SIMETAL CONDITION MONITORING SYSTEM: INTEGRATIVE MONITORING FOR MECHANICS, AUTOMATION AND PROCESSES[1]

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Abstract

The key to successfully improving the efficiency of a manufacturing facility or its individual equipment is the collection, analysis and interpretation of all relevant data. A fully integrative condition monitoring system - in conjunction with a competent maintenance service - helps to visualize the plant's condition and serves as the basis for predictive and focused maintenance activities. The resulting avoidance of unplanned downtimes and equipment damage leads to an increase in the overall productivity of the facility, while also keeping product quality at a high level. This paper shows a concept to turn today's standard solution, with different specialized tools and systems with different user interfaces, into a versatile system that gives the best condition monitoring information with just one mouse click.

Keywords: Condition monitoring system; Data acquisition; Maintenance service; Increase of overall productivity.

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1 INTRODUCTION

In the metals industry, monitoring the condition of machines, automation and processes is crucial for preventing unplanned downtimes and unintentional impacts on product quality. To derive the necessary information, a huge amount of data has to be analyzed – data that needs to be gathered from a variety of systems throughout the entire plant without having to generate the information twice. Existing information must also be incorporated. Because it is inevitable that the plant and its processes change over the years, the information system must be adaptable to the ongoing needs of the plant without influencing the operative automation system. For maintenance and quality reasons, new conditioning monitoring information and analyses (evaluation packages) should be easy to install.

2 TODAY’S LANDSCAPE OF CONDITION MONITORING SYSTEMS

Condition monitoring systems (CMS) are used over a long period of time to monitor single components like motors, hydraulics, gears or single functions. This leads into a various number of different systems from different suppliers with different user interfaces that are spread over the entire plant. Each system has specialized functions to give the optimal condition and the best potential for detailed analysis and diagnostics. Some of them are integrated in the automation system; others are additional stand-alone systems.

This presents a major challenge for the maintenance teams, as the information required for predictive maintenance comes from different CM systems with different content. Even when the distributed alarm messages are integrated into an automation system, in most cases only minimal information is transferred, which is not sufficient for an initial evaluation of the condition reporting and requires a diagnosis within the CM systems. Also, many maintenance engineers would prefer operative and maintenance systems to be separate. This is because while a facility’s operative system is preferably changed as little as possible during the life cycle of the facility, a condition monitoring system has to be adapted to the changing operating conditions and experiences of the plant operator during that life cycle. As far as possible, these changes should be able to be made by maintenance teams, so that the operating units can concentrate on achieving optimum production. The system must also be easily extendable.

Systems currently on the market that are closed and do not have a sufficient number of interfaces are also not comprehensively extendable if, at a later date, it is found that information from other existing systems needs to be incorporated in order to improve an analysis.

Most condition monitoring systems also have predefined functions and can only be extended by the user to a limited extent. But it is precisely in complex facilities that experienced maintenance engineers tend to know exactly which analysis functions are needed to determine the condition of the system. In many cases there are also research units working on this problem. In order to turn these functions into a condition monitoring system that is suited to the industry it is normally necessary to collaborate with the system manufacturer, which usually means an outflow of know-how, as well as resulting in development periods that are incompatible with requirements within plants.

In addition to this, the industry is currently in the middle of a technical revolution[1] that is bringing the physical and virtual worlds together. The first three industrial revolutions came about as a result of mechanization, electricity and IT. Now, the introduction of the "Internet of Things and Services" into the manufacturing environment is ushering in a fourth industrial revolution.
Machines and objects become smarter and can communicate with each other. The Internet of Things means the connection between a physical object and its representation in the internet or an equivalent structure (e.g. intranet). One example for this could be the evaluation of conditions of a plant using sensor technology and translation of that evaluation into actions. The use of individual, independent CMSs makes provision of the required information in analyzed form much harder.

3 REQUIREMENTS FOR A VERSATILE CONDITION MONITORING SYSTEM

A comprehensive condition monitoring system should make the maintenance engineer's work easier, providing all condition information (CM info) for a facility, regardless of the point at which it is generated. The following is a list of important requirements for such a system:

- Provision of the condition information from all monitoring systems within the plant, regardless of whether these are existing or newly installed (example: integration of an oil analysis sensor, the results of which can be found in a control system).
- Enhancement of stand-alone condition monitoring systems with or without also linking them to further information (example: the changing of existing analysis results with production speed or loading condition; generation of charts of long-term trends).
- Using CM info as a direct basis for decisions on work orders and recommended actions, or for monitoring recommended actions received (example: CM info charts clearly identify the first signs of damage to drives; the tendency for valves to leak shows progression of the damage; monitoring and exceedance of limit values of change coefficients of stand control shows the condition of the control modeling).
- Being a host system as the entry point for a remote service with scalable data access. (Example: The Siemens service can be connected to the CM Management System, only obtaining access to CM information, without raw data. When required, the customer can activate the service in order to be connected to the CM source, which can be reached via the CM information from a server-client, HTML or remote desktop connection. Once the connection has been set up, a detailed analysis can be conducted on the basis of the raw signals.)
- Separation of the CMS from the operative system, with change being possible over the entire life cycle (example: fatigue breaks are more frequent as a result of changing a mechanism. A new function for monitoring this is to be incorporated. Separation from the operative system means that changes of this sort can often be made while the plant is in operation).
- The performance of complex monitoring functions by the user, in order to avoid disclosure of internal knowledge.

- Interfaces to CMMS, MES, QMS and other systems (example: production data can be used for the analysis of damage which gives additional information on the operating point; forwarding of CM information for generating a work order in CMMS).
- A memory concept for data, for the detailed analysis and monitoring of long-term trends (example: on the basis of new knowledge about the origin of damage, the measured data from two years previously needs to be reanalyzed; in order to identify the causes of a damage event all data measured in the last few days needs to be reevaluated.)

4 INTRODUCTION OF SIMETAL CONDITION MONITORING SYSTEM

Siemens offers an innovative condition monitoring system[(2)] that integrates information from several automation levels in order to provide the best description of the condition of functions, equipment and even complete plants. This system is designed for the metals industry and combines specific expertise of a process turnkey supplier and the technological skills of a leading automation solution provider. The SIMETAL Condition Monitoring System introduces new communication principles to allow even third parties to connect condition monitoring information automatically. An information broker concentrates the required data from each individual source to centrally display the condition of the plant.
As shown in Figure 1 the system consists of the following components:

- Information management
- Data acquisition and data evaluation
- Cooperation with IT solutions (IT4Metals)
- Integration of 3rd party systems

The individual components are described below.

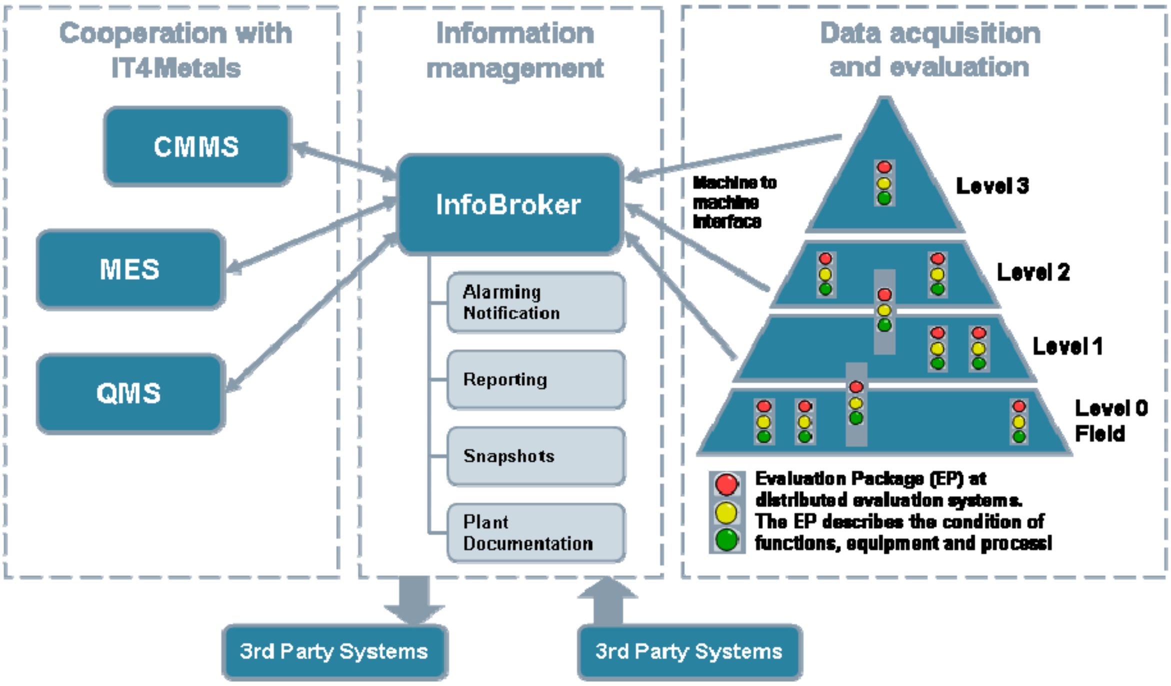

Figure 1: Overview of an integrative condition monitoring system.

4.1 Information Management

The Condition Monitoring Info Broker is the interface from maintenance or operations to the condition monitoring information. It gathers data from evaluations (evaluation packages) across all automation levels. In addition to the standard colored alarm messages, the information contains additional details called "info packages", which provide more data on any detected abnormalities to production and maintenance teams. This supports a quick assessment of the situation without the involvement of specialists. Through individualized views and report classifications, the information broker’s output can be adjusted to the needs of different user groups (Figure 2). This solution works alongside the operative system and provides an ideal access point for remote services without connection to or interaction with other systems in the plant (for example, online automation).

Information management thus holds the information on all the existing condition information for the plant and, as a result, can represent an effective interface between the physical and virtual worlds for the purposes of "brokering" required data.

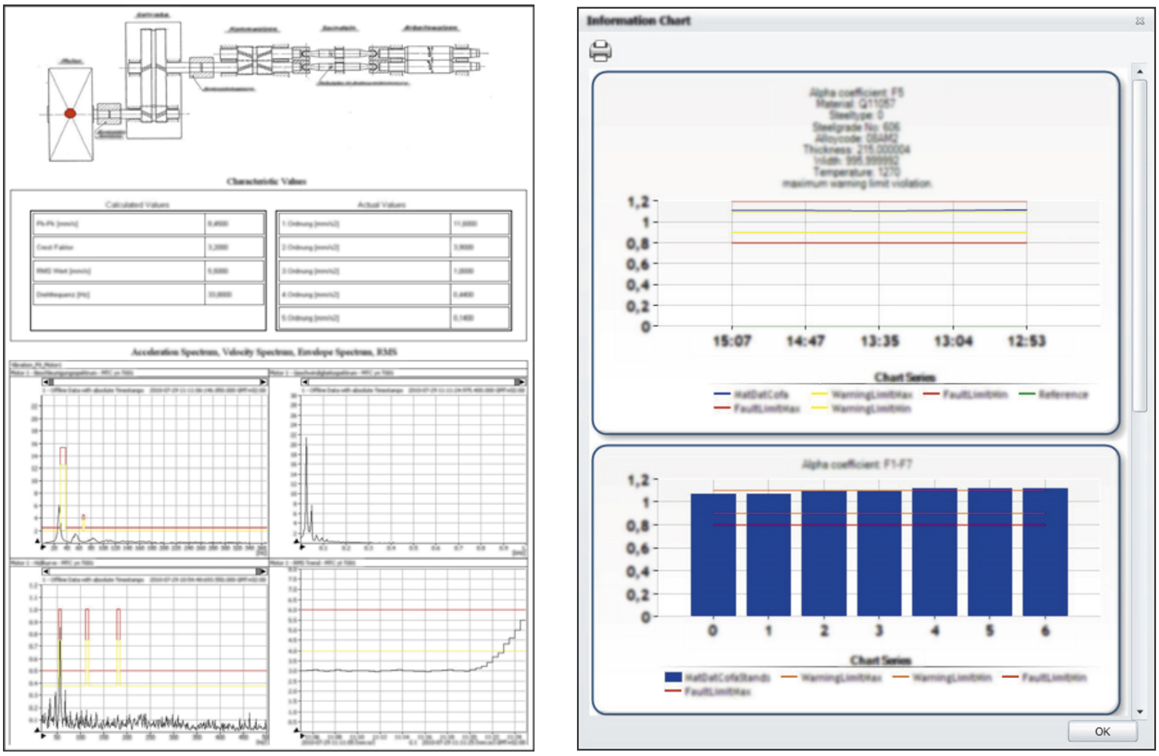

Figure 2: Examples for automatic vibration report (l.) and model coefficients for stand control (r.)

To ensure that systems are easy to extend, communication between information management and the data acquisition and data evaluation systems is based on an machine to machine interface[3] in which each item of CM information "registers itself" in information management and informs it of which information it is transferring and which assembly or function is being monitored. The following data is transferred during this process:

Table 1: CM Definition Language (based on the example of vibration monitoring)

CMname	EP vibration (EP=Evaluation Package)	CM definition
CMlocation	FM_F2_ET_GBX_S2_BA	
CMdescription	FM F2 main drive, level 2, roller bearing A: vibration analysis	
CMunit	Unit of CM information: "status" or unit as text, e.g. [mm], [V], [A], etc.	
CMsourcename	ID code of the sensor	
CMsourceID	Name of PC on which analysis is being conducted	
CMvalue	For "status": 0/1/2 for green/yellow/red For "unit": the value to be transferred	CM info
CMaddinfo	Additional info, e.g. plain text message or instruction	
CMtime	Timestamp of the event	
CMtype	Name of type of "binary large object" (e.g. png, pdf, …)	
CMchart	Binary large object (optional)	

In addition to the transfer of CM information, other functions are supported such as, for example:

- Request of the last evaluated CM information (info management → evaluation)
- Registering of additional information on an existing item of CM Information (evaluation → info management)
- Parameter setting (info management → evaluation)

4.2 Data Acquisition and Evaluation

X-Tools(4) is a flexible evaluation system that allows data to be collected from multiple sources through different interfaces in a synchronous mode. It has a library for analysis and monitoring to cover nearly all kinds of monitoring tasks. X-Tools is also used as a gateway for third-party systems to send "info packages" to the CM Info Broker.

Most of the systems on the market have predefined condition monitoring systems that are parameterized using standard input screens. This works well with many applications, but it also limits freedom to optimally adjust a condition monitoring system to the requirements of plants. In contrast to this, the X-Tools system is configured similarly to a programmable logic control system. It has options for graphical and script-based programming and can perform almost any monitoring task (Figure 3). Also, any combination of views is possible. The object-based configuration of the overall system enables modules, functions and even entire projects to be created and copied using "drag & drop" and "copy & paste".

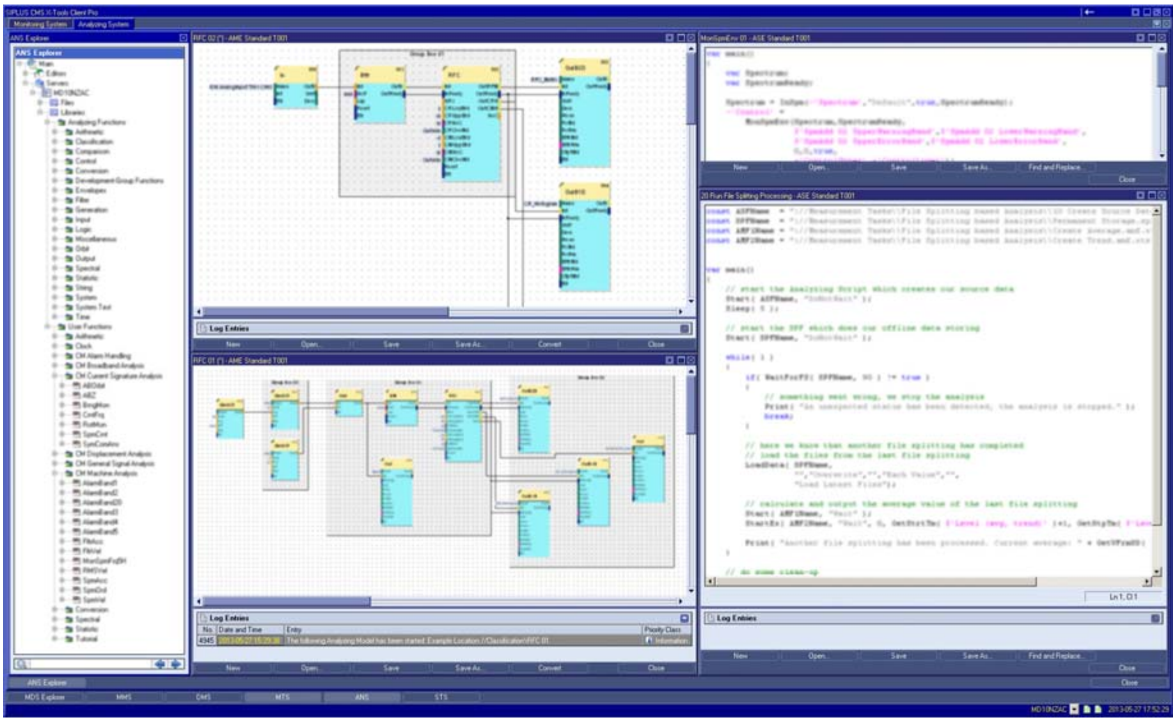

Figure 3: Analysis system with, from left to right: library elements, graphical programming and script programming.

To enable easy engineering, X-Tools contains, in addition to standard functions, a monitoring library with IEC 61499 compliant function blocks. Figure 4 shows a basic example provided by the VDMA Condition Monitoring working group.[5]

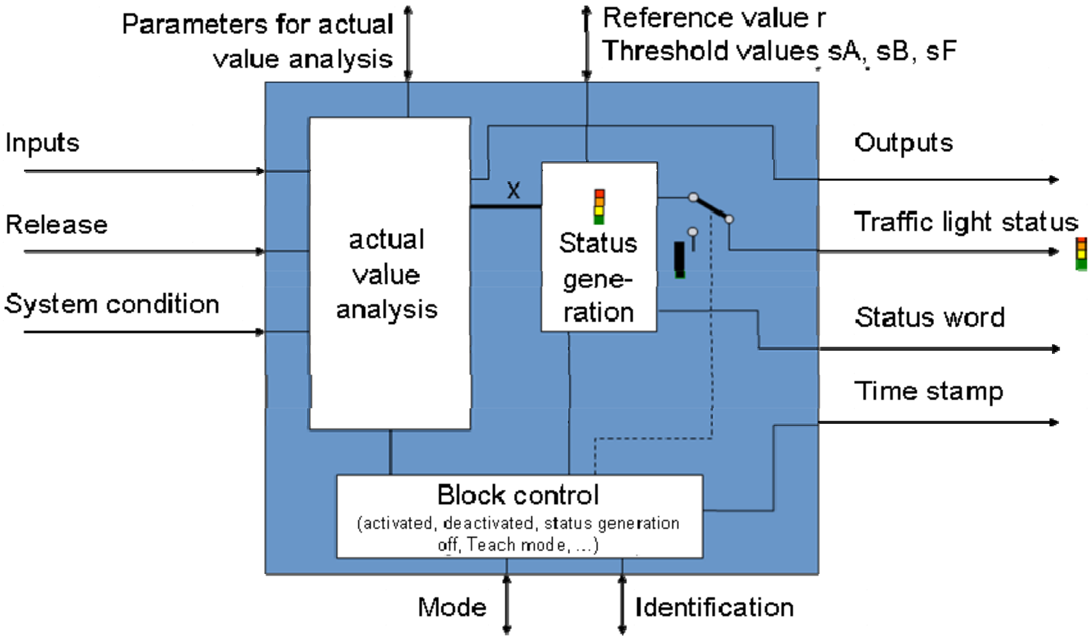

Figure 4: Function block based on CM reference architecture.[2]

In addition to its purely analytical functions, the X-Tools system also has the necessary graphical options for results visualization, which can be used to show alarm limits, variable alarm curves or complex alarm bands (a selection is shown in Figure 5). Examples include:

- x/t and x/y diagrams (example: monitoring of trend and pressure-path characteristic curve)
- Frequency and order spectrum (example: vibration analysis for constant RPMs and measurements during changes in RPM)
- Orbit chart (example: monitoring of sleeve bearings)
- 2D and 3D histogram (example: display of mechanical loads and operating points)
- Waterfall diagram and isometric diagram (example: display of transition conditions and changes)
- Bode diagram (example: monitoring of controls)
- Presentation of image elements with traffic light displays and input and output (example: graphical condition overview)

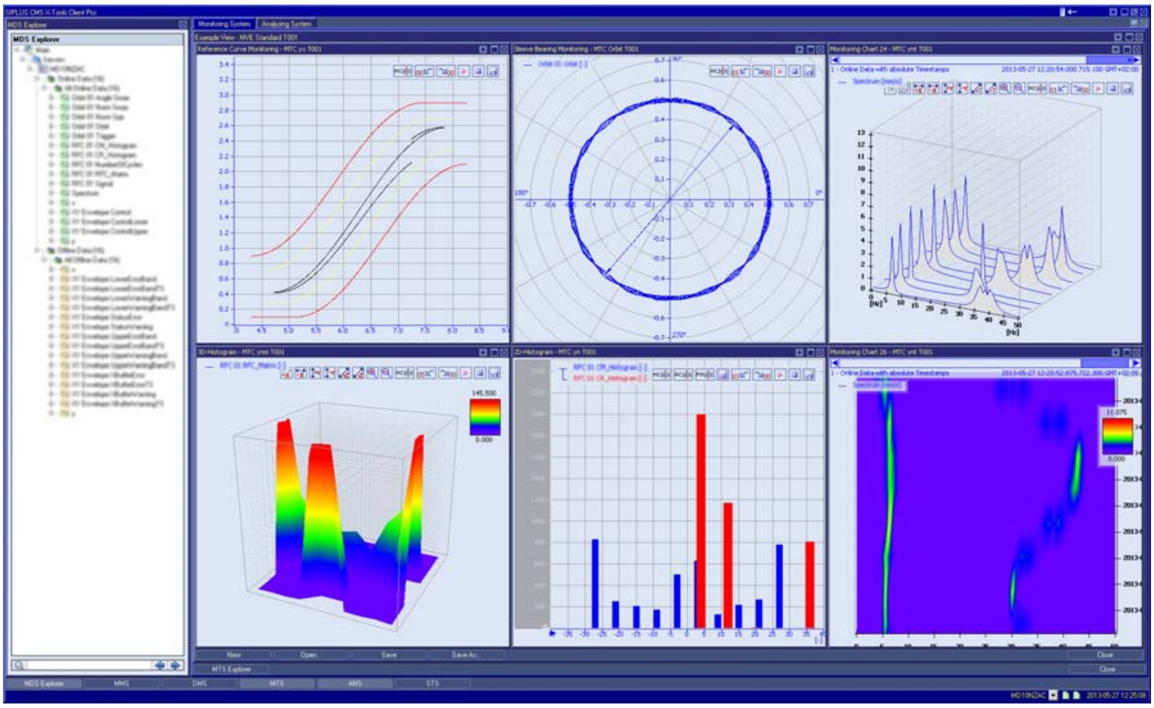

Figure 5: Visualization options, from left to right: tree structure with signals, x/y diagram with alarm monitoring, Orbit, waterfall diagram, 3D and 2D histogram, isometric diagram

The memory concept allows storage of a complete dataset containing both the raw data and the calculated curves, the alarm limits used and characteristic data. The long-term storage of these complete datasets enables the representation not only of behavior over the course of the life cycle (e.g. in a waterfall diagram) and adjustments to alarm limits but also, when necessary, enables subsequent analyses to be conducted with new algorithms based on the raw data. This can help in the verification of new condition analysis results with old data and damage events. The memory concept can also be adapted to the needs of the plant as required, both as regards data quantity and memory requirement.

4.3 Cooperation with IT solutions (IT4Metals)

Interfaces for the transfer of both condition information and raw signals are provided for the exchange of information between the CMS and other IT solutions. Figure 6 shows other IT solutions in Siemens' IT4Metals portfolio.

Figure 6: System overview - IT4Metals.

4.4 Integration of 3rd Party Systems

In order to be able to meet the requirements of a comprehensive CMS, 3rd party systems can also be integrated, alongside Siemens' own systems. Integration into information management depends on the type of system to be integrated. There are two types of system and objective:

- Systems of which the condition information is to be directly integrated
- Systems of which the condition information is to be enhanced and integrated.

For direct integration the condition information can be directly exchanged with information management. If the condition information is to be enhanced the data is first pre-processed by the X-Tools evaluation system and then sent to information management. Examples of enhancement of condition information or signals:

- The generation of trends from individual values or waterfall diagrams from spectra
- The merging of several items of condition information in one report
- The changing of measurement results with process signals
- The generation of alarm messages and alarm texts.

5 SERVICE

With a comprehensive condition monitoring system that holds condition information at a central point as described, the work of the plant service(6) is made easier through the reduction in the number of interfaces. The plant operator can obtain all condition information gathered with a single mouse click in their web browser. When necessary, access can be allowed to the CM systems that provide the condition information, so that diagnoses can be made on the basis of the raw data held by the distributed CM systems.

6 CONCLUSION

Siemens offers an innovative condition monitoring system that integrates information from several automation levels in order to provide the best description of the condition of functions, equipment, and even complete plants. This system is designed for the metals industry and combines the specific expertise of a process turnkey supplier and the technological skills of a leading automation solutions provider in this industry. The SIMETAL Condition Monitoring System introduces new communication principles to allow even third parties to connect condition monitoring information automatically. An information broker concentrates the required data from each individual source to centrally display the condition of your plant.

Unlike an online automation system where the first priority is to control the plant in the defined operation mode, the actual and the reference condition of the plant or its individual parts may change during their lifetime.

This makes flexibility an important requirement for a condition monitoring system, so that it can easily be adapted to new situations – or extended with additional evaluation packages.

Benefits:

- Increased plant efficiency – by reducing the number of unplanned downtimes
- Additional analytics and evaluation packages – designed for the metals industry
- High product quality – ensured by high-level maintenance of equipment and controls
- More focused maintenance and operation – thanks to qualified CM messages
- Flexible and easy-to-maintain monitoring system – based on a modular, scalable, and integrative design
- Versatile condition monitoring – with just one system for the supervision of process quality aspects, automation functions, and equipment vibration

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