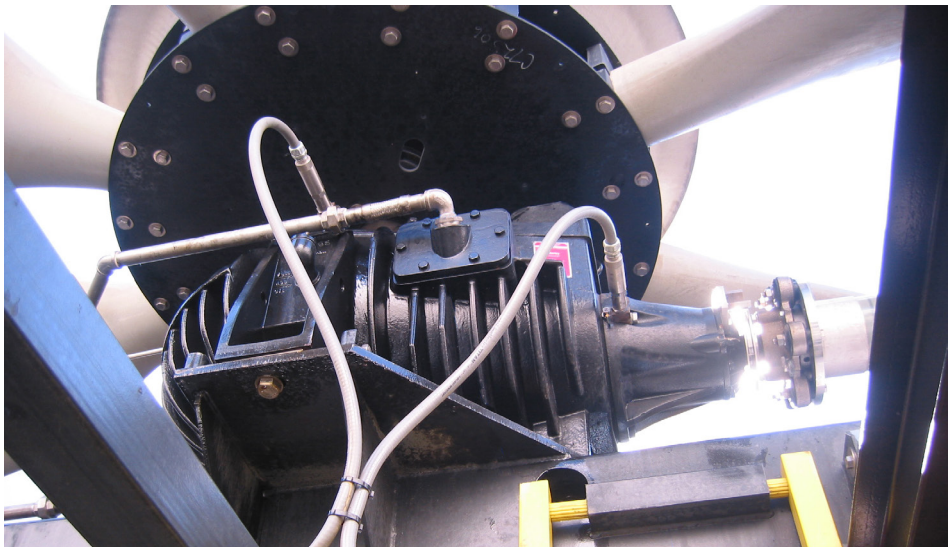
As a piece of machinery operates, it vibrates. If measured and analyzed, the frequency and amplitude of this vibration can provide insight into the machine's condition. With the proper tools, these vibration signals can alert personnel, even shut down the equipment when deteriorating conditions or events occur. Vibration monitoring equipment is available to aid in maintenance forecasting as well as to help prevent further damage to machinery and components.

The level of vibration management adequate for protecting the cooling tower and supported processes must be determined by the owner. The five options identified in this paper can help monitor and protect cooling tower components from the potentially destructive effects of vibration.

Definitions

A basic understanding of components and vibration terminology is helpful in choosing an appropriate vibration monitoring option.

- A vibration analyst can identify the source of vibration based on its *frequency* (the rate at which it occurs) and determine its severity based on the *amplitude* (the amount of vibration).
- A *transducer* is a device that converts one form of energy into another.
- An *accelerometer* is a type of transducer commonly used in vibration measurement that generates an electric charge proportional to the acceleration force applied to it. Accelerometers can be very sensitive and output signals for simultaneous occurrences.
- A *velocimeter* is a type of accelerometer that has on-board electronics to integrate the data into velocity units.
- A *signal conditioner/transmitter* is a solid-state electronic device that can include an integral transducer or connect to a separate transducer. Its purpose is to convert the raw signal into an amplitude measurement proportional to the overall condition. It is useful for simplifying the signals for basic trending, alarm or shutdown. It is also useful if long cable runs are required to connect the transducers to an auxiliary system such as a plant supervisory control and data acquisition (SCADA) system or distributed control system (DCS).
- *Fast Fourier Transform* (FFT) converts a vibration waveform from the time domain (time vs. amplitude) to the frequency domain (frequency vs. amplitude). The results of this process substantially simplify the identification of the vibration frequencies and the associated amplitudes of each. A graphical example of the time waveform plot and the transformed spectrum data is shown in Figure 1.
- *Vibration analysis* is the process by which an analyst uses measured vibration responses to evaluate the condition of a system and make appropriate recommendations.



Two accelerometer transducers are mounted on a Geareducer® near the low speed output/fan shaft (left) and the high speed input shaft. This arrangement could be utilized as part of vibration-management options.

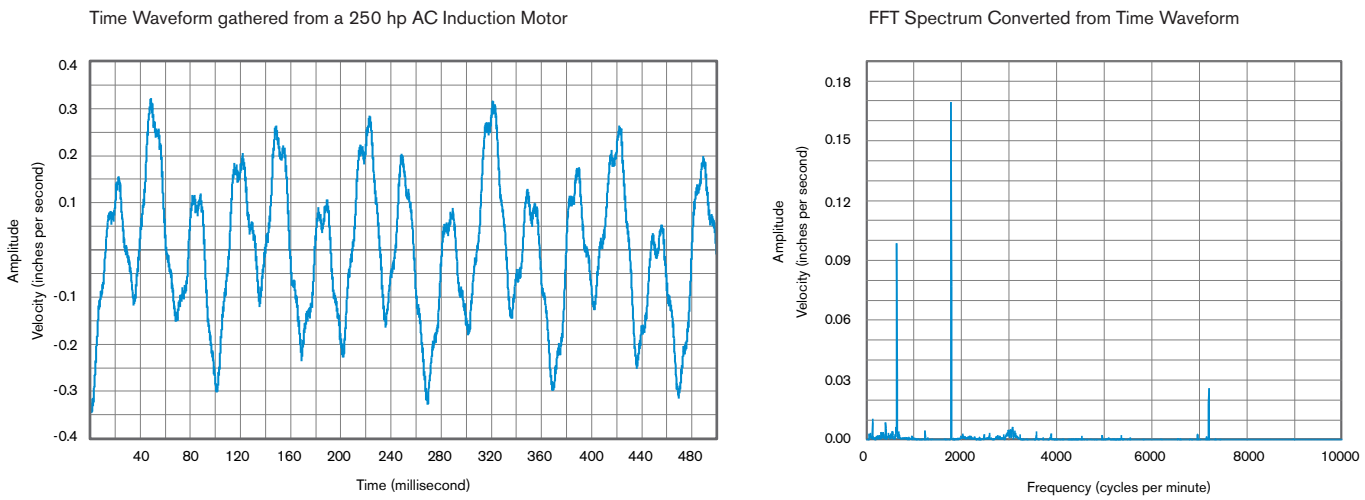


Figure 1 FFT converts a vibration waveform from the time domain to the frequency domain (frequency vs. amplitude). The result is simplified identification of the vibration frequencies and associated amplitudes of each.

Vibration Management Options

Mechanical Vibration Switch A mechanical vibration switch (Figure 2) is the simplest way to manage vibration. The switch is typically mounted onto the mechanical equipment support and connected to the motor starter circuit. If it realizes a vibratory event that exceeds the set-point (typically 1g), it will "trip". These switches may be set up so that the trip initiates an alarm to alert the system operators and automatically shut down the equipment.

These mechanical inertial switches "sense" acceleration in one direction. They are a good first step to potentially mitigating damage caused by excessive vibration, but they are not monitoring devices. They do not measure vibration or collect data; rather they react to a specified level of acceleration. In many instances, it may be too late to prevent failure; in such cases, the switch is intended to notify and prevent further damage.

It is important to note that during cooling tower startup, it is common for vibration levels to be temporarily elevated. An important option for mechanical vibration switches is the remote reset function, which is an electric coil used to reset the switch to the normal condition or hold it as such during startup. Another benefit is that the trip set-point may be set at a level appropriate for normal operating conditions rather than for the relatively higher startup level. This results in a significant improvement in protection as well as convenience.

Electronic Vibration Switch These switches have important advantages over mechanical switches. The upgraded solid-state electronic versions utilize an accelerometer that measures the amount of vibration. The transducer may be integral to the switch housing or external and connected to the switch by a cable. Some switches output an overall, proportional signal (4-20 mA) for plant management connectivity to a DCS or SCADA system. Additionally, a BNC terminal allows the transducer's raw signal to be transmitted to an analyzer.

Figure 2 A mechanical vibration switch, typically mounted on the mechanical equipment support and connected to the motor starter circuit, is the simplest way to manage vibration. During an event that exceeds the setpoint, the switch can initiate an alarm and/or shut down the equipment.

An important option for an electronic switch is a trip delay function. This feature has an adjustable time delay counter that will initiate once the preset vibration level is exceeded. If the vibration still exceeds the limit at the end of the delay, the trip engages. This allows for transient vibration events, such as startup, to be overcome.

Accelerometer or Velocimeter With or Without Signal Conditioners/Transmitters To gather data from a cooling tower gear box, the cooling tower cell must shut down to mount the transducer, then reenergize for data to be collected. Then the process must be repeated in order to retrieve the transducer. To avoid this, it is possible to permanently mount transducers within the cooling tower cell. This also saves money by avoiding costly shutdowns that reduce cooling tower capacity and tie up manpower. To simplify the process, a switch or junction box that serves as a central connection point may also be installed for the vibration analyst, allowing the analyst to gather data from multiple accelerometers via one switch. Data can be gathered more quickly and more often for additional reliability. This option is recommended when the analyst wants to collect data at regular time intervals.

These transducers may also be powered and equipped with a signal conditioner for transmitting the overall, proportional signal into a separate system. Additionally, permanent transducers may be used in conjunction with vibration switches to add analysis capability to the basic protection system.

Surveillance System Surveillance (monitoring) systems are a good option when frequent data collection is warranted and the collection location is difficult to reach. These systems regularly and automatically poll the transducers for overall amplitude values several times a day. Amplitude changes may signal conditions that require investigation by the preventive maintenance staff.

The data gathered by these systems typically are stored in a database for trending. Some surveillance systems can automatically shut down equipment or set off alarms if vibration exceeds levels specified by the operator.

The system may include automatic notification features that send alerts through email or mobile apps. Wireless systems are growing in popularity but may not poll and transmit information as rapidly as conventional wired systems.

Protection System Advances in computing power make protection systems a cost-effective upgrade from surveillance systems. They have the added benefit of collecting data almost continuously across all transducers installed on the equipment. When system failure carries severe consequences, a protection system can be a good investment.

Summary

Vibration switches provide a good first step towards risk mitigation by alarming and/or shutting down equipment when excessive vibration occurs. More sophisticated devices provide data needed to analyze maintenance requirements and reduce downtime. Surveillance and protection instrumentation provide additional risk reduction and maintenance scheduling tools for critical systems.

Regardless of the vibration-monitoring system, vibration response data must be actively managed in order to be useful. The data collected show the transducer's reaction to vibration rather than the machine's actual motion. Consequently, it is critical that the transducer be mounted, connected and calibrated properly.

Finally, no level of automation is a substitute for a trained analyst. Understanding of cooling tower system components and vibration monitoring devices is required to install and connect monitoring tools, then gather, maintain and interpret the vibration data. Only then will data management promote increased component reliability and reduced downtime.

Reference:

Introduction to Applied Vibration Analysis, copyright 2004, M. J. Stansloski, Ph.D., P.E., Pioneer Engineering Company, Inc., Fort Collins, CO 80524

Features	System					
	Mechanical Vibration Switch	Electronic Vibration Switch	Transducers	Transducer(s) with Transmitter(s)	Transducer(s) with Surveillance	Transducer(s) with Protection
Basic Protection / Event Reaction	standard	standard		optional	standard	standard
Alarm Notification	optional	optional		optional	optional	optional
Automatic Shutdown Protection	optional	optional		optional	optional	optional
Overall Proportional Amplitude Output		optional		standard	standard	standard
Raw Data Output for Analysis		optional	standard	optional	optional	optional
Plant Control Integration	optional	optional		optional	standard	standard
Intermittent Automatic Polling		standard		standard	standard	standard
Constant Automatic Polling						standard

Summary of Available Systems and Features. blank = not available

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