Equipment Performance Monitoring

Web-based equipment monitoring cuts costs and increases equipment uptime

This document explains the process of how AMS Performance Monitor operates to enable organizations to focus on their core strategic objectives by outsourcing their requirement for performance monitoring.

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AMS Suite: Equipment Performance Monitor – Equipment Performance Monitoring

Degradation of Equipment Performance

As the performance of gas turbines, compressors, heat exchangers, and other types of process equipment deteriorates over time, their efficiency decreases, power consumption goes up, throughput is reduced, and operating costs rise. Performance monitoring using Emerson Process Management's AMS Performance Monitor system offers an effective way to offset that toll.

The most common forms of degradation occur due to physical changes to machine parts. This may be mechanical wear as a result of prolonged operation, physical wear such as pump impellor corrosion, or surface degradation as on heat exchanger plates. Many of the effects of degradation are avoidable or reversible with appropriate maintenance.

However, if declining performance is allowed to continue, the cost in reduced productivity and lower product quality can reach into many millions of dollars. The key to preserving long-term performance in process plants is a steady influx of information that lets maintenance personnel know when the performance of mission critical equipment degrades to the point that appropriate maintenance must be scheduled.

By accurately monitoring the efficiency of production equipment and also examining the cost implications of equipment degradation, processors can greatly reduce or eliminate the excessive costs associated with inefficient preventive maintenance or unexpected shutdowns. The result can be astounding. **For example, AMS Performance Monitor is currently being used to provide intelligence on critical equipment at a remote gas production facility. Identification of just one poorly performing compressor in a critical application followed by repairs resulted in a reversal of slumping production rates and a US$3 million gain. Using AMS Performance Monitor has now enabled that company to optimize equipment maintenance schedules, reducing the cost of equipment downtime by an estimated US$1.5 million annually.**

As preserving the efficient operation and performance of plant equipment takes on greater importance in the face of global competition, maintenance can no longer be considered a necessary expense. If all available tools are put to use in the battle against deteriorating equipment, maintenance can make a significant contribution to plant productivity.

Performance or Condition Monitoring?

A good deal has been written in recent years about condition monitoring as vital to effective predictive maintenance. If the "condition" of production equipment is known, it should be possible to schedule maintenance accordingly. Condition monitoring may identify mechanical faults such as imbalance in rotating machinery, bearing wear, seal damage, etc., and this information can be used to determine a maintenance strategy. Many companies now measure vibration, evaluate oil, examine electrical motor circuits, and assess the mechanical health of key equipment, but raw data or manual calculations don't provide sufficient information on the actual *performance* of the equipment being monitored.

The insertion of snapshot values into homemade spreadsheets cannot substitute for a continuous flow of information as a way to prevent catastrophic results in case a condition suddenly changes. Instrument drift or errors, bad data, or the inaccuracy of data used in calculations are often not taken into consideration.

Condition monitoring is not necessarily concerned with a machine's thermodynamic performance (although many elements are inextricably linked). This is where performance monitoring assists as an indication of longer-term behavior. A combination of the technologies provides a solution that covers both short-term "mechanical" performance and longer-term "thermodynamic" performance. Indeed, performance monitoring often indicates degradation in the thermodynamic performance of a machine before any "mechanical" indications are observed. Maintenance engineers can look at both the short-term effects of operation (oil quality, bearing wear, etc.) and longer-term performance (thermodynamic efficiency), and determine a strategy based on the whole picture.

The most important element of performance monitoring is the distillation of the large amount of raw data available into useful information that can be acted upon. Application of this information may lead to improved maintenance cycles, fault detection and rectification, and process improvements identified through performance behavior trends.

A structured performance monitoring approach using model-based technology (allowing for the accurate comparison of actual versus design conditions), such as that used by AMS Performance Monitor, improves decision-making based on derived performance and economic data. Thus, guesswork is removed from maintenance activities.

How AMS Performance Monitor Works?

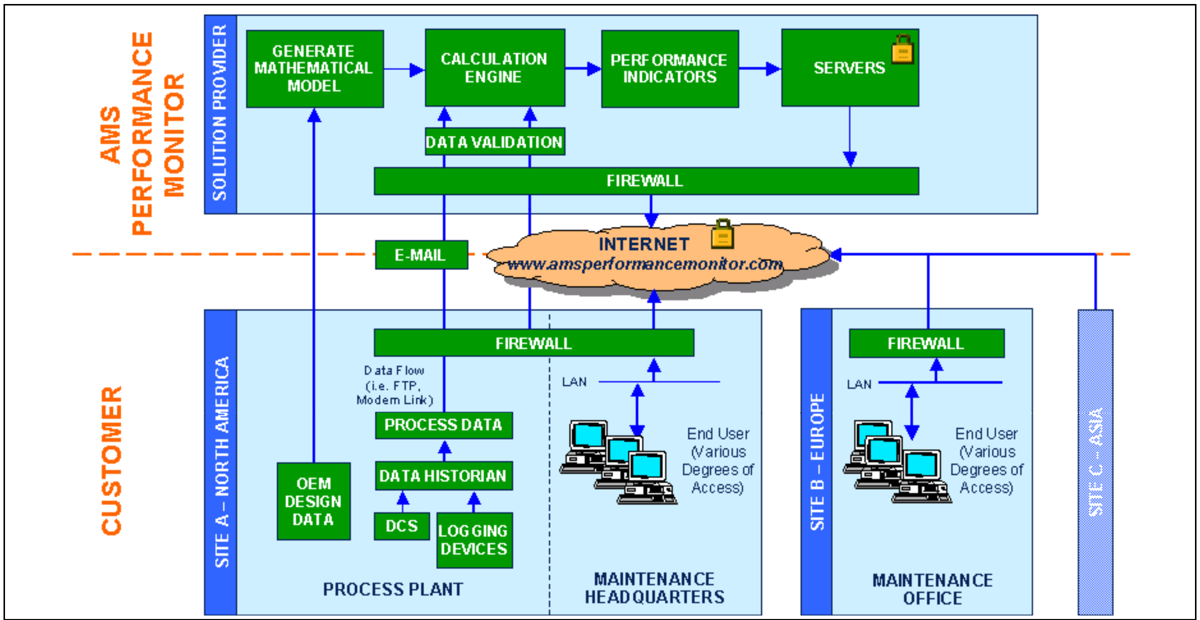

Figure 1: The AMS Performance Monitor Approach.

Figure 1 illustrates AMS Performance Monitor's approach to performance monitoring that sets it apart from alternative in-plant systems. Design data or specifications are used to pre-configure rigorous performance models for all types of chemical processing equipment such as gas turbines, compressors, heat exchangers, pumps, furnaces, boilers, steam turbines, expansion turbines, hydraulic turbines, and more. The data needed to uniquely characterize a piece of equipment may include such information as power consumption, throughput, pressure ratio, etc., as well as operating points showing expected operation at "normal", "min", and "max' conditions.

The model itself is supplemented by design data provided with the unit at delivery or acceptance. This is an important factor in performance monitoring solutions that may often be overlooked. The design data allows two important elements of the performance monitoring solution to be implemented:

1. Characterization of the individual unit, which changes the representation of the unit from a generic chemical engineering model to one that represents the unit as delivered to the plant.

2. Reference of current performance of the unit to performance that would be expected of a unit at design condition.

The data is gathered on-site over a period of time, transmitted to a central file server, and processed continuously versus alternative periodic snapshots. AMS Performance Monitor software detects and corrects measurement errors, thereby providing accurate and reliable data for analysis on a continuous basis. This data is then compared with the thermodynamic models of each piece of equipment being monitored using a calculation engine.

The model-based technology feeds highly accurate information about the current performance of each machine back to the end-user via the Internet, providing a basis for informed decision-making. As a result, each machine's performance can be optimized and its availability extended.

Equipment Modeling

The AMS Performance Monitor calculation engine operates to interface plant data with a mathematical representation of that equipment. Design curves are interpreted within the system to supplement the chemical engineering model, and the software generates performance indicators that apply to current operation.

Design data for a piece of process equipment is applied to standard "chemical engineering" mathematical models to create a detailed model that operates over the equipment's expected operating envelope. It is important to recognize that a mathematical model requires a minimum number of defined variables in order to perform the required calculations. Given the defined variables as inputs to the model, the results can be said to be predictions of a machine's behavior under the input conditions. For most mechanical models of process equipment, the inlet conditions are defined, and the outlet conditions predicted.

The use of a predictive model has several advantages over one that simply generates performance indicators. The primary advantage is that the predictive model can be exercised over a different range than the actual plant operation with confidence that the model reflects the performance of the machine operation at that operating point. This is most important for asset optimization systems where, by definition, the monitored equipment probably does not perform at the optimum level. Secondly, the predictive model provides a more detailed representation than a simple performance indicator model, but generally requires less input to generate results.

Finally, a predictive model can be used in multiple forms for the same problem to generate comparative results simultaneously. This is possible because the predictive model has "tuning parameters" that allow it to account for equipment degradation. In effect, these tuning parameters can be used to generate "copies" of the model in different situations. Some systems implement this functionality in predictive models to allow simultaneous generation of the machine operation in both clean (design) and current states. Predictive models can be used for a variety of other calculations (e.g. run at "worst" condition, run today's conditions at last month's degradation).

Over time, the machine being monitored begins to drift away from the mathematical model, since the model, by itself, assumes the equipment is in design condition. To counter this effect, statistical and optimization techniques are applied to "tune" the mathematical model according to observed behavior. Effectively, these techniques adjust the mathematical model using defined parameters, such as efficiency, so that the predictions match the observed behavior.

In essence, the model predictions are overlaid onto the actual plant data, and this acts as a confirmation of the model's fidelity. It also allows model inaccuracy to be easily highlighted, since the predicted and actual curves will not coincide.

A model representing a specific item of plant equipment can be updated whereby the software will be able to reconcile the model calculated and actual plant values to ensure that the model continues to represent actual performance in the plant.

Data Management

AMS Performance Monitor is designed to remove the burden of managing and supporting a complex monitoring solution at the plant level. This system acts as an interface that brings performance data to multiple users, rather than forcing them to retrieve the data, allowing both machinery and maintenance experts from around the world (see Figure 2) to diagnose problems and implement solutions immediately.

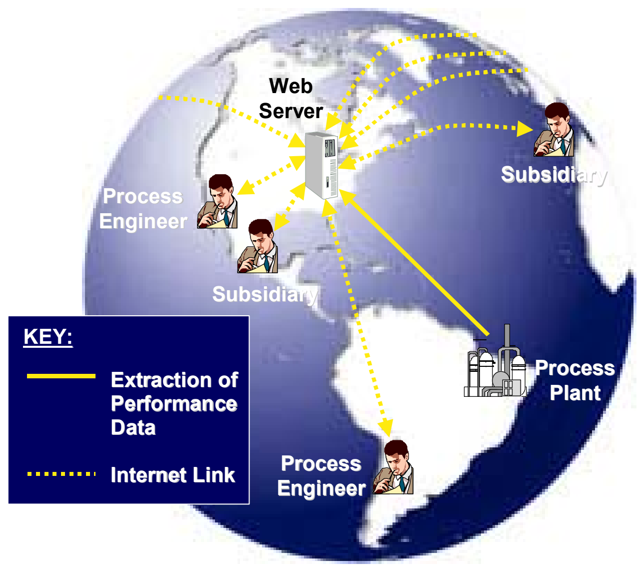

Figure 2: Access performance data across corporate sites.

It is not even necessary to install specialized software. This type of solution takes over the responsibility of managing a plant's data, storing the results in a secure environment, and making it available to the end-user wherever and whenever necessary. Data access can be provided to those who need information from the field. For example, plant managers can view all units in a particular plant or even several plants, while certain individuals may be given access to the information on only specific pieces of equipment.

Performance Indicators

The results of AMS Performance Monitor can be analyzed to determine the effective performance of the machine, and hence indicate any maintenance needed and the relative timing of that activity. This is possible through a variety of mechanisms – the most obvious is to simply look at machine performance trends, particularly with respect to previously performed maintenance to determine its effectiveness and determine the need for further activity. It is also possible to assign a cost to the degradation. When combined with an associated maintenance cost, an effective indicator of the optimal time to perform the maintenance can be easily produced. See Figure 3.

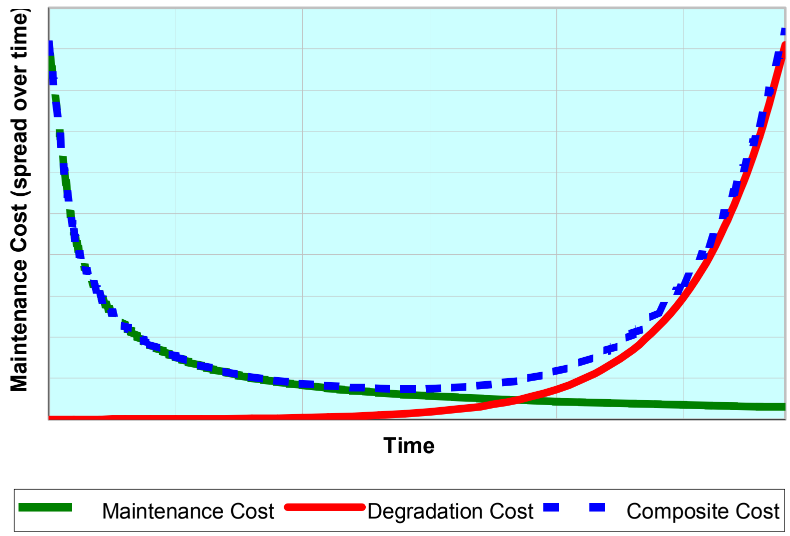

Figure 3: Equipment Degradation.

In general, it is important to recognize that machine performance is defined as much by its current operation, as by any degradation it may exhibit. To this end, the deviation from design, or expected performance, is arguably a more important indicator than the "spot value" of performance. A good performance monitoring system provides both actual performance indicators and deviation from design.

Example Applications

Case No. 1:

Using AMS Performance Monitor identified suspect instrumentation that is essential to the turbine control algorithm of a steam turbine. Replacement of the faulty instrument improved control of the turbine, and ultimately output, by 5%.

Case No. 2:

A heat exchanger that is subject to fouling was normally cleaned at two-month intervals. Performance improved but soon began to diminish as the fouling built up once more. When the cleaning cycle was changed to every three months, monitoring showed that degradation was no worse than with the previous maintenance strategy. Utilizing AMS Performance Monitor helped justify the new schedules, eliminating two maintenance operations annually, saving on downtime, labor, and production losses.

Case No. 3:

Monitoring the performance of a compressor train, using AMS Performance Monitor, comprising several stages with associated knockout and interstage cooling, revealed significant performance loss. When the compressor bundle (rotor and stator) was changed, severe wear on the first row of blades was evident, confirming the reduced efficiency and head, and explaining the increased (while still within limits) vibration indicated by condition monitoring. The repairs improved the performance of the compressor unit, but not as much as expected. Continued monitoring showed less deviation from design on start-up, with the intercoolers performing better before reaching normal operating temperature. Testing on the intercooler set points revealed that better compressor performance could be achieved by lowering the interstage temperatures further during normal operation, so the intercooler set points were changed and compressor performance was again increased.

Additional Benefits

Such benefits are often gained by implementing new process strategies based on the indicators produced by performance monitoring. Actual programs have met with considerable success to-date for operators in the chemicals, upstream sectors of the oil and gas production, and in the power generation industries. The ease-of-use, accuracy, and completeness of AMS Performance Monitor typically exceed expectations, making appropriate actions possible. However, significant savings can be realized only when the knowledge is acted upon.

AMS Performance Monitor offers a means of optimizing critically important processing equipment subject to degradation. In addition to being able to pinpoint poor performance and stimulating corrective action, AMS Performance Monitor has proved beneficial in:

- ✓ Analyzing the effect of washes and other maintenance activities on overall compressor efficiency resulting in streamlining maintenance frequency.
- ✓ Detecting failures of critical equipment.
- ✓ Detecting faulty instrumentation so maintenance action could be taken to improve instrument performance.

As a result, many thousands of dollars are saved through reduced downtime and greater yields.

Further information

A full guided tour is available at www.AMSPerformanceMonitor.com/tour

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