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Integrating condition monitoring and computerized maintenance management systems can enhance production and maintenance decisions and support optimized plant asset utilization.

Condition monitoring (CM) and computerized maintenance management systems (CMMS) have evolved and coexisted as separate disciplines. Many efforts have been made to integrate CM and CMMS with nominal success.

Conceptually, CM and CMMS have different functions and their applications yield different results. Understanding these roles provides significant insight into the benefits of an integrated system. In general, the role of CM is to implement a maintenance strategy and the role of CMMS is to manage the execution of maintenance. These separate disciplines have been successfully practiced for years, each on its own merits with relatively little knowledge or interaction with the other. When considered as an integrated whole, it becomes clear there are exciting possibilities for greater benefits.

Benefits of integration

The integration of CM and CMMS provides clear opportunities including:

- More effective and automated implementation of maintenance strategy. Research has shown that condition-based maintenance provides the lowest maintenance cost and highest availability for many plant assets. In practice, these benefits can be elusive. Effective communication of CM recommendations and tracking the results provides a powerful tool to support complete realization of the CM benefits. Meaningful communication between CM and CMMS provides automatic, paperless execution of CM, minimizing man-hours and increasing effectiveness. This connection between the systems allows a maintenance strategy based on machinery health to be institutionalized as a part of the user's business.
- Improved accuracy of CM analysis. Communication of information between CM and CMMS improves CM analysis in two important ways. First, it allows the analyst to observe the work history of the machine being analyzed. Armed with this knowledge, the analyst can recognize the difference between a new bearing that may produce high readings as it wears in and an older bearing that will produce high readings as it degrades. Most maintenance actions will impact CM measurements, and understanding this work history results in dramatic improvements in CM analysis.

The second improvement in CM analysis is from systematic feedback on CM recommendations. The two most important outputs from CM are diagnosis and prognosis. Diagnosis identifies what is wrong with the machinery, and prognosis estimates how bad the condition is or,

ideally, answers the question, "How long will it last?" With an integrated approach to CM and CMMS, CM recommendations are tracked and the actual findings documented. This provides a tool to confirm the diagnosis and prognosis that CM generates. Prognosis based on CM information is not an exact science and it will depend on the site-specific application of the machinery. Tracking CM recommendations and supporting them with factory floor or shop observations is a powerful tool for improvement.

- Identification of repetitive failures for root cause analysis. At many plants, the biggest savings opportunity is designing out repetitive failures. In most cases, this doesn't happen because these repetitive failures either are not noticed or are tolerated by an adaptive maintenance philosophy "Oh yeah, that machine breaks every six months." CM alone can be very effective at identifying this problem and CMMS can make fixing it efficient. When the two work together, the repetitive nature of the problem and the associated costs become apparent. The measurement tools used for CM also often can be applied to study a repetitive failure and identify its root cause for design-out consideration.
- Effective communication of machinery health throughout the enterprise. Availability of machinery health information from the CM system throughout the enterprise creates the opportunity for significant benefits in production, engineering, and other business segments. When this understanding of machinery health becomes institutionalized, production schedules can be optimized, selection and design of plant machinery improved, and maintenance practices fine tuned. Providing the tools for continuous improvement of plant operations, generally, and the maintenance function, specifically, is the biggest benefit to integrating CM with CMMS.

How these systems work together

The premise of CM is that carefully selected measurements made on a regular basis can show machine condition accurately. With this understanding of machine condition, specific maintenance actions can be carefully planned. Maintenance interval and machine availability are optimized, driving maintenance costs down and production up. The CM domain has evolved in a technical fashion wrapped around measurement technology. Measurements can range from simple parameters such as temperature, pressure, or flow to complex data such as vibration spectra or infrared images. In all of these cases, the objective is to determine what is normal for the machine, how much change is allowable, and what the changes indicate. In practice, CM has a well-developed vocabulary and data set including:

- Plant machinery hierarchy
- Criticality
- Measurement locations
- Measurement definitions
- Measurement interval
- Severity
- Alarm status or exception

- Trend
- Spectrum
- Time waveform

- Thermographic image
- Frequency component

- Diagnosis

- Prognosis CMMS

CMMS also has been practiced for decades. It is an information-intensive application offering significant benefits through gathering and distributing information about the maintenance function. Managing maintenance information has been a driving force in this development. CMMS also has a well-developed vocabulary and data set that includes:

- Plant machinery hierarchy
- Work requests/orders
- Work plans

- Work schedules
- Labor resources/costs

- Parts inventories/costs

- Storage locations
- Preventive maintenance actions
- Purchase requests/orders

- Safety procedures

Creating an intelligent connection

It is ironic that two disciplines such as CM and CMMS that are practiced, in many cases, by the same people fulfilling their assigned duties, have such little overlap in the data they handle. In fact, the biggest overlap is probably plant assets, represented within both systems as a machinery hierarchy. Unfortunately, these hierarchies usually develop at different times to fulfill different purposes and they have little direct connection. The challenge in achieving greater efficiencies through connecting these systems begins to emerge. Although there are visible synergies to pursue, in most cases there is no inherent commonality between the systems. Each of these tools operates in a different domain with different data of interest and vocabularies.

Failure to recognize this challenge has been one of the root causes for the limited success of many efforts to integrate CM and CMMS. In order to address this effectively, it is necessary to effectively connect the shared data between these systems and establish new methods for the systems to exchange other information that will allow users to realize the potential benefits. The approach presented here establishes these new types of information and relationships between the systems:

- Connection between the machinery or asset hierarchies of CM and CMMS
- Creation of a new CM result known as Advisory
- Creation of work requests based on Advisories
- A gateway to automate communication between the systems
- Tracking work requests within the CM system
- Display of equipment histories and work plans within the CM system

The role of people

The integration of the business processes needs to be driven by the organization and its business requirements, not the software. The organization should, however, take into consideration the functionality within the software and database platforms in order to achieve integration as simply and straightforwardly as possible. Although it is a common objective to minimize the human effort required, integration does not necessarily mean without human intervention.

The integration presented here recognizes the expertise of the CM analyst and CMMS maintenance planner. It provides meaningful automation of the work request process for the CM practitioner, but it in no way attempts to create work orders automatically from gathered data without human intervention. The CM systems available today provide useful diagnostic tools to assist in the recognition of machinery faults and specific defects. Armed with that information, it is a straightforward task for the analyst to confirm the diagnosis and submit the work order using the gateway to CMMS. This gateway then offers a view of this work request as it is processed and the maintenance is executed. This makes the work process visible to the CM practitioner, ensuring follow through on his recommendations and feedback on the entire maintenance process. **MT**

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