PLANT-LEVEL ASSET MANAGEMENT

Introduction

The frequently quoted statement from a report by the E.I. du Pont de Nemours Company[i] that "*the largest single controllable expenditure in a plant today is maintenance, and in many plants the maintenance budget exceeds annual net profit*" clearly highlights the importance of finding new ways in which we manage our plant assets. It is estimated in industry that maintenance [ii] related costs account for up to 40% of a plant's total operational costs. By adopting a new culture on Plant Asset Management, several operations around the world have successfully turned maintenance from being the "largest single controllable expenditure" to being a source of profit. Through proper Plant Asset Management, assets cannot only be maintained close to their original state but their lifespan can actually be extended and the individual and collective asset efficiencies notably enhanced throughout the entire lifecycle of the plant. The result is to maximize the benefits (profits) derived from these assets (improved ROI).

Much has been researched, written and presented on Plant Asset Management philosophies and strategies. This paper focuses on Plant Asset Management predominantly at the Field and Control levels of the Plant Operational Hierarchy, but also touches on the systems that are employed at the higher levels (see Figure 1 – Simplified plant operational hierarchy). Examples of condition monitoring are described to demonstrate how non-intelligent assets can effectively be managed.

What is meant by "Plant Asset Management"?

Process plants are associated with high capital expenditure and operational costs. Plant Asset Management is a collective of corporate culture, strategies, methodologies, systems and procedures aimed at maximizing the benefits derived from all material and human assets in a plant. Assets should not be viewed as costs but rather as an investment towards achieving high productivity (quality and quantity) and profits.

How does Plant Asset Management Work?

In order to maximize the output of a plant, all assets need to be maintained at certain intervals – i.e. monitored, serviced, refurbished or replaced. Plant Asset Management assists in determining these intervals through continual asset condition monitoring, predicting time-to-service, providing detailed diagnostics with guidance of required service actions and system supported planning and execution of service tasks.

Effective Plant Asset Management requires the buy in of all plant staff members. It also involves all levels of the plant operational hierarchy, namely the Process or Field level 1, the Control and Operator level 2, the Management level 3 and the Enterprise Resource Planning level 4 (see Figure 1 – Simplified plant operational hierarchy).

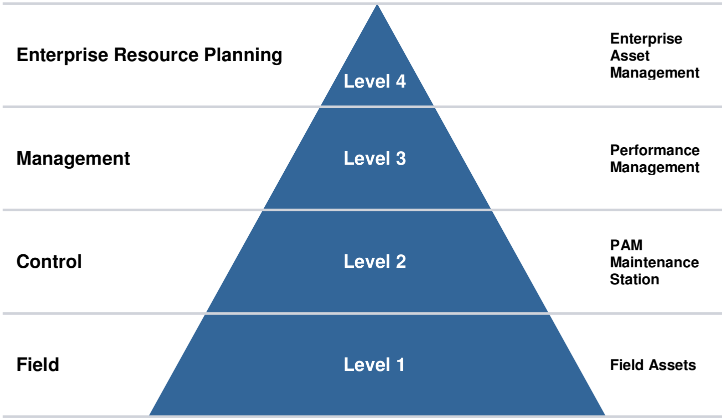

Figure 1 – Simplified plant operational hierarchy

In a typical PAM scenario the condition statuses and diagnostics of all assets are routed from the Field level via digital networks to the Process Control Systems (PCS) and from there to a dedicated Maintenance Station (MS). The maintenance station acts as a dashboard to the maintenance team. It displays the assets as unified symbols in a hierarchical structure. Asset symbols are capable of indicating the device states and severity (priority) levels[iii]. The maintenance team can drill down from a plant overview to individual assets, displaying the asset identification data, manufacturer's details, error messages, detailed diagnostics with service hints and the offline / online device parameter list (if applicable). The maintenance station also supports managing each asset's maintenance workflow (e.g. maintenance request, maintenance in progress, maintenance completed, cancel request etc.).

The maintenance station passes the asset status information on to the management and enterprise resource planning levels. At the management level the asset statuses are evaluated and combined with other process data to yield Key Performance Indices (KPIs) such as Overall Equipment Efficiency (OEE), Cost of Ownership (TCO), True Downtime Cost (TDC) and Total Effective Equipment Productivity (TEEP). These measures present management with the "bigger picture" of how effective a plant is operated and maintained and at the same time identify possible shortcomings in the process. With this important feedback management can continually revise their maintenance strategies and debottleneck the processes, thereby improving the plant's overall profitability.

The Enterprise Resource Planning (ERP) or Enterprise Asset Management (EAM) system provides the platform for scheduling, workflow, inventory, purchasing, and other related maintenance activities. Planning is done in accordance with one or more maintenance strategies. There are a number of different maintenance strategies, which are however not exclusive of each other. They can be divided into two main categories, namely Corrective and Preventative maintenance (see
Figure 2 – Maintenance strategies and Table 1 – Other maintenance strategies).

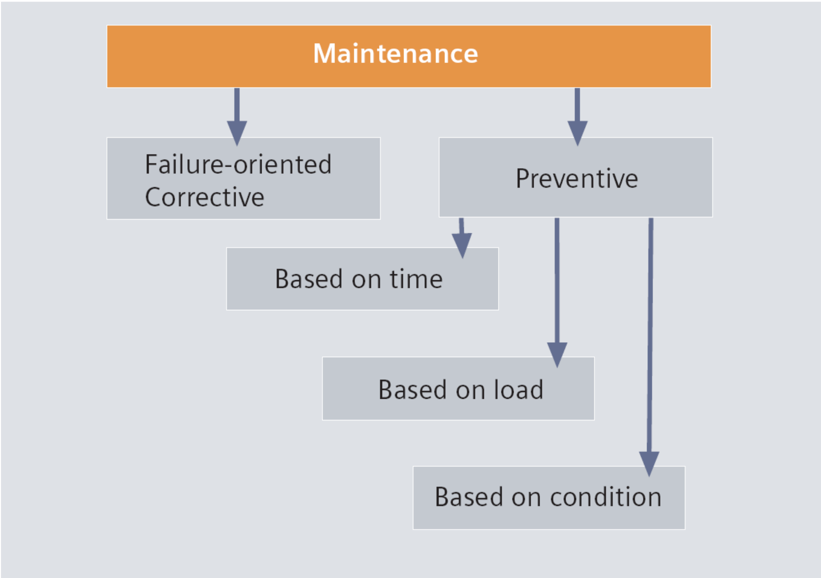

Figure 2 – Maintenance strategies

• Failure Mode and Effect Analysis	FMEA
• Time Based Maintenance	TBM
• Load Based Maintenance	LBM
• Condition Based Maintenance	CBM
• Root Cause Analysis	RCA
• Value Based Maintenance	VBM
• Reliability Centred Maintenance	RCM

Table 1 – Other maintenance strategies

Condition Based Monitoring

The objective of Plant Asset Management is to do proactive rather than reactive maintenance wherever possible. Condition Based Monitoring (CBM) focuses on optimizing the timing of maintenance. It seeks to avoid unexpected equipment failures on the one hand (too late maintenance) and unnecessary maintenance on the other (too early maintenance). To achieve this goal the individual assets either require embedded intelligence or specific condition monitoring techniques at a higher level.

There are two main asset classes. Automation assets such as field transmitters, actuators, sensors, electrical switching & protection gear and automation system components have far advanced with embedded condition monitoring. Process assets on the other hand such as pipes, valves, pumps, conveyors, filters, scrubbers and other mechanical apparatus still largely lack effective condition monitoring. While process assets typically constitute only 20% of failure instances in a plant, these failures contribute to up to 80% of the total maintenance costs. Various techniques for monitoring mechanical equipment have therefore been developed. These include using control equipment for monitoring controlled devices (e.g. electro-pneumatic positioners monitoring control valves; electrical drives monitoring conveyors etc.), installing specialized sensors, measuring and diagnostic equipment (e.g. infrared thermography, ultrasonic noise sensors, oil analyzers etc.) and process modelling at a higher system level.

Practical examples of condition monitoring

An example of how to monitor controlled equipment is the intelligent electro-pneumatic valve positioner. Control valves vary in dimensions, from pipe sizes a fraction of an inch to a few feet in diameter. Valves control the flow rate of various types of abrasive, corrosive or viscous substances and are therefore subjected to wear and tear. State-of-the-art electro-pneumatic positioners not only perform extensive self diagnostics but also determine the condition of the physical valves or flaps which they control. At first the positioner “learns” the correct behaviour of a “good” valve. Then during normal plant operation it detects any deviation from this “normal” behaviour. By this principle one can detect valve stickiness, pneumatic leaks (e.g. torn membrane), breakage of the valve cone, deposit build-ups on the valve cone or seat, wear and tear of the valve cone or seat and various other mechanical deteriorations. To the operator the valve may still appear to be functioning correctly at this stage, but on the maintenance station the valve is indicated as having a problem and signals the degree of seriousness of damage. Maintenance can immediately be planned and the necessary repair actions executed before serious damage is caused.

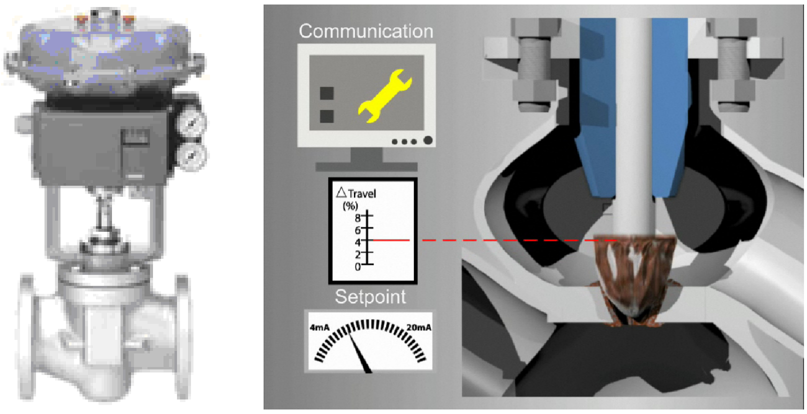

Figure 3 – Condition monitoring on valves – deposit build-up on valve cone & seat

Another practical example is the condition monitoring of centrifugal pumps. A Pump Asset Monitoring block in the process control system “learns” the characteristic curves of a “good” pump. The characteristics include the flow curve, power consumption curve and NPSH curve. During normal plant operation the Pump Monitoring block reads the electrical power consumption, input and output pressures and the flow rate of the pump. From these variables it calculates the actual pump operating points and plots them on the original characteristic curves. Deviations between the actual operating points and the original characteristic curves imply that something is wrong with the pump. The system can identify various problems such as blocking, high gas content in liquid, dry run, cavitation or a damaged impeller. The block further distinguishes between sudden breakage and gradual wear and tear, and reports the status and severity level to the maintenance station. This method of condition monitoring is very cost effective as it makes use of existing measurements instead of requiring additional specialized field equipment.

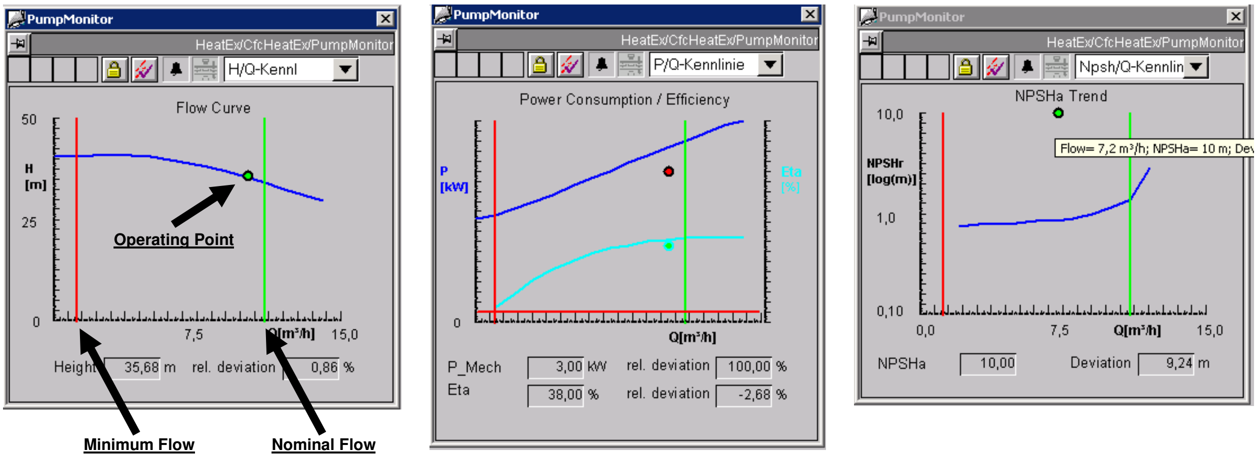

Figure 4 – Characteristic curves and operating points on centrifugal pumps

In a similar way condition monitoring can be performed on other non-intelligent process assets such as heat exchangers, vessels, filters, scrubbers and even pipes and elbows by using innovative algorithms in the process control system.

Consideration for evaluating a Plant Asset Management system

There a many different approaches of implementing Plant Asset Management. Before deciding on which system to use, it is imperative to evaluate the options. Various guidelines and study results have been published (please also refer to “Additional literature” and the “References” at the end of this paper). Here is a brief list of pointers to be observed during the evaluation of a Plant Asset Management system:

- use of Intelligent field devices and electrical equipment in green fields projects
- condition monitoring of all asset classes (automation and process)
- good alarming, visualization and navigation hierarchy
- enhanced diagnostics with guidance on necessary maintenance actions
- support for managing the maintenance workflow
- audit trail and maintenance reporting
- integration of PAM into process control system [iv]
- separation of operator and maintenance information
- uniform symbolic representation of all asset classes (with prioritization of severity)
- PAM should involve minimal engineering and maintenance effort
- modularity to allow future expansions and enhancements over plant’s entire lifecycle
- PAM / MES / EAM / ERP interoperability

Conclusion

Plant Asset Management is aimed at maximizing the return on investment of a process plant. Sponsored by the operation’s executive it creates a culture according to which every staff member contributes to the most effective way of running the plant. This process is supported by selected tools and systems at the various levels of the plant operational hierarchy, which facilitate managing, planning, monitoring, executing and controlling of all maintenance related activities. The result is the optimal utilization of all assets.

The chosen maintenance strategy plays an important role. According to the ARC Advisory Group [ii] up to 90% of maintenance cost can be saved when implementing Predictive rather than

Reactive or Corrective maintenance (see Figure 5 – Potential cost savings when using the correct maintenance strategy).

While no ideal Plant Asset Management exists, there are many good examples of how operations have benefited from implementing various Plant Asset Management systems and solutions. In order to remain globally competitive and attain a leading edge every process plant should implement Plant Asset Management and furthermore constantly strive to expand and improve these systems.

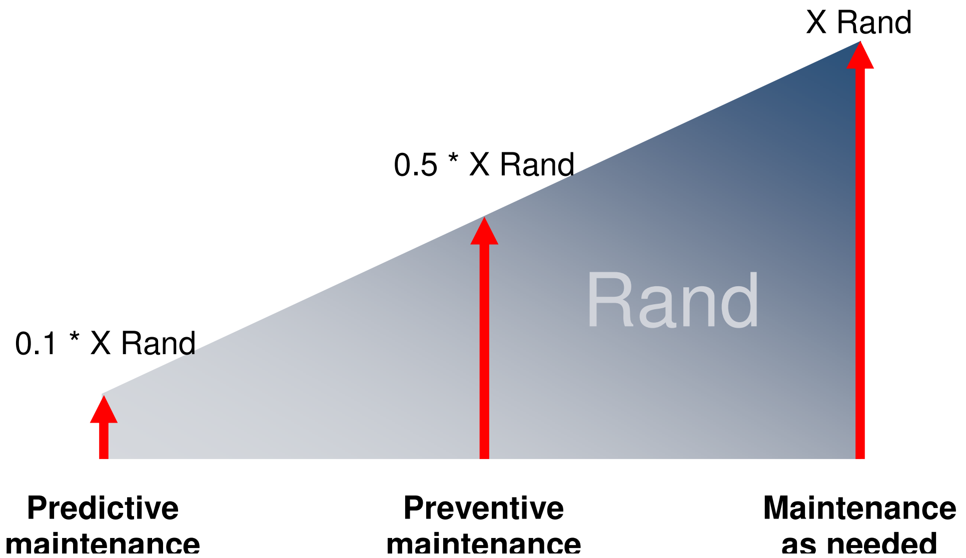

Figure 5 – Potential cost savings when using the correct maintenance strategy

Terminology and abbreviations

CBM	– Condition Based Maintenance
CPM	– Collaborative Production Management
EAM	– Enterprise Asset Maintenance
ERP	– Enterprise Resource Planning
FMEA	– Failure Mode and Effect Analysis
KPI	– Key Performance Indices
LBM	– Load Based Maintenance
MES	– Manufacturing Execution System
MRO	– Maintenance Repair & Operations
MS	– Maintenance Station
NAMUR	– Interest Group of Chemical & Pharmaceutical Industry
NPSH	– Net Positive Suction Head of a pump
OEE	– Overall Equipment Efficiency
PAM	– Plant Asset Management
PCS	– Process Control System
RCA	– Root Cause Analysis
RCM	– Reliability Centred Maintenance
ROA	– Return On Assets
ROI	– Return On Investment
TBM	– Time Based Maintenance
TCO	– Total Cost of Ownership
TDC	– True Downtime Cost
TEEP	– Total Effective Equipment Productivity
TPM	– Total Productivity Management / Total Productive Maintenance
VBM	– Value Based Maintenance

Additional literature

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Resources

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[iii] "Status Message of Field Devices" NAMUR NE107
[iv] "Requirements for Online Plant Asset Management Systems" NAMUR NE91, November 2001