APM: Asset Performance Management[i]

– Increasing the Value Created by Facilities –

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VALUE CREATED BY ASSETS

Yokogawa Electric Corporation is involved mainly in the process control business. The materials that are to be measured and controlled flow through facilities, instruments, and devices (collectively, "assets") and become end products. Control involves measuring the quantities and properties of these materials, predicting their future conditions, and adjusting various parameters to maintain these materials in predetermined ranges. Meanwhile, it is also important to maintain assets properly. This is because assets are vessels or supports that must be well looked-after to ensure safe, high-quality, and high-performance production.

The following three points are important for asset maintenance.

(1) Enabling assets to deliver the maximum performance
(2) Keeping maintenance costs at a reasonable level
(3) Using advanced technology for asset maintenance

Point (3) is also an effective solution for addressing the serious issue of the dwindling number of skilled workers.

Time-based maintenance (TBM) is a method of improving the reliability of assets by performing checks and repairs at fixed intervals. Over the lifecycle of an asset, the failure rate is high in the initial phase, falls and stabilizes in the middle phase, and then goes up again later because of aging. This trend is known as the "bathtub curve." Although TBM, the interval of which is determined by many factors, is effective for smoothing out this curve, it still has the following disadvantages.

(1) Failure may occur during an interval.
This is because TBM relies on probability.
(2) Time and expense are wasted.
Maintenance is performed even on healthy assets, reducing uptime and production efficiency.
(3) Failure may be caused by maintenance itself.
Over-maintenance often adversely affects assets.

Condition-based maintenance (CBM) aims to achieve the same goal as TBM from a different viewpoint. As process control involves repeating the cycle of measurement, calculation, and adjustment, CBM repeats the cycle of identifying the current status, predicting what will occur and when, and performing appropriate maintenance on the asset. Since this method aims to identify any sign of failure and predict possible problems, it is called predictive maintenance. CBM does not involve performing maintenance on all assets at fixed intervals, but on individual assets as needed. This helps reduce expenses and improve reliability.

How can we identify the status of assets, detect signs of failure and predict possible problems? The first step is to continuously measure characteristic parameters that show the status of assets. Continuous measurement can identify unusual vibration and temperature. But does this predict the future? Are such measurements useful for preventing deterioration? New sensors, status analysis algorithms, and machine learning can help identify the status of assets more easily and predict the future to some extent. However, to improve the accuracy of forecasting and examine measures even in the P&ID process, it is necessary to gather and use a wider range of information.

For example, it is effective to compare the asset information with production data (production results and process control information). The information on assets includes availability; process values such as temperature, pressure, and flow rate; chemical and physical properties; and operation. Events that occur during operation also provide valuable information. These data are saved in control systems such as distributed control systems (DCS) and programmable logic controllers (PLC). Production results are recorded in a manufacturing execution system (MES). Is it possible to find a relationship between these data and the decreased performance or failure of an asset? Identifying such a relationship can be very valuable, and so it is important to address this challenge.

Maintenance records also provide valuable information. These records are stored in the computerized maintenance management system (CMMS) and used for planning and implementing maintenance. If a correlation with real-time information from sensors and production results and status

i The whole activity of planning, implementing measures, and conducting assessments for making full use of the value offered by assets

is found, it is possible to identify signs and predict failures more accurately. In addition, CMMS includes unstructured data such as reports, documents, and images. These are often redundant but should not be disregarded. Tools are being developed to extract characteristics from these data and identify and structure their meanings.

It is necessary to find correlations between the following three types of data and failure probability (without trying to create an equation).

(1) Asset status (sensors, monitoring algorithms)
(2) Information on production (production results, process values, events)
(3) Maintenance records (structured data, unstructured data)

If a correlation is found, it can be used to improve the accuracy of prediction, optimize maintenance plans, production plans, manufacturing methods, and operation procedures, as well as maximize asset value and prevent accidents.

In practice, much information needs to be obtained by asking workers and turning their answers into explicit knowledge, in order to improve maintenance. There are facts, information, and know-how that are not recorded on the system. In addition, the types and amounts of information held by various departments differ considerably. Although this is a very difficult task, there are many examples in which major progress was made by associating these. To enhance cooperation among different departments, it is also important to motivate these departments to work on improvements and to work together cooperatively. To achieve this, not only knowledge about plants, processes, assets, and operation but also the effects of consultation and facilitation will be crucial factors.

ASSET PERFORMANCE MANAGEMENT AND IIoT

The industrial internet of things (IIoT) will play a key role in achieving advanced asset performance management (APM). It was pointed out above that the status of assets must be measured in order to maximize the operational efficiency of assets ("things" for the IIoT). For example, there are innumerable assets in an oil plant, such as thousands of pumps and perhaps 100 km of piping in total. It is difficult to detect corrosion along all these lines. To prevent unexpected shutdown and plant accidents, there are many things to monitor such as the vibration of facilities, leakage of liquid and gas, abnormal temperature, and unusual noise. Furthermore, even though many of these are measured, the data are not transmitted beyond control panels and indicators in the field to the central control room. To obtain valuable measurement data, human workers patrol various locations in the field every day including high locations and other hard-to-access places and physically touch facilities to check the temperature and vibration, listen for noise, or look for any abnormality. Thanks to such meticulous efforts, plants are kept accident-free and running.

Meanwhile, the evolution of sensing technology has made it possible to read data that used to be impossible or only indirectly estimated. New compact sensors featuring wireless communication and long-life batteries are being installed in plants. Therefore, it is now possible to receive signals from thousands of remote sensors over long periods. Sensor-equipped assets display their status over the network. Time and distance are no longer restrictions; the status of assets can be monitored at any time from multiple offices wherever they are located. Except for the initial cost for sensors, various expenses are no longer needed; data are transmitted almost for free and there is no need for cables, racks, and the work of installing them. In addition, human errors and differences among individuals in reading values are eliminated. High-performance sensors will be able to detect light, sound, smell, long-period vibration, distortion, and other objects to be measured that cannot be sensed by human workers. These data are digitally recorded and accumulated for analysis and improvement in the future.

The value that is added by APM is determined by the following two points:

(1) Application products achieved by advanced sensing technology
(2) Operational improvement obtained by analyzing and considering information in the three areas of assets, production, and maintenance

In particular, point (2) is crucial for companies with assets because this improvement increases their cost competitiveness. Although it is also advantageous that information can be stored in servers or in the cloud and can be transmitted quickly to distant places, these factors are not so crucial.

Note that the significance of improvements and added value offered by APM is not proportional to the cost incurred except for sensors and other hardware. Consider a construction project: its costs are determined by the quantities of concrete, steel, and other materials, construction period, and so on, and all of them are proportional to the size of the building to be constructed. Meanwhile, the added value offered by APM is not necessarily proportional to the cost. The amounts and kinds of data and their transmission distance do not affect the cost. The significance of added value is determined by how one analyzes these data, identifies relationships with the failure rate, and uses these findings to improve the manufacturing process and maintenance. The additional expense (marginal cost) for ratcheting up added value is approaching zero.

A well-designed system enables symptoms detected by sensors and judged by the algorithm to be compared with past data accumulated in the maintenance management system. If necessary, the system warns maintenance staff and proposes appropriate action to be taken while showing relevant documents. The system also notifies the manufacturing execution system and the control system of any abnormality and urges these systems to take appropriate action for production. Depending on the state of processes, the system shows support information to workers. Maintenance records are accumulated in the equipment maintenance management system for analysis in the future. These systems are expected to cooperate more effectively and share information with one another.

Although this paper focused on plant assets in the manufacturing industry, the concept of APM can be applied to infrastructure assets. A new vibration sensor is introduced in this special issue; it is designed to include the concept of APM, and is expected to be effective for achieving it.