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Factoring In Condition Monitoring's Real Costs

While most owners and operators consider a condition monitoring system's initial price tag, many do not realize that the annual analysis costs can also be significant.

BY BROGAN MORTON

Vibration-based condition monitoring systems (CMS) are critical for use in predictive maintenance programs that require early indications of faults. However, the major hurdle to wide-scale adoption of these systems has been their costs. As the hardware price of these CMS has come down, adoption has accelerated. These new CMS users have discovered there is a significant amount of analysis and expertise needed to translate a complex vibration wave form into an actionable recommendation.

The analysis is important because the performance of systems is dictated by its effectiveness, but doing the analysis well can incur significant costs. When evaluating CMS, prospective users should take a holistic approach to the total cost of ownership. The overarching goal of a CMS is to provide users with recommendations that allow them to make optimal operations and maintenance decisions. It is important to understand the process through which a CMS converts a physical measurement – in this case, vibration – into a recommendation for action.

Luckily for prospective users, there is a generic, six-step process that all CMS follow:

1. Data acquisition: translating vibration into an analog measurement, which is then converted into digital format;

2. Data processing: processing the digitized measurements into meaningful indications of component health;

3. Detection: classifying whether the condition indicators are "normal" or "abnormal";

4. Diagnosis: validating the fault and determining its location and severity;

5. Prognosis: estimating how much longer the faulted component will last before it needs to be replaced; and

6. Recommendation: determining what maintenance action is necessary and when it should be performed.

Only the first step actually deals with measuring the vibration; the remaining steps are focused on turning the data into actionable information. Steps two through six can be clustered together and referred to as the "analysis" portion of the system. The analysis process is significant for two reasons: The performance of the system is dictated by the effectiveness of the analysis, and there is typically an associated service cost, which can be significant.

The performance of the CMS refers to the system's ability to detect faults in a timely manner without false alarms that drive more maintenance actions. Comparing relative performance among CMS vendors is complicated, and field trials on wind turbines are the best way to judge performance. Fortunately for prospective customers, however, costs are much easier to characterize.

Cost considerations

Instead of only focusing on the initial cost of the CMS hardware, it is appropriate to look at the total cost of ownership for a CMS. There are two different categories of costs to consider from the total cost perspective: the initial capital costs and the recurring costs.

The initial capital cost is the most commonly understood portion of the total CMS cost. Capital cost includes the cost of the hardware that is installed in each wind turbine, as well as any information technology (IT) infrastructure needed to store and process the data. The hardware costs include all sensors, data collection units and communication hardware necessary to outfit the turbine. The IT infrastructure includes the server hardware (if required) and analysis software needed to process the vibration data.

The recurring costs are often less well known, yet they are an integral part of the total cost of ownership. The recurring costs include any IT service needs and the analysis costs. IT service includes local server maintenance (if applicable) and analysis software updates. The analysis costs include the cost of converting the data that comes from the CMS into an actionable recommendation. This can be either an

Total Cost of Condition Monitoring System Ownership

CMS Cost per Turbine	Initial Capital Cost	Annual Cost Year 1-10	Lifetime Cost
CMS Hardware	$7,000	$ –	$7,000
Diagnostic Engineering Support	$ –	$750	$7,500
Local Server & Software*	$333	$22	$556
			$15,056

**site cost spread across 45 turbines*

Source: NRG Systems

annual payment in order to contract the service to a third party or the cost of internal resources to do the work. It is important to consider these costs because they are not trivial. Imagine that for every wind turbine monitoring system, these services cost $750 per year. Since the wind turbine is a long-term asset, this fee will be paid for the entire life of the wind turbine.

Analysis options

The difficulty with vibration-based condition monitoring is the sheer amount of analysis and expertise needed to translate a complex vibration wave form into an actionable recommendation. Finding the changes in vibration caused by component faults is the crux of the analysis. Unfortunately, the changing speed and load the gearbox experiences also change the vibration signature, so establishing a normal baseline to see a change can be difficult. For this reason, the primary method for analysis involves a vibration analyst interpreting the data.

Every CMS varies in how much automation there is in the diagnosis. Almost all CMS will provide some data processing, and most systems will offer basic detection, such as an alarm to signal when further analysis is necessary. Few systems offer a diagnosis without further analysis, and almost none offer automated prognostics. Therefore, it is up to the CMS owner to determine how to fill the gap between the detection of an anomaly and a maintenance recommendation.

The most common method is to outsource the work to a diagnostic engineering support center. The main advantage is that CMS owners do not have to train and retain a vibration analyst. Vibration analysis of wind turbines is challenging due to the unique machinery (planetary gears) and dynamic operating conditions (varying speed and torque). The level of experience also matters. The downside to outsourcing the analysis is that CMS owners are completely reliant on a third party for critical data, and each diagnostic support center varies in the amount of data that it will share.

The second method is to develop the analysis capability in-house. The main advantages to this option are that an in-house analyst will gain experience on a potential CMS user's own turbines and all of the data will be easily accessible. This level of expertise could be leveraged to perform root-cause analysis on the damaged components to try and avoid damage in the future. The downside to this method is that a potential CMS user must develop a monitoring program. This includes training analysts in vibration monitoring (ISO Category II Vibration or greater) and retaining these now-critical resources. Depending on the size of a potential CMS user's organization, this may not scale well and could be more expensive than simply outsourcing.

To understand how the total cost of ownership is affected by ongoing costs, it is helpful to use a concrete example. The example is for illustrative purposes only; potential CMS users should do the math themselves using their specific situation and assumptions.

In the example, it is assumed that the CMS will be deployed on a 45-turbine wind farm. The CMS hardware costs $7,000 per turbine, and the IT infrastructure (local server and analysis software) for the entire site costs $15,000, with an annual cost of $1,000. The unit cost of the local server and software was calculated by spreading the capital cost and annual fees across the 45 wind turbines.

The annual analysis service cost of a third-party provider is in the range of $750 to $1,000 per turbine. For this example, the conservative value of $750 is used. If a CMS user considers bringing the analysis in-house, the cost would be the salary of the analyst. This example of an analysis cost of $750 per turbine would be equivalent to an analyst with a salary of $67,500 spending half of his or her time analyzing data. Because every system requires a different level of analysis, a potential CMS user must consider how many turbines an analyst could reasonably manage. This is something that is best judged during a trial.

The total cost of ownership for this example is $15,056. The initial capital cost of the CMS ($7,000) is actually less than the total cost of analysis ($7,500) over the life of a turbine. This emphasizes the fact that characterizing all the ongoing costs associated with each system is imperative to making an informed purchase.

All CMS use a similar process to proceed from the vibration measurements to a recommended course of action. From this process, the importance of vibration data analysis becomes immediately evident. CMS users can choose to either outsource this analysis or keep it in-house, depending on their preference. In either case, the cost of this analysis is significant. In the example presented, the lifetime analysis costs are actually larger than the initial investment in the CMS hardware. To avoid any surprises down the line, potential CMS users must understand how much analysis is needed and how much it costs before making a purchasing decision. WP

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