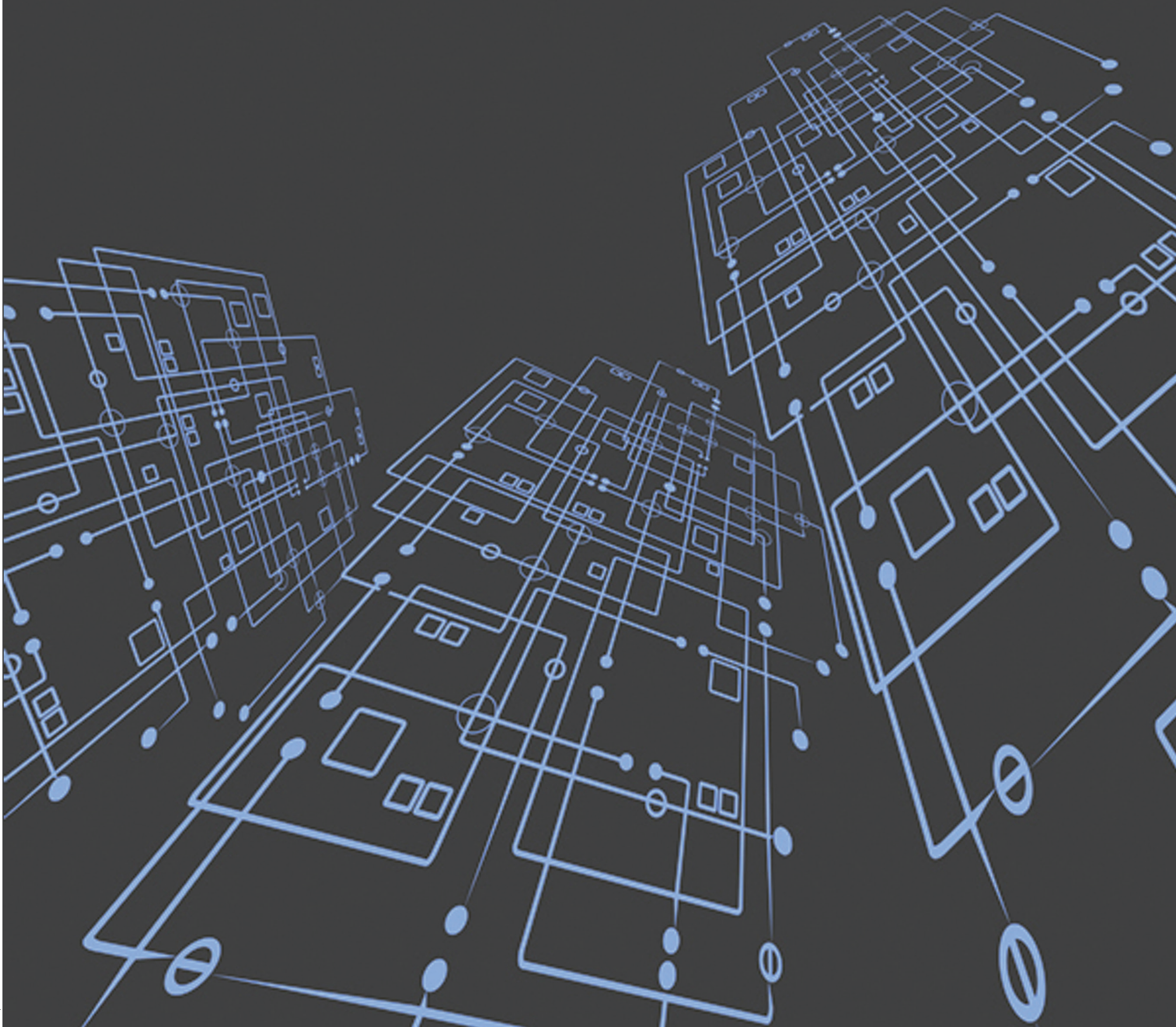
Technical Papers



Fleetwide Monitoring – State of the Art Collaboration Meets Predictive Analytics for Optimizing the Entire Fleet

Joël Wagner
STEAG Energy Services GmbH
Essen, Germany
Tel: +49 201 801 4037
Email: joel.wagner@steag.com

Lea Boche
STEAG Energy Services GmbH
Essen, Germany
Tel: +49 201 801 4035
Email: lea.boche@steag.com

Abstract

In this paper a fleetwide monitoring solution is presented that provides the essential information for a reliable plant operation right at the fingertips of the users. The innovative approach combines predictive analytics for early warnings with a powerful, easy to use web-based user experience.

1 Introduction

The operation of power plants is highly complex. For the utilities, managing a reliable plant operation with frequent start-up and shutdown procedures, different fuel qualities, and a high availability at maintenance costs as low as possible is both a challenge and a chance.

One reason for the changed boundary conditions is the addition of renewable energies to the market. The objective is to be able to successfully meet the volatile requirements of the energy market with a flexible and economically efficient power plant operation in future.

The expert software solutions of STEAG Energy Services ensure an assessment of plants in procedural and technical terms. By continuously evaluating available performance values, the systems provide reliable information enabling an optimized mode of operation and reliability-centered maintenance (RCM) of the plant and help to increase the plant's availability early on.

Information on the efficiency, load-independent performance factors, coal qualities, heat rates, and availabilities describes the quality of the operation and is available on site. Fouling and wear of the plant components, i.e. creeping changes of the operation, can thus be detected in a timely manner, and additional costs can be avoided. Further key figures regarding planned and unplanned shutdowns, load regime, and economic KPIs like sales and EBIT can be queried via further expert systems.

The existing systems all have one thing in common: they are designed for the responsible experts on site. A linkage of strongly condensed procedural and commercial information is required for comprehensively assessing the individual plant as well as for optimizing the entire fleet.

The fleetwide monitoring solution of STEAG Energy Services integrates state of the art software components to build a scalable solution and to match the demands of both management and operating crew on site. The use of the latest collaboration tools and methods avoids the drain of knowledge and enables a fast communication across technical and organisational borders.

2 Status quo – Demand for Real-Time Access to Essential Information

Performance monitoring in power plants has become widely used in the last ten years. This involves data archiving, thermodynamic and mechanical data analysis with first principle models on-line and off-line, neural networks for data-driven approach on data analysis, and diagnostic tools.

Meanwhile, many expert software systems like the SR solution of STEAG Energy Services are available at numerous power plant sites to assess the highly complex plant operation and to support the decision making process of plant engineers and the operating crew on site. The data administration and visualization are effected in a local data management system. Periodically, operational data are extracted from DCS systems and other source systems.

The existing systems all have one thing in common: they are designed for the responsible experts on site. The systems cover different technical topics which are mostly not linked within the software. A successful collaboration about current queries depends on the human factor.

The fundamental challenges for utilities are:

- Important management information is available in different IT systems.
- The same information is prepared new again and again in different places in the company.
- A transparent feedback of the information passed on to management is not ensured for each site.
- Usually, sites only know their own key figures.
- High investment of time for compiling the reports (diligent but routine piece of work, risk of errors due to manual transmission of data)
- No direct inference to the data origin possible
- Comparability of information not ensured due to different data conventions
- Poor availability, low proliferation of the reports (manual filing, small group of users)
- Bottom-up analysis very elaborate as different source systems with different condensation stages are used

Those issues pose a tremendous challenge to the decision making process and include some risks which are:

- Important findings may be overlooked due to the vast amount of information
- Mismanagement and communication conflicts between management and site
- Unscheduled downtime and poor maintenance practices

For executives there are plenty of reasons to demand a greater return on their enterprise assets due to rising fuel and material prices, changing industry regulations and an increasing complexity of the power plant operation. One way to ensure optimal conditions of components and efficiency of the entire fleet is to provide decision-makers with access to real-time information about the health and performance of their assets.

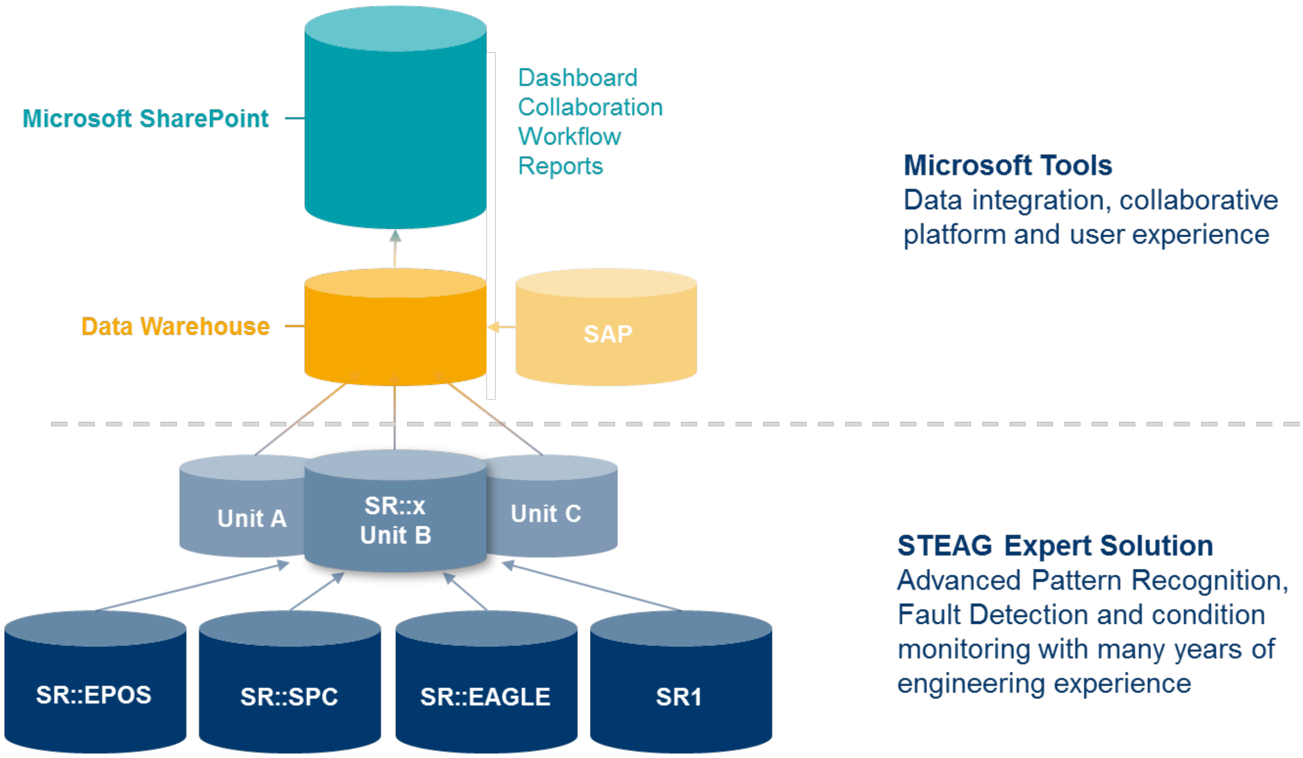


Figure 1: Data Management of the STEAG Fleetwide Monitoring Solution

3 Preconditions for a Powerful State of the Art Fleetwide Monitoring

The challenge is to automate the compression of information to the greatest extent possible in order to differentiate between important information and less relevant data. Besides methods for SPC (statistical process control) in terms of an early warning system, criteria for the weighting of information are considered for this as well.

The assessment of events regarding the plant availability, the process performance, and the operational safety enables an event ranking in order to detect essential operating potentials early on and to avoid controlling errors. In doing so, the respective current plant condition, a comparison with reference conditions, or the medium- up to long-term change of performance indicators can be assessed.

The question for all currently relevant information also depends on the range of duty of the user of the fleetwide monitoring system. Thus the system has to support different user roles and customized views. For more on this refer to Chapter 5.

The essential precondition for the representation of so-called meta-KPIs that describe the current overall condition of a plant consists in reliable findings on process quality, component conditions, and external influences. The following modules are vital elements of the comprehensive fleetwide monitoring solution of STEAG Energy Services GmbH.

3.1 Performance Quality Monitoring – SR::EPOS

Continuous monitoring of process quality is an essential way of discovering optimization potentials in power plant operation. Deviations from optimum operation develop slowly and are often concealed by the effects of external boundary conditions, such as environmental parameters. The result is a considerable deviation from maximum efficiency.

SR::EPOS continuously monitors the power plant process under technical and economic aspects. Important plant components are assessed cyclically. Within the scope of online diagnostics, additional operating costs are shown to reflect deviations from the optimum conditions that are possible at that time. This allows to weigh the individual deviations and to take the required measures.

Depending on the plant's design and on the possible modes of operation, SR::EPOS can suggest an optimum mode of operation from both economic and ecological aspects. Typical applications for optimizing operation with SR::EPOS are setting the optimum cooling water volume, especially in partial load operation, optimizing the use of soot blowers, and optimizing grinder operation.

SR::EPOS fully automatically conducts what-if calculations in order to determine the influence of individual process parameters or components of the plant on the overall efficiency. The results calculated here clearly show how large the contribution of a specific process parameter or of a certain component to the increased heat rate is. On the basis of this information, the operator can assess the individual influences and design the countermeasures in such a way that the greatest effect is achieved as quickly as possible.

3.2 Statistical Process Control – SR::SPC

Power plants and their components are subject to continuous changes in their operational behaviour, which, for instance, can be traced back to wear-and-tear or fouling. Every now and then, these changes lead to failures of components.

In order to get early indications of developing faults through the continuous evaluation of relevant measured values, the use of statistical methods is recommended here. By this means, non-disposable non-availabilities can be converted into disposable ones. Then necessary repairs can be prepared foresightedly and they can e.g. be purposefully scheduled in periods of weak load or during weekend shutdowns.

SR::SPC imitates the engineer's work of analyzing time series and – just like the experienced engineer who looks at a recording strip or history of measured values, but automatically – detects significant trends and patterns or sudden leaps in the monitored characteristic. By applying various procedures and suitable rules for evaluating the results, the reliability of the statements can be further enhanced.

This module is able to deduce indications for an optimized mode of operation of the plant on the basis of simulation in the context of thermodynamic modeling or also by means of heuristic approaches like fuzzy logic. Prominent examples of such applications are the optimization of the cold end of a power plant regarding the amount of cooling water / the mode of operation of the cooling tower or intelligent sootblowing.

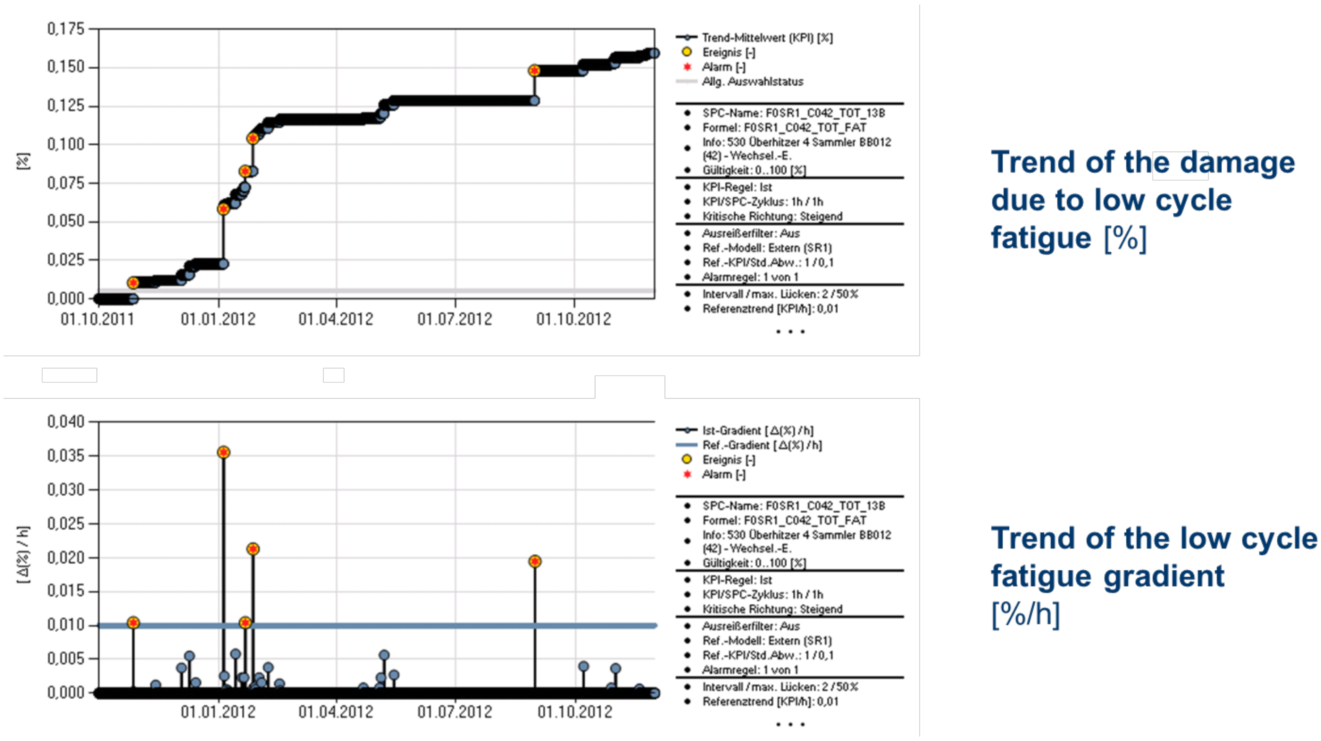


Figure 2: Event Detection of Low Cycle Fatigue

3.3 Decision Tree Based Fault Detection – SR::EAGLE

Decision tree analysis is a technique by which the possible causes which can lead to undesirable top event are identified and organized in a logical manner. The 'Top Event' is the major failure to be analyzed in the fault tree. The primitive or basic failure events that ultimately cause the TOP event are connected through logical AND-gates and OR-gates. The gate symbol denotes the type of relationship of the input events to the output event.

The attractive nature of decision trees stems from the fact that it can isolate multiple fault conditions simultaneously. In many cases there are multiple causes for an undesirable event.

SR::EAGLE performs real time evaluation of the decision tree. The active causes of the event are isolated when the system is in on-line or operating mode by evaluating the root causes. The evaluation of decision tree is triggered only if the expression at top event returns a true value. The on-line decision tree has the advantage that is possible to define personalized trees for plant-specific phenomena; one is not limited to predefined trees.

3.4 Condition Monitoring for thick-walled boiler components and steam pipes – SR1, SR::SPM

In a scenario of increasing use of renewable energy the conventional power plants will be more and more forced to compensate for the volatility of the natural resources. Even huge coal fired units which have been designed for base load operation will face an increased

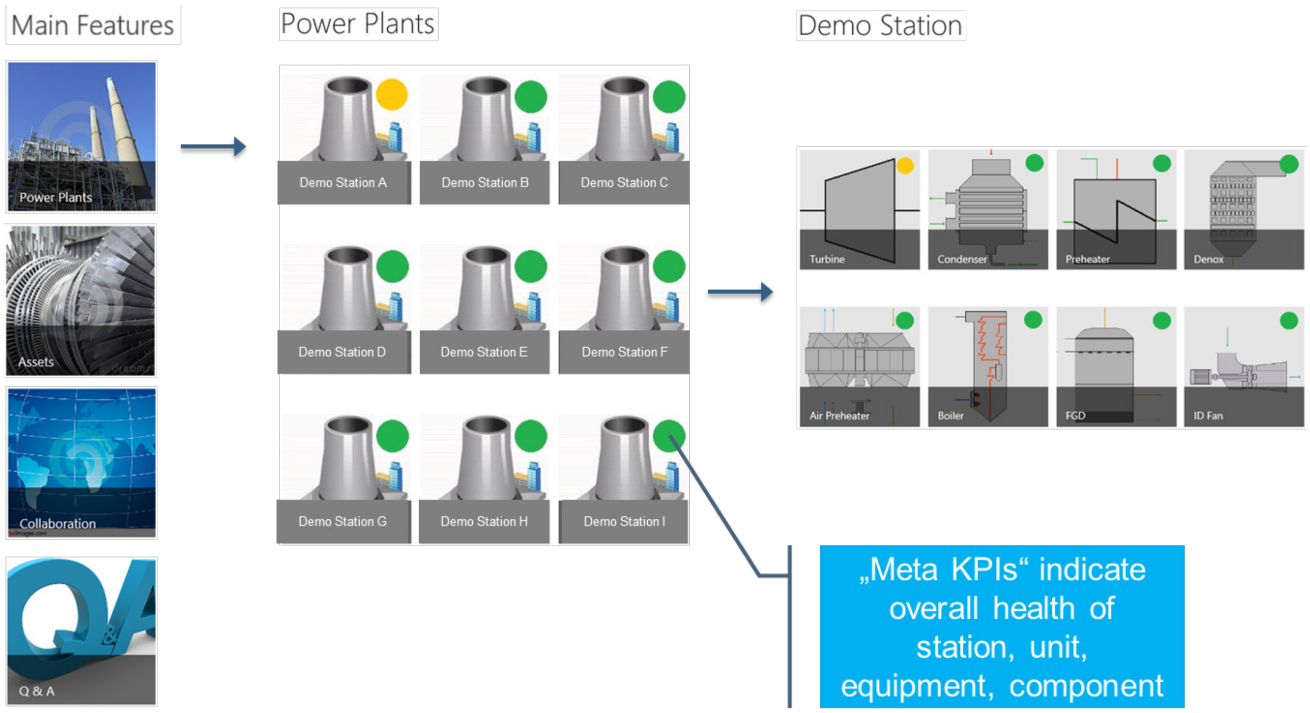


Figure 3: Visualization of "Meta KPIs"

number of start-up/shut down cycle and the requirement for faster load changes.

Particularly regarding thick-walled boiler components (e.g. drum, separator vessel, headers, moldings), the high cyclic loading by internal pressure and temperature leads to an increased alternating stress.

The calculatory stress is determined by means of online monitoring systems in order to allow for a realistic projection for optimizing the mode of operation. Thus the systems significantly contribute to ensuring a safe and economical plant operation.

A continuous monitoring of the component stress using statistical methods is particularly helpful in this context. The increase of creep damage and alternating fatigue is monitored by means of the online system SR::SPC. When an admissible warning limit is transgressed, the user is immediately informed about the status (Figure 2).

In addition, the trend analysis can be used for an extrapolation of creep damage and alternating fatigue into the future. For this, the projection period and a fatigue admissible in this period are defined. Planned shutdowns of the plant (no increase in fatigue) can be taken into account. If the expected fatigue is transgressed during the projection period due to the current mode of operation, one can react with a more moderate mode of operation, or the additional consumption can be economically assessed and tolerated if applicable.

3.5 Data Management and Visualization – Microsoft SharePoint

In order to allow all users direct access to the information relevant to them, the data

visualization is effected in a web browser. With SharePoint, Microsoft has developed a powerful enterprise platform for a company-wide collaboration. Besides views for different user groups, individual reports can be configured as well.
SharePoint supports a workflow management for forwarding, editing, and commenting. The activities are saved per KPI. In the case of recurring events, it is possible to quickly assess which findings and measures were chosen and carried out in the past.

The central data management of the fleetwide monitoring solution is preferably effected with an SQL server technology as data warehouse in combination with SQL Analysis Services for the configuration of different query and filter requests. By means of SQL Integration Services (SSIS), the integration of numerous data sources can be implemented without any problems.

4 IT-Based, Partly Automated Workflow for Plant Optimization

STEAG Energy Services has long years of experience in the field of on-line diagnostic systems for condition assessment and process optimization. In the context of the continuous development of the SR::Suite, modules have been developed to support the analysis and decision process as well as automate it depending on the progress of the solution, as part of a fleetwide monitoring solution.

The workflow is divided into the following five steps:

1. Detecting the event
2. Analyzing the cause
3. Assessing the effects of the cause
4. Carrying out measures
5. Building up the knowledge pool

4.1 Detecting the Event

Various IT tools are available for detecting events. The performance quality monitoring provides findings on the current process quality. SR::SPC allows detecting changes of process parameters and component conditions long before DCS warning limits are reached. SR::Query enables the systematic evaluation of processes limited in time (like e.g. fuel consumption during start-up, load change velocities as well as start-up times).

4.2 Analyzing the Cause

Basically it can be assumed that a cause in the operation leads to a large number of events that are identified by means of the tools which are described in Chapter 3 (like e.g. alarms in the field of vibration measurements due to a damaged bearing). The root cause analysis can be effected manually involving a sometimes significant expenditure of time, or IT-supported.

Manual Root Cause Analysis:

Initially, the analysis of the events is carried out isolatedly. Detailed procedural knowledge of the plant as well as operational experience are required to be able to draw inferences about possible causes. The manual root cause analysis is often time-consuming and requires involving various departments as the necessary knowledge is often not available from one and the same person.

Automated Root Cause Analysis:

STEAG Energy Services has developed the module SR::EAGLE for supporting the fast and systematic root cause analysis. The logic heat rate trees for coal-fired power plants of the EPRI (Electric Power Research Institute) are already preconfigured in the system. Further plant-

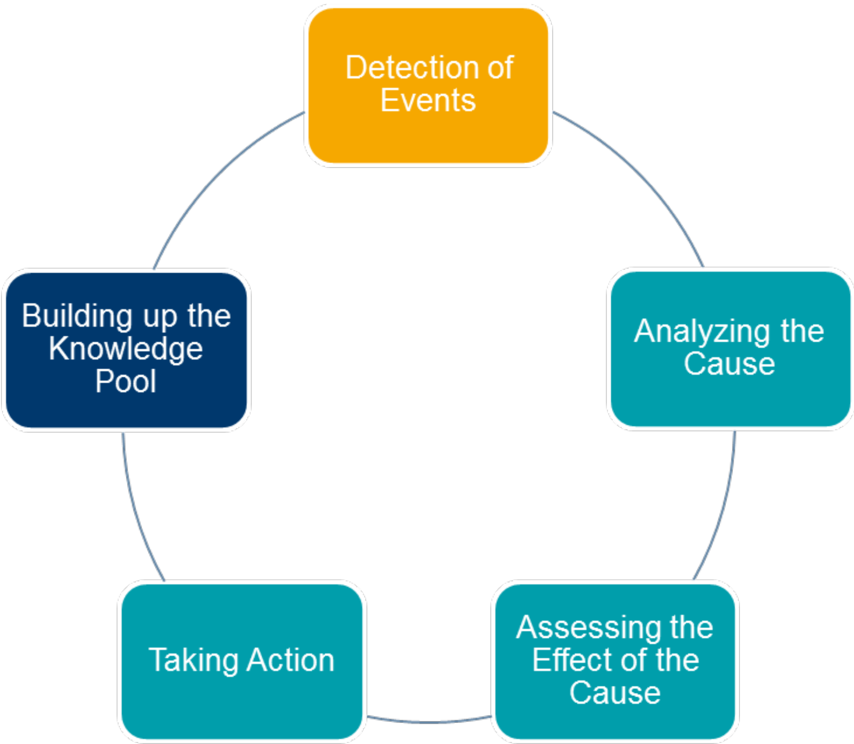


Figure 4: IT-Based Workflow for Plant Optimization

specific coherences are put into effect in the context of the implementation phase of the fleetwide monitoring system. The visualization of the automatic fault analysis is directly integrated into the web display of the fleetwide monitoring.

4.3 Assessing the Effect of the Cause

To be able to assess when and if a measure for problem solution is required, the effect is assessed with reference to performance, availability, component condition, and operational safety. For this, information from commercial systems (like e.g. SAP), tools for the planning of maintenance and overhauls, systems for condition monitoring as well as the performance quality monitoring are incorporated. For instance, the influence of the cause on the additional heat consumption and the efficiency loss respectively is assessed this way.

4.4 Taking Action

When it is certain that a measure is useful and necessary, workflows can be initiated. In the simplest case, these comprise a forwarding of the previously gained experiences to colleagues for further processing. This includes:

- Further analyses
- Optimization of the plant operation
- Initiating repair orders
- Planning of shutdowns for repair

Linkages with existing operation management systems and systems for maintenance management are possible.

4.5 Building up the Knowledge Pool

In the context of the event analysis, findings are gained that may be of great interest when events occur repeatedly. Which causes were identified lately? Which measures were successful / necessary? Who was involved in the workflow and might have more information? With its collaboration methods, SharePoint supports the user in setting up a knowledge pool. Besides a wiki and a Q&A report, a comment history per KPI is available as well.

5 Different User Roles for an Efficient Workflow

Not all information is of equal importance to all users. In order to optimally support the users in their daily tasks, different user roles are defined first of all in the context of the implementation phase of the fleetwide monitoring system. Later, individual views and favourites can be created per user.

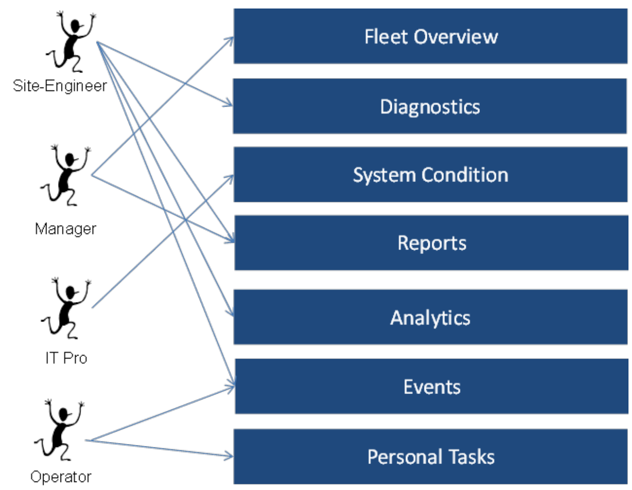


Figure 5: Different User Demand

By way of example, four user roles (site engineer, manager, IT expert, operator) are briefly described in what follows: while the operator is responsible for the current operation of the plant (measured value quality, compliance with DCS system limits and operating procedures for process control), the site or performance engineer, for instance, concentrates on medium- and long-term changes of the process quality in particular and analyzes conspicuous events.

In the overview of the entire fleet, the manager is interested in strongly compressed meta-KPIs like e.g. availability, maintenance costs, fuel consumption, and start-up costs.

The IT expert checks the system availability and the condition of the server hardware.

According to requirements, the access to reporting and analysis tools, to the event ranking and to the workflow manager can be set up for the different user roles in order to support an efficient workflow within the own scope of duties.

6 Summary

The combination of procedural, physical, and statistical methods of analysis with promising tools for pattern recognition is an essential feature of the fleetwide monitoring solution of STEAG Energy Services GmbH.

This makes events detectable earlier, causes can be analyzed and assessed, and measures can be initiated. Overviews of all plants enable a benchmarking in the positive sense in order to detect similarities and differences in the operation of the plants and learn from each other. The company-wide collaboration ensures that all departments for process optimization can be involved. A modern data management and open system architecture allow for a flexible scalability of the intended solution and for the integration of different data origins.

FLEET WIDE MONITORING & DIAGNOSTICS

Reema Kumari, Lead Engineer
Core Technology & Diagnostics, Tata Power

Sanjay Kumar Tiwary, Lead Engineer
Core Technology & Diagnostics, Tata Power

Ashok Kumar Panda, Head, Control & Instrumentation
Core Technology & Diagnostics, Tata Power

ABSTRACT

Equipment deterioration is inevitable and in spite of best maintenance efforts and modern management methods, equipments surprise us with failures. Unscheduled and/or breakdown maintenance of power plant equipments remains one of the most significant O&M expenses, some resulting in unplanned outages and reduced financial margins.

Equipment monitoring systems are already in use to detect and trend anomalies in process parameters but the challenge remains to know at an early stage when bad stuff is beginning to happen. The early warning signs that a piece of equipment is starting to fail are often subtle and can go unnoticed even to the most trained operator.

In a typical plant, making the accurate assessment of equipment operating conditions requires huge volume of data for the complex assets like turbines, pumps and fans, which is very well possible in today's digital age. But there has to be predictive analytic software which process these information efficiently and timely separating the wheat from the chaff to find an imminent or emerging problem so that we can schedule and plan the maintenance actions, instead of react and scramble.

Fleet-wide monitoring involving the predictive analytic software has already been implemented in various utilities in USA and has recently started in Tata Power. The concept has gained a lot of significance due to the potential benefits of advance warning of impending failures, economics of centralized monitoring compared to individual locations, comparative monitoring of similar units and equipments across the fleet, knowledge capture from the experience etc. Process (Plant data), Technology (Predictive Analytic Software) and People (Subject Matter Expert) are the key elements of the Fleet wide monitoring program and has put into place the 'Right Information' to 'Right People' at 'Right Time' and enables information sharing between various stakeholders before an optimal decision is taken.

The software uses Advanced Pattern Recognition (APR) Technique to predict desirable values of each parameter modeled and detects anomalies that are outside the normal expected pattern.

The paper discusses in detail the fleet wide monitoring concept, usefulness and focus mainly on data-driven empirical models for various assets of the power plant. It further elaborates how the predictive analytic software identifies the impending equipment failures in advance (days, weeks, or sometimes months) before they happen for the entire range of equipment covered under the fleet.

The paper also discusses the approach adopted and the method of implementation in Tata Power. It also describes the deliverables, in the form of some of the initial notifications or 'catches' as they are called, with the help of the diagnostic software pointing to the huge possibilities of the system.

KEYWORDS: Fleet Monitoring, Advanced Pattern Recognition, Operation Profile, Model, Tag, Catch

INTRODUCTION

Unscheduled and/or Breakdown maintenance of equipments remains one of the most significant operations and maintenance expenses, some resulting in unplanned outages and reduced financial margins. In today's digital age, data has been exploded exponentially but the current systems don't provide operations personnel the insight needed to leverage all of the data to obtain optimal performance from both process and equipment assets. Even if they do, skilled resources are scarce and difficult to retain.

Today, asset health monitoring is often comprised of fixed alarm limits defined within control systems, smart devices, SCADA, or historians. It is a daunting task to fix the alarm limits that can vary based on the actual device characteristics, operating history, operation regime, ambient conditions, and device settings. Hence, this calls for advanced predictive analytics and diagnostic software that can provide early warning of potential failure by detecting incipient leading indicators of equipment degradation and to improve the skill base of the plant.

The fleet wide monitoring and diagnostic tools allow for continuous evaluation of plant parameters and provide precursory indications that are identified as anomalous to normal operation, thereby forewarning of incipient equipment failure. The reach and Power of the condition monitoring tools – which were mostly local and components centric approaches - could be enhanced when integrated with fleet dimensional knowledge arising from the predictive software. As utilities move toward centralized monitoring and diagnostics, the integration of advanced monitoring applications with existing condition monitoring and maintenance technologies will lead to an intelligent top-down approach to plant maintenance and scheduling.

FLEET WIDE MONITORING AND OBJECTIVE:

Fleetwide Monitoring (FWM) is the implementation of applications for monitoring, maintaining and optimizing generating assets from a centralized location. Fundamentally, it involves monitoring the most critical equipments in a fleet to detect operational and equipment problems early enough to mitigate damage, manage risk, identify performance problems and manage market conditions. Potential applications include equipment condition monitoring, heat rate monitoring, systems performance and benchmarking, unit startup monitoring, and dynamic threshold limit alarming. The main objectives the fleet wide monitoring program are:

- Continuously monitor health and performance of critical power plant equipments across the fleet of power stations in Tata Power.
- Assessment of equipment operating conditions to minimize operational risks of unacceptable schedule interruptions or increased maintenance.
- Early identification & Advance warnings of incipient failure modes & impending equipment problems to avoid forced outages and catastrophic failure.
- Identify subtle changes in system and equipment behavior based on real-time data, present trends and historical data.
- Use of state-of the art Analytics, algorithms, pattern-recognition and decision making tools, together with performance assessment tools, gap analysis and cause-effect scenarios.
- Provide the generating stations with expert advice on equipment performance-health scenarios and operating regimes changes towards optimal asset lifecycle management.

In order to achieve fleet-wide dimension, it is thus necessary to manage relevant knowledge arising from the fleet taking into account heterogeneities and similarities amongst components, operational context, behaviors etc. Hence, a higher volume of data is necessary to reduce uncertainty and to have more confidence on the hypothesis generation about the causes producing a drift or more information about the degradation trajectory of a unit.

Within the fleet dimension, data interpretation is much more complex due to the higher volume and variance of conditions and contexts among fleet of units. Relevant knowledge needed to convert data into meaningful health state information falls in the domain of subject matter experts. Hence, it becomes necessary to manage corresponding knowledge arising from monitoring equipment data and complementary information gathered at the scale of a fleet.

PREDICTIVE ANALYTIC SOFTWARE:

Predictive Analytic Software is installed at ADoRE for fleetwide monitoring and diagnostic application. It uses Advanced Pattern Recognition (APR) technique - the principle of Clustering of objects into groups whose members are similar in some way. It aims at finding a structure in a collection of unlabeled data and is very much useful for:

- Extracting the locked information from the actual operating data
- Learning to recognize patterns from history
- Making decisions based on the category of the patterns

It learns from an asset's individual operating history and develops a series of normal operational profiles for that equipment and then compares the known operational profiles with real-time operating data to detect the subtle changes in system behavior that are often the early warning signs of corrections required or pending equipment failure and identify why an asset is not performing as expected.

The APR system learns patterns of behavior that represent healthy states of systems or equipment. When the actual pattern diverges from normal patterns, the system reports the anomaly as an indicator of potential degradation. These anomalies are further analysed to diagnose specific problems.

USEFULNESS OF PREDICTIVE ANALTIC SOFTWARE:

- With constraints of the workforce in terms of staffing/ experience and thin maintenance/ and capital budgets, Fleet wide monitoring approach provide improved maintenance planning based on predictive philosophy.
- On-line condition monitoring systems are installed only on equipments like Turbine, while other equipments, though vital to operation of the plant, are only monitored or tested manually. With the FWM approach monitoring all critical parameters, the overall diagnosis improve enhancing the reliability of the plant.
- Getting the right information to the right person at the right time. Earlier specialists visiting the machines on demand and 60% of specialist manpower time to collect sensory data, with limited time left for analyzing.
- Centralized monitoring more economical than establishing individual centers at multiple locations
- Dedicated focus of center personnel towards reliability and performance enhancement of fleet
- Mitigate the loss (through retirement) of experienced resources.
- Co-location with Subject Matter Experts (SMEs). Brick-and-mortar facilities in a location central to monitored units
- Comparative monitoring of similar units and equipment
- Centralized communications and data management
- Uniform and standardized procedures across the fleet for operations and maintenance problems detection and resolution.
- Knowledge capture to improve understanding of little-known equipment failure mechanisms.
- Fusion of technology exam sensory data with process data, with the end result as improved visualization, enabling engineering and specialist workforces to perform higher value tasks.
- Conversion of raw sensory data to key condition indicators and to actionable information.

- Multidisciplinary focus including operations, maintenance, instrumentation and engineering
- Establishing a partnership with operations

TATAPOWER APPROACH:

OSI Soft PI system, being the database management software, is used for data collection, historizing, finding, analyzing, in all our generating station. To transform this abundance of data into actionable predictive analysis, fleet wide monitoring project was initiated with its implementation in 2 x800 MW units of CGPL, Mundra.

The steps considered while implementing a Fleet-wide monitoring system can be listed as follows.

- A dedicated task force was identified comprising of experts in various domain across the organization to form the ADoRE project team.
- The first step is to identify the assets within the fleet identify the assets within the fleet for which a business case exists that justifies the expense of fleet monitoring project. The assets selected include Boilers, Steam Turbines, CW pumps, coal pulverizers, FD/ PA/ ID fans, BFPs, Generators, and transformers .In total 44 assets were identified per unit.
- Using the Predictive analytic software, models were built under four major categories namely Reliability Models, Performance Models, System Models & Transient models.
- Furthermore other features like Fault Diagnostics and Web Dash boards for each model were finalized.
- With understanding of the asset type, it was prudent to identify the key components whose failure directly or significantly impacts the function of the asset. E.g. Booster Pump, Motor, Lub oil System etc. may be some examples of components within BFP asset class.
- Next step was the parameter (PI Tag) selection that was available for particular asset. Analysis of sensory data allows the fleet monitoring system to transform data into useful information and therefore in predicting a failure of the asset to perform its intended function. Hence, this step was the crucial one.
- Each and every steps right from tag selection to model building was reviewed by Subject Matter Experts across stations.
- The output of analysis algorithms reduces the raw sensory data into features which describe the original measurement. These features or descriptors are the numeric inputs which prognostic algorithms use to perform association of an asset's current state of health with historical machine health patterns, or models of machinery health.
- Data driven empirical models required historical operational data to derive estimates and predictions of health and reliability for a given asset. The models were trained with one year operational data and then fine-tuned as per the equipment history and dynamics. Further it was tuned with Operational & performance Design Curves, Equipment Manuals, HBDs, Maintenance History, Condition Monitoring Reports, Records of any up-gradation/ renovation etc.
- Based on the Defined operation profile, thresholds were set for warnings and alarms for individual model. Even alarms and warnings thresholds also were set on some of the critical parameters as per its critical behavior.
- Communication was most important aspect for the fleet wide monitoring project. Single point responsibility approach was followed at the plant level for the smooth exchange of information. All notifications after preliminary analysis by ADoRE team were forwarded and validated by the plant personnel. Not all notifications were significant 'Catch' because some of them may be due to some operational changes or due to some temporary arrangement made at the plant

level or may be any instrumentation problem. Hence, it requires the intervention of operation & maintenance personnel before declaring as 'Catch'

- Any parameter outside the defined operating profile must be having a reason. Process of communication was established for reporting of the notification, technology exam and further inspection at site level and analysis by Equipment/ System Experts.

- The confirmed alerts are analyzed by the expert team before maintenance/corrective actions are notified. Experts seek - for detailed Technical examination - data (like vibration, motor current signature, previous test results, off-line diagnostic test etc.) which lead to determination of specific maintenance actions and outage schedules.

The following indicates Implementation Process Block Diagram adopted in Tatapower.

Historical & Real Time Data from PI system
↓
Model Training & Creation of Operational Profile by Advanced Pattern Recognition (APR) Technique
↓
Tuning of Models (Filtering Outliers & Bad data)
↓
Deployment of Models
↓
Comparison of Operational Profiles with Real-time Operating Data
↓
Advance WARNING & ALERTS at Dashboard

CASE STUDY-I:

During Load variation, there was rise in Motor DE bearing VIB (X) by 18 - 20 microns from the predicted value (though it was below the DCS alarm value) and also temperature of bearing is found increasing by 5-7 Degree C. After local inspection and other checks, the deviation was confirmed as abnormal. The fan is kept

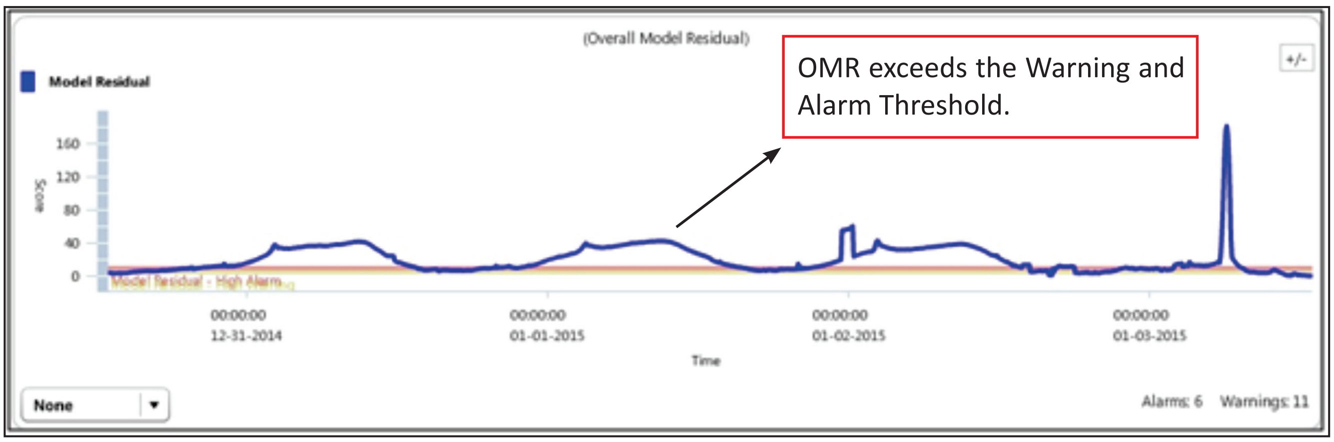


Figure-1: Overall Model Residual of FD Fan-A reliability model

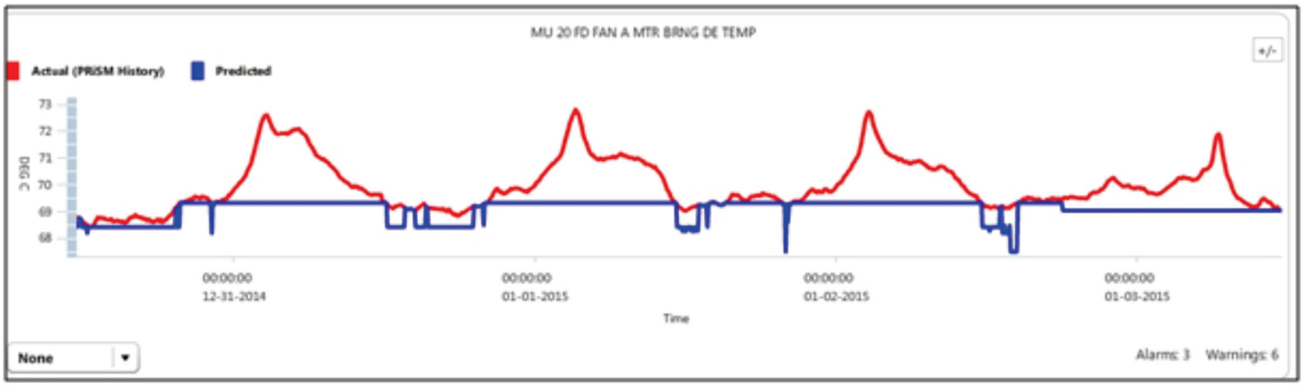


Figure-2: The excursion of Motor DE bearing Temp over Predicted Pattern

under observation and inspection is planned in the next opportunity.

CASE STUDY-II:

CWP A top thrust & guide bearing temps were on rising trend, above the predicted values. Rise was of the order of 15 to 20 Deg C. CWP-A outage was taken for inspection/maintenance after which the bearing temp got normalised (The clogged bearing cooling water line was cleared).

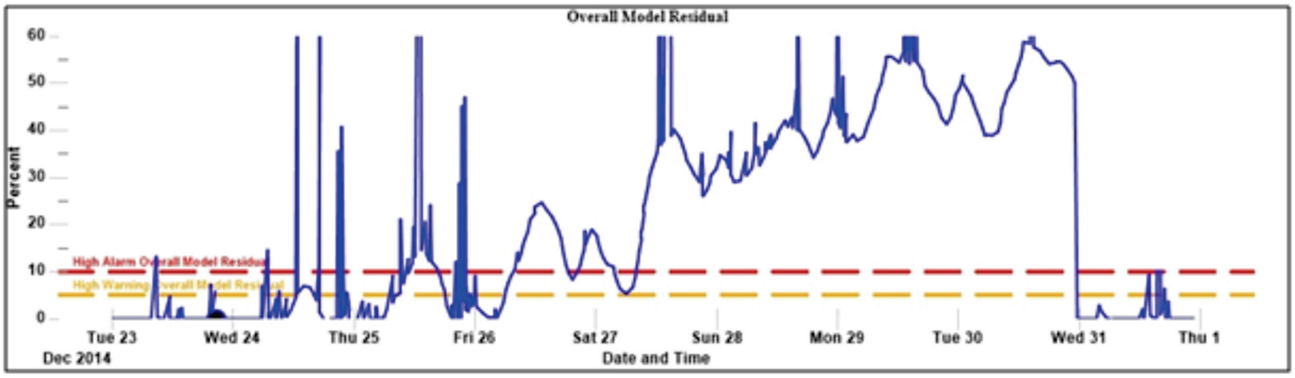


Figure-3: Overall Model Residual of CWP reliability model

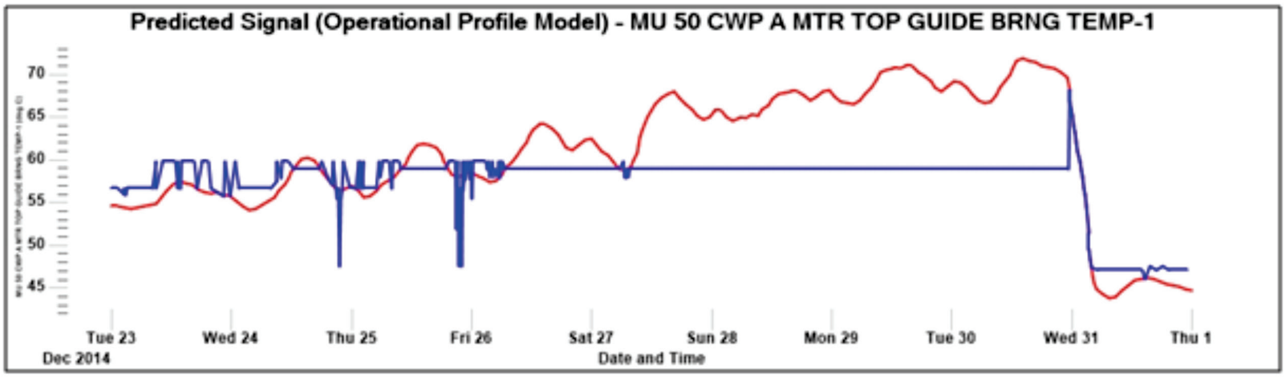


Figure-8: Rise of CWP Motor Top Guide Bearing Temp over Predicted Pattern

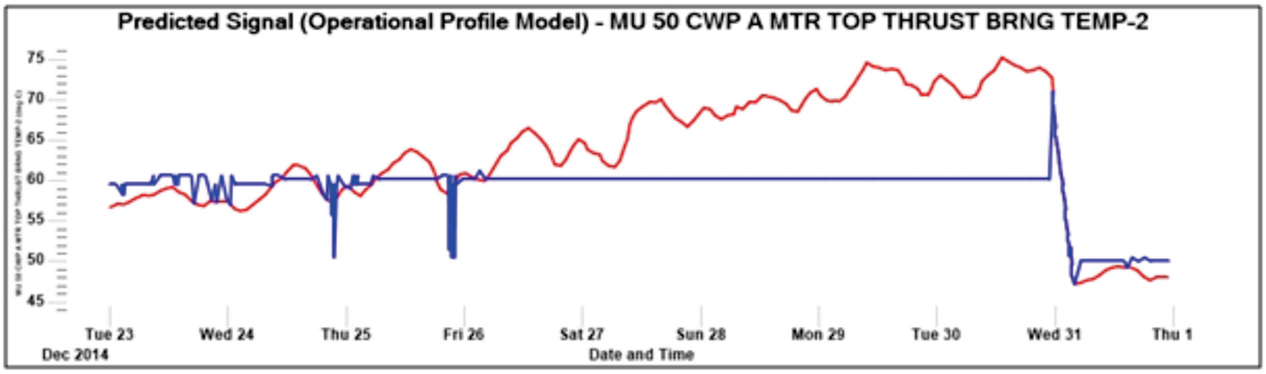


Figure-4: Rise of CWP Top Thrust Bearing Temp over Predicted Pattern

CONCLUSION

The concept of Fleet-Wide Monitoring involving the predictive analytic software has gained a lot of significance due to the potential benefits of advance warning of impending failures, economics of centralized monitoring compared to individual locations, comparative monitoring of similar units and equipments across the fleet, knowledge capture from the experience etc

The solution delivers dynamic insight and deep-dive diagnostics for the behavior change of the equipments. In several cases across the industry, the solution has successfully identified various plant anomalies at an incipient stage and helped plant engineers take timely mitigating actions before they lead to catastrophic failure or loss of production. This has resulted in significant savings and availability improvements, while increasing equipment health visibility and optimizing logistics of maintenance.

The system has got Fault Diagnostics capabilities also, which has to be implemented based on detailed equipment specifications and O&M history. The contribution of Plant Engineers and Subject Matter Experts are crucial in establishing a reliable fault diagnostics as part of the software, which will lead to accurate diagnostics and correction. When this fault diagnostic advisor becomes operational across the industry, it will serve an increasingly important role in knowledge retention by capturing cause-effect relations associated with equipment degradation.

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BIOGRAPHY

Ms. Reema Kumari graduated in Electrical engineering from Veer Surendra Sai University of Technology (Formerly UCE), Burla. At present she is working as Lead Engineer, Core Technology & Diagnostics in Tata Power

Company Limited, Noida and is assigned the role of project coordination for ADoRE. She joined Tata Power in 2011 as a Graduate Engineer Trainee and has been working as SCADA engineer in Coastal Gujarat Power Limited, Mundra from 2011 to 2014. During her career she has been associated with engineering, procurement and various development related activities for the SCADA systems.

Sanjay Kumar Tiwary has done B.E. in Electronics and Communication Engineering from GIET, Gunupur and Diploma in Business Management from ICFAI Tripura. He is presently working in Tata Power as Lead Engineer, Control & Instrumentation in Core Technology & Diagnostics department (CTDS). He is the key member in ADoRE implementation and has developed various models using the predictive analytic software. Earlier to joining in CTDS, he has worked in Tata power Trombay in C&I Department (2007-2014).He has worked in different areas of O&M and has been involved in R&M of various control system at Trombay. Earlier to joining at Tata power, he has worked with M/S Wartsila for a Year as O&M support.

Ashok Kumar Panda has done B.E. in Electronics and Telecommunication Engineering from NIT, Silchar and M.Tech from IIT, Delhi. He is presently working in Tata Power as Head, Control & Instrumentation in Core Technology & Diagnostics department. Earlier to Tatapower, he has worked in Lanco EPC division (2008-2012) as HOD, C&I engineering. He had joined NTPC in 1991 as EET and left NTPC at 2008 as Chief Design Engineer in C&I engineering department. During NTPC, he had worked in areas of O&M, Engineering and had been involved in several power plant optimization projects.

ASSET MANAGEMENT IN FOUNDATION FIELDBUS

Unnikrishnan R
Sr Manager, Process Automation Division
Pepperl & Fuchs (India) Pvt Ltd

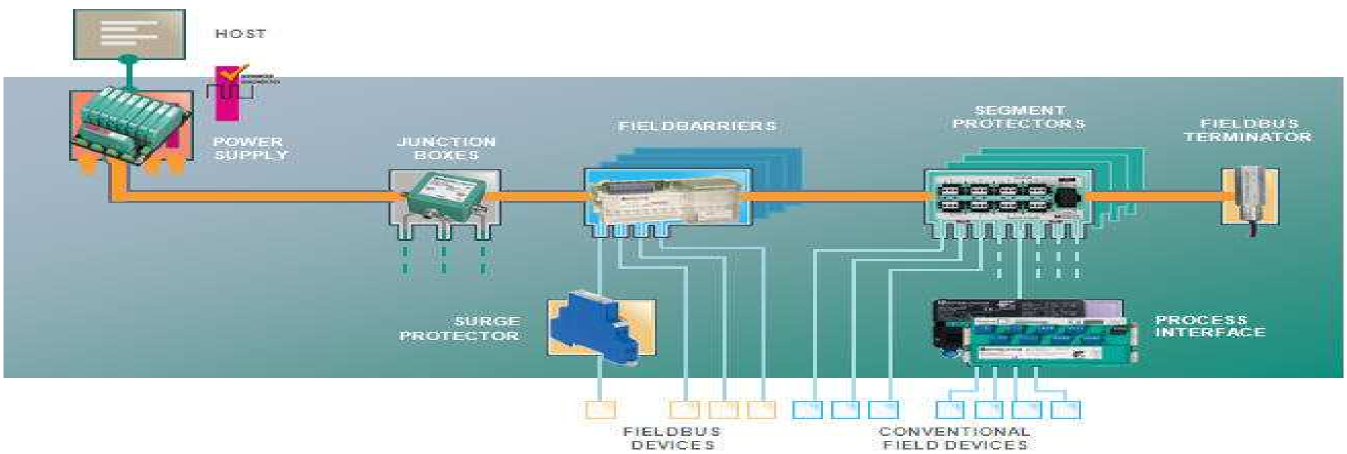
ABSTRACT

Various technologies or methods are aiding in the automation field in Process industries like Oil and Gas or Power plants. There is a drastic change in technology from pneumatic to analog to digital to wireless. Out of the many digital technologies available in the market, Foundation Fieldbus is widely accepted and used because of its efficiency, reduced cost and proactive maintenance feature which helps to reduce the plant down time. Foundation Fieldbus technology can increase plant availability and reduce capital and operational costs. This paper discuss about the advantages or benefits of inclusion of Foundation Fieldbus in Process Industry.

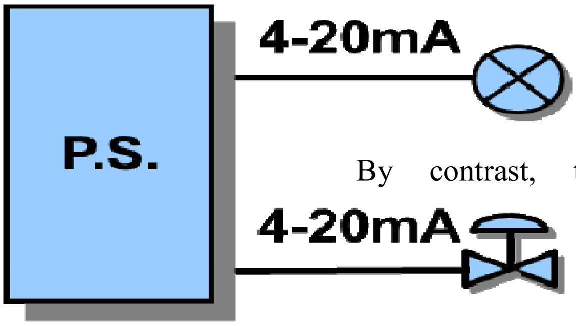
INTRODUCTION

Pepperl+Fuchs around the world is known by customers as a pioneer and an innovator in electrical explosion protection and sensor technology. Our main focus is always on your individual requirements: With a passion for automation and groundbreaking technology, we are committed to working in partnership with you now and in the future. We understand the demands of your markets, developing specific solutions, and integrating them into your processes.

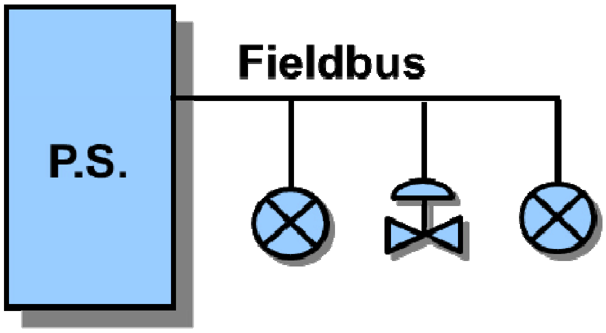
Foundation Fieldbus as a digital technology is increasingly driving changes in the process industry. Its application is evident in all sectors of the process automation industry. The introduction of Foundation Fieldbus technology for instrumentation is closing the digital data communication gap between automation systems and field devices. The result is more accurate values and transmission of values, bidirectional communication, and flexible structures with fewer components.



The conventional 4-20mA signal is the standard used in the process industry for the transmission of process values from the field devices to the control system and from positioners to actuators. The introduction of this standardized current signal resulted in a process automation revolution, saving users time and money with instrumentation. The 4-20mA signal, however, has reached its transmission capacity limits i.e limitation in diagnostics and centralized layouts resulting in more hardware.



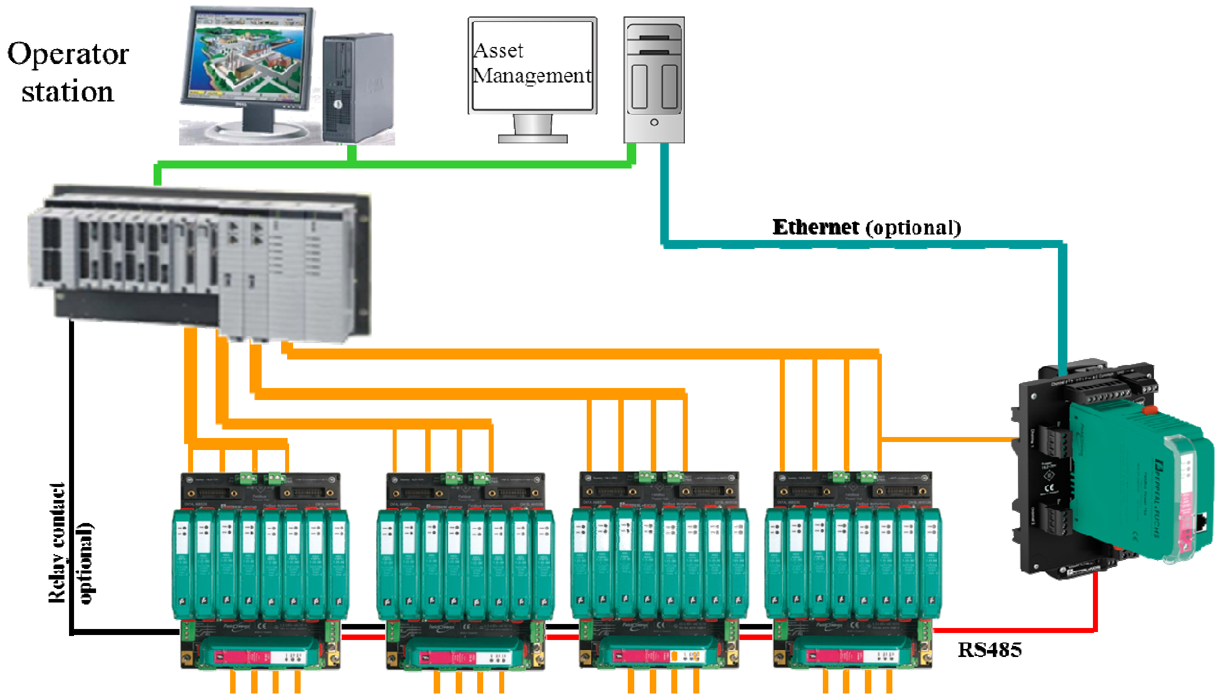
By contrast, the digital signal transmission offers broader bandwidth for plausibility checks and status signals. The digitization of process signals and the associated decentralization represents the most important development that paves the way for the application of a fieldbus system. The subsequent introduction of the fieldbus in process plants has changed the structure of control systems. Foundation Fieldbus allows “multiple variables” from each device to be brought into the control system for archiving, trend analysis, process optimization, reporting, predictive maintenance and for asset management. Fieldbus technology allows shifting central functions into field devices and leads to decentralized structures in the automation systems. Control in the field (CIF) can be acheived with Foundation fieldbus which will reduce the processing load of controllers, process will not be affected



because of controller communication breaks. These decentralized structures reduce the costs for wiring and assembly and increase the availability. Availability is also increased by improved maintenance and diagnosis through foundation fieldbus instrumentation. Additional cost improvements can be achieved for installation, commissioning, operation, and also space requirements.

In a process plant the assets are not only the end products like gasoline or electricity but also materials under civil, mechanical and electrical departments. For our discussion we will consider electrical assets in Oil and Gas or Power Industry. Assets include cable, electrical and instrumentation equipment’s, field devices etc. To have a profitable business these assets also need to be well maintained. For the same, we can make use of FOUNDATION fieldbus and Plant Asset Management system.

Today, companies are coming up with various names or definitions to represent the process variables and the performance or life of the assets. Plant equipments can be categorized as field instrumentation (transmitters, valve positioners, etc), physical layer equipment (power supplies, wiring, etc), or process equipment (heat exchangers, pumps, compressors, etc). Some asset management systems solely rely on data entry to populate a database. Certain systems are capable of displaying information generated by FOUNDATION fieldbus system. This enables operators and maintenance personnel to view the near real time, actual health of their instrument assets.



In the era of automation, administrative and optimizing capabilities of devices are also gaining importance. The concept of Asset management brings forth the necessity of this system. Asset management is the system of monitoring and maintaining things of value to an entity or group. It is a systematic process of operating, maintaining, upgrading, and disposing of assets cost-effectively. Asset Management System can help facilitate quality advice and decision-making within organizations, including the development and review of investment proposals. Transition of field devices and equipment to digital technologies has proven to provide benefits to the typical process plant operation. Digital devices offer a great deal of data about the operating environment. This data can be utilized by asset management system that prevent losses/disruptions, enhance quality and reliability,reduce maintenance costs. Asset Management System helps in predictive analysis and using the extracted data to predict future trends and behavior patterns. It produces interpretable information allowing oil and gas personnel to understand the implications of events, enabling them to take action based on these implications.Maintenance cost reduction drives End Users. 40% of mfg. cost is maintenance. 50% of maintenance is corrective action only. Corrective action is 10 times more costlier than preventative maintenance. Preventative maintenance is done 25% of time which is 5 times more costlier than predictive maintenance.60% of Predictive maintenance is unnecessary. What has been largely missing upto now is **timely, relevent and accurate information.**

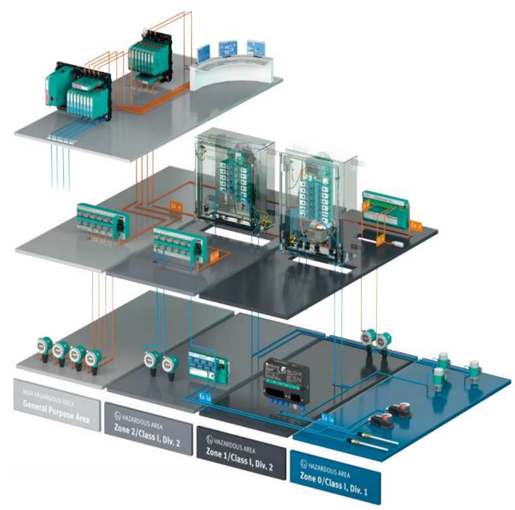


Fig. a

With the advent of Founfation Fieldbus technology, we are able to go far beyond than providing only the process variable. Information generated at the field level with the Foundation Fieldbus technology can be used to significantly improve production efficiencies. Field devices of latest technology contains embedded information set such as device diagnosis , statuses of measured variables and alarms , maintenance requirement flag notifications . Foundation Fieldbus make use of NAMUR NE 107. This implement condition based maintenance strategies to monitor the health of the equipment, better predicts when maintenance is "going" to be required making the physical layer more inteligent. In the Asset Management Sytem the operator will not dumped with alarm pop-up rather it will provide the right information to the right person at the right time.In order to enable the full potential of the technology , the information of both field devices and fieldbus needs to be fully integrated into an Asset Management system . Fieldbus technology provides us the ability of predictive maintenance which will avoid any unwanted plant shutdown. Foundation Fieldbus schematic layout is provided in (Fig.a)

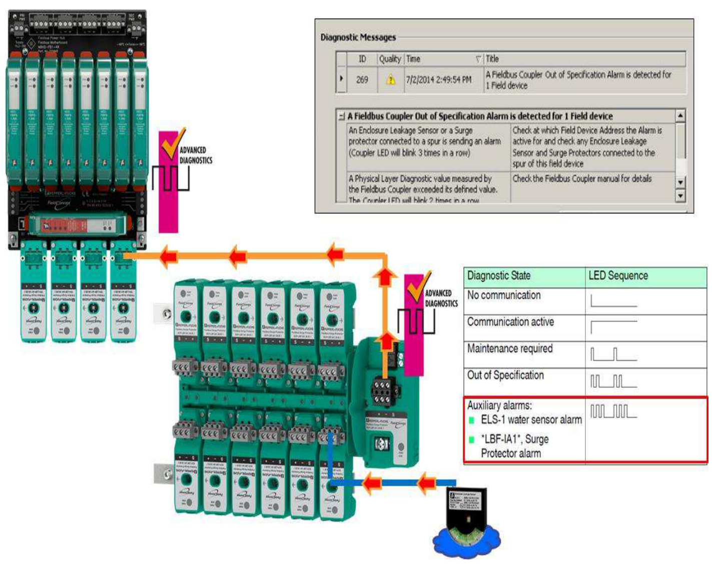


Fig.b

By implementing proper advanced diagnostics features in the physical layer and linking it with the asset management system will drastically reduce the OPEX.

Fieldbus technology is more than just pure process control. Remote configuration, asset management, and proactive maintenance are all made possible with fieldbus technology. With advancement in Foundation Fieldbus technology many new field products are available in the market (Fig.b).

Devices (Fig.c) to detect water in the field devices or junction boxes. Monitoring the inside of the enclosure.These devices can be placed inside the enclosure of any choice. We need to Connects in parallel to the fieldbus segment. Device will detect water presence and sends alarm all the way to plant asset management.

Fig. c

Intelligent wiring blocks which will identify and alert the user if certain problems found in the field. Progressive spur short-circuit protection. Jabber protection – cuts off devices talking too much. Contact bounce protection – suppresses unintentional bounce.Reliable containment of gradual overload conditions. Protects operations from manual intervention and device failure.

Surge protection devices with life sensing ability. Now it is Condition-based replacement. The new foundation fieldbus surge protection devices Monitors strike severity and count .It will reports end of functional reserve to **Asset Management System**, instead of repetitive scheduled maintenance. Surely the new SPD will protects you from the next strike

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Biographies

Unnikrishnan R was born in the year 1976. He holds B.Engg in Electronics and Communication Engineering from Bharathiyar University of Coimbatore, TamilNadu. He is having 14 years of Industrial experience in various sectors of automation field. At present he is working as Sr Manager – Technical Support responsible for Indian operations of **Pepperl+Fuchs** (India) Pvt Ltd. Pepperl+Fuchs is a leading developer and manufacturer of **electronic sensors** and **components** for the global automation market. He involves in various Fieldbus seminars, trainings, technology promotion activities across India.

Virtualisation: A Strategy to Manage Control System Obsolescence (A Case study of 660 MW Simulator)

K.V. Prasad, Vikash K Malhotra
NTPC Ltd.

Abstract

Arrival of new technologies in any area, always brings good things and new features to life. However it also brings in, the issue of obsolescence of the existing technologies. The introduction of computers into power plant controls have exposed most of our power plants to this risk of either hardware or software obsolescence. The recent announcement of Microsoft that they will be discontinue support for Windows XP operating system, has created a new risk of obsolescence of all the DCS systems presently operating on this Windows XP OS. Dealing with DCS system obsolescence is becoming a major challenge for NTPC. While the wholesale replacement of obsolete DCS system should be the last resort for dealing with obsolescence, virtualisation could be a cost-effective way to deal with DCS system obsolescence. Virtualisation will allow us to retain DCS systems that still provide business benefit. Operation and maintenance staff will see no difference between legacy system and the new systems built on virtualisation technology.

The concept of Virtualisation, has been implemented successfully in the 660 MW simulator at PMI by creating a virtual Windows XP environment on Windows 8 operating system. The Yokogawa Centum CS3000 which can be installed only on Windows XP, is currently running on Windows 8 machine. The virtualisation software used for the purpose is VMWare. This paper discusses the advantages and issues faced during the virtualisation process in addition to the generic concept of virtualisation. Virtualisation can also be tried as a solution to overcome the risk of obsolescence faced by NTPC plants on DCS systems based on other Windows Operating System like Windows NT, Windows 2000 etc , before jumping on to the, rip and replace solution. Presently we have proven the virtualisation solution only on TCP / IP based networks and usage of this solution on proprietary protocol based networks is yet to be proven. This paper also discusses the various options, opportunities, challenges and limitations of this concept.

KEYWORDS

Virtualisation, DCS System, Microsoft XP, Simulator, Software obsolescence

Introduction

Simulator 660MW was installed and commissioned in the year 2010 in the heart of the Noida city to facilitate participants from all over the country to increase their knowhow on supercritical technology. It is the only simulator of its type in the nation to exactly meet the dynamic characteristics of supercritical power plant. The system is comprised of HP (Hewlett Packard) machines – (HP xw 4600(no.19), HP Proliant ML350 (no.01), HP integrity rx2660(no.01)) which are well proven in its functioning. Full redundancy is provided to take care of any kind of failure, in case the present system has developed any technical snag, the redundant system could be taken into service. Dual LAN Star network is provided, so that communication link won't break down.

The main plant Distributed Control System (DCS) controls are emulated using the Yokogawa CS3000 control logic software running in a PC based environment in the Simulator. The HMI related component of the main plant DCS are also emulated using the Yokogawa CS3000 graphics builder software. CS3000 software provided by Yokogawa runs on Windows XP OS environment.

I. Issue : Effect of M/S Microsoft decision to discontinue Windows XP.

"The only big companies that succeed will be those that obsolete their own products before someone else does." The famous quote by Bill Gates, founder of Microsoft describes the strategy of his company. This strategy of Microsoft may have lead to the success of Microsoft but has created faster obsolescence of software and control system in the process and manufacturing industry. Since, windows were developed for the consumer market, its application to the automation and control world introduces new challenges in the plant environment. One of the major challenges in maintaining the windows based control system is the system obsolescence. Normally Microsoft supports the current version of software over a period of time. Simultaneously, it develops the newer version of software and with time stops supporting the older version of software. As Microsoft stops supporting the software, PC Manufacturer stops supporting older version of OS on existing and new hardware. Also control system supplier also stops supporting the older version of control system and develops the newer version of software. So with the fail of the old hardware, if the industry changes the hardware which comes with newer version of operating system, industry also needs to change the control system. While the cost of upgrading the operating system software is not high, the cost of changing the control system is huge and runs into crores.

The windows XP operating system is acting as the heart of control system of PMI 660 MW Simulator. After **April 8, 2014** Microsoft has stopped support for the Windows XP OS. It is presumed that future hardware will not support the Windows XP. **Thus, when in future if we change the hardware of the simulator we will be not able to install Yokogawa DCS Centum 3000 because it is supported only on Windows XP.** And if we go to upgrade the HMI software the cost will be substantial.

There are similar problems faced by the project C&I as their DCS systems are running on Windows 2000 Server, Windows XP, and Windows NT which are becoming obsolete and now these OS are not supported either by Microsoft or DCS Supplier. **Due to obsolescence of old hardware and operating system NTPC will be compelled to go for up gradation of existing HMI software which will cost a lot.**

II. Analysis

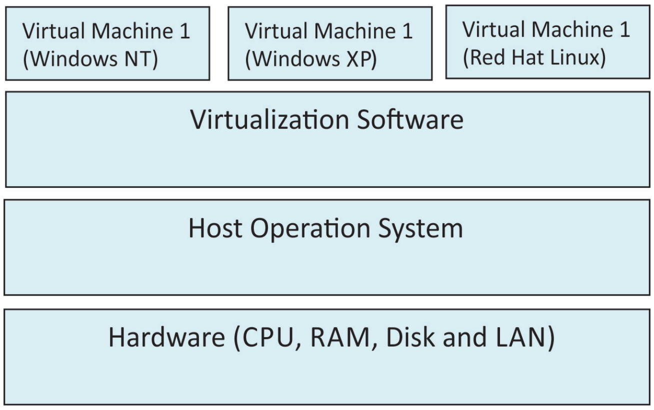
The above issue suggests that it was the hardware which became obsolete while the OS and DCS Software were still useful for NTPC and are serving the desired propose for the organization. Also the substantial cost is involved in the up gradation of DCS System. The solution of the above problem lies in the fact that "Is there any way by which we can install the obsolete OS like Windows 2000, Windows NT, XP etc on the new machines? " The answer of the above problem lies in the Virtualisation of Operating System.

III. Virtualisation

As with all emerging technologies, there are several definitions or perceptions of what constitutes Virtualisation. The definition provided by Amit Singh, author of kernelthread.com, in "An Introduction to Virtualisation" is as follows:

"Virtualisation is a framework or methodology of dividing the resources of a computer into multiple execution environments, by applying one or more concepts or technologies such as hardware and software partitioning, time-sharing, partial or complete machine simulation, emulation, quality of service, and many others." Virtualisation allows industry to retain systems that still provide business benefit. Process engineering could run 100 virtual applications on single server. The obsolete applications included older platforms like Windows NT, XP etc.

Concept of Virtualisation



(Figure-1)

Server Virtualisation can be understood as the masking of server resources, including the number and identity of individual physical servers, processors, and operating systems, from server users. The server administrator uses a software application (Virtualisation software) to divide one physical server into multiple isolated virtual environments. The virtual environments are sometimes called virtual machine, but they are also known as guests, instances, containers or emulations. Virtual machines are based on the host/guest paradigm. Each guest runs on a virtual imitation of the hardware layer. This approach allows the guest operating system to run without modifications. It also allows the administrator to create guests that use different operating systems. The guest has no knowledge of the host's operating system because it is not aware that it's not running on real hardware. It does, however, require real computing resources from the host -- so it uses a hypervisor to coordinate instructions to the CPU. The hypervisor is called a virtual machine monitor (VMM). It validates all the guest-issued CPU instructions and manages any executed code that requires addition privileges. VMware, Oracle Virtual Box and Microsoft Virtual Server use the virtual machine model.

IV. Benefits of Virtualisation

Avoids Software & Hardware Obsolescence

Suppose that we have an old Windows NT Server that's running a proprietary application that will not run under any other version of Windows. Now, imagine that one day the ancient hardware that the application is running on decides to give up the fight and die. We could go out and buy a new server, but may be this new server will not support the windows NT server. The solution might be to create a Windows NT virtual machine on an existing server and run our proprietary application from there.

Saves the Host Machine

While the virtual machines are running on top of host operating system, Virtual Server is designed in a way that isolates each virtual machine from the core operating system and from other applications and virtual machines that might be running on the system. Therefore, if a application were to crash, it might bring down the virtual machine, but it will not have any effect on the machine's host operating system.

Backup and Restoration is Easy

Virtual machines are stored as hard drive image files. This means that we can create a virtual machine that's running a specific operating system and configuration. It is then possible to back up the virtual machine's hard drive image file. That way, if the virtual machine were to be destroyed or if the configuration were altered, it would be possible to restore the virtual machine to its original state by simply restoring a single file.

V. Challenges with Virtualisation

Migration to virtual environments is not always an easy operation. It does have some caveats. Some of them are described below:

Deciding Virtualisation Software

Today we have a wide range of Virtualisation software (VS) to choose from. Some of them are free , others carry a price tag. It is always better to determine what functionality and security is required before its implementation. In some cases Virtualisation may not support certain functions.

Performance Issues

To successfully run Virtual Machine, the physical server must have sufficient hardware to run the host operating system, plus any necessary virtual machines (guest operating system). Each virtual machine has its own individual operating system and its own set of applications, and the server needs to have enough resources to handle running all of this software simultaneously. The hardware requirement varies depending on the number of virtual machines that are running and on the operating systems and applications running on each virtual machine. However the latest hardware do come with built in capabilities to meet the demands of both the host and guest operating systems.

Networking Issues

Presently Virtualisation supports TCP/IP network. So connecting any virtualized machine to any proprietary network will be a challenge.

Security Issues

If the machine's host operating system goes down by a virus or other exploit, the virtual machine could potentially also crash since virtual machine as it is dependent on the host operating system. Another security issue is that virtual machines must be secured, patched, and maintained, just like any other server in the organization. Lax on security on virtual machine can make it vulnerable and it could allow the virtual machine to be more easily hacked. Hackers often use a machine with weak security as a platform for gaining access to the rest of the network. To prevent a virtual server from being used to compromise the rest of your network, we must insure that all servers (real and virtual) use the proper security. However in NTPC scenario, the C&I UNIT LAN is connected to the Station LAN and NTPC WAN through secured firewalls, and hence this should not be a issue.

VI. Implementation of Virtualisation

In PMI 600 MW Simulator we have implemented the Virtualisation. The Yokogawa Centum 3000 system is currently running on Windows 8 machine. The Virtualisation software used for the purpose is VMWare. The specification of the machine used for Virtualisation vs Original machines is given below:

Category	Specification of machine on which Virtualisation was done	Specification of original Machine
Manufacturer	Acer	HP
Type	Desktop	HPxw 4600 Workstation
Processor	Intel ® Core ™ i5-3470 CPU @ 3.2 GHz 4 Core Machine	Intel ® Core ™ 2 Duo CPU E4500 @2.2 GHz
Memory	4 GB	4GB
Hard Disk	500 GB	300 GB

In the first phase the Virtualisation of OWS (Operating work Station) was done using the above desktop machine. The OWS in Simulator is being used by operation engineer (trainee) to view the updated operational data & give command to different drives for smooth reliable operation of Simulator. The Virtualisation of the OWS worked successfully.

In the second phase, Virtualisation of C&I Model stations was done using the above system. C&I Model station in Simulator is being used as FCS (Field Control Station) which takes the real time simulated data from Plant Model and passes to the EWS (Engineering Work Station) and OWS (Operating Work Station). Initially while virtualizing C&I Model stations the response of OWS became sluggish also FCS failed frequently. The problem was rectified after we increased the RAM of the new machines from 4GB to 8GB.

VII. Recommendation

Due to the obsolescence of Windows Operating System like Windows XP, NT, Windows 2000 power sector may face the obsolescence of DCS system which will lead to increase of DCS system upgradation increasing the R&M cost. One of the way R&M cost of DCS system can be reduced by using Virtualisation may be used as one of the strategy to avoid software/hardware obsolescence.

For using Virtualisation it is recommended to use the Oracle Virtual Box which is free software and can be easily downloaded from internet. Also Oracle Virtual Box supports most of the Windows Operating System.

Pervasive Sensing For Smart Refineries
A Strategy That's Changing the Fundamentals of Automation

Anupam Srivastava
Emerson Process Management India

Abstract

Today's customers have many business challenges, and the biggest involve Site Safety, Environmental, Reliability& Energy.The purpose of this paper is to illustrate how pervasive sensing enables customers to address these most critical challenges.

Business Challenges for Customers

Reliability	**Energy**	**Site Safety**	**Environment**
Customers are looking for ways to reduce lost production time, and reliability is a big cost when they have to fix things.	Energy savings is a huge potential improvement area	Customers have the same safety goals in any plant anywhere in the world - zero incidents. They want to run their plant with no surprises.	Environmental performance of products, facilities and operations remains key challenge for the industries
36% of a typical refinery maintenance budget is spent on corrosion remediation and repairs[1].	**50%** of the world's energy is consumed by industrial facilities [3].	**16B$** ofestimated customer spendingin area of environmental, health and safety[5].	**268B$** invested by Oil & Natural Gas industry since 1990 towards improving the environmental performance of its products, facilities and operations[7].
5% of lost production is due to unplanned equipment failures[2].	**50%** potential for improvement in energy use, sub-segment you are in -manufacturing or process control.	The industry is committed to a goal of zero fatalities, zero injuries and zero incidents[6]. However, that is not being achieved by anyone in the industry today.	
	This translates to big potential savings to customers[4]		

Pervasive Sensing TM

This is where we introduce the theme of "the lens," and use of "Pervasive SensingTM"

What is pervasive sensing?

Pervasive Sensing is simply the use of sensors to capture data on anything in a plant that could affect its operation. It is driven to a large extent by the increasing availability of inexpensive sensors - many of them wireless. While it is now gaining acceptance in industry, pervasive sensing is found in other areas as well, some of them in our daily lives.

Pervasive sensing in daily life

Today's cars have 10 times as many sensors as those of 20 years ago, and more are coming. The information collection, analysis, display and control actions that is now possible because of ubiquitous sensing has transformed our lives in terms of

1.) Reliability– Throttle position, Crankshaft position, Engine oil level, Coolant level, Transmission gear position and speed

2.) Energy – Detailed tire pressure, Current sensors for battery management, Ethanol fuel sensor, Injection Pressure Sensor

3.) Safety – Brake fluid level, Anti-lock brake sensor, Air bag deployments, Seat belt verification, Reverse object detection, Door Ajar/Open, Blind spot detection, Wash Fluid Level, Lane departure warning, Drowsiness Alert

Benefits of pervasive sensing in industry

In manufacturing, pervasive sensing provides measurable and significant improvements in process and worker safety, regulatory compliance, equipment reliability and energy efficiency. It makes it possible to detect and respond to hazards early, protect people and equipment, predict failures and reduce slowdowns and shutdowns. It helps to avoid environmental issues and fines, and to spot potential security threats early.

Pervasive sensing makes it possible to achieve business-critical results with incremental investments that acquire new insights without adding complexity. It provides better insight into operations and makes it possible to optimize processes and thus increase productivity and profitability.

Where it all began

What made pervasive sensing possible was wireless mesh technology. A network of small (generally self powered) devices communicate with each other and with a central station (Fig. 1); while each device in the network might have a radio range of only a few meters, the devices organize themselves into a self-healing network that can pass messages over considerable distances, route signals around obstacles, and continue to communicate even if several devices go off line. With wireless there is no need to design much of anything, and no need to pull cables, as the devices are battery-powered, and can be added, subtracted and moved from place to place with essentially zero impact on the system.

The first widespread sensing application of these mesh networks was in vibration monitoring: radio-equipped sensors were mounted to pumps and other rotating equipment to report (generally at intervals ranging from a few minutes to a few hours) on the health of the equipment. Asset-management software kept track of the readings and predicted when something was getting ready to fail. The result was a considerable reduction in unplanned downtime.

Since that time wireless sensors have proliferated immensely. There are predictions that over the next ten years sales of equipment in this area will more than double the $16 billion traditional measurement market. Oil processing plants have potential to deploy full wireless infrastructure to allow Pervasive Sensing instruments; approximately 60% beyond the base of traditional process measurements - in order to better detect energy losses, equipment corrosion and safety releases.

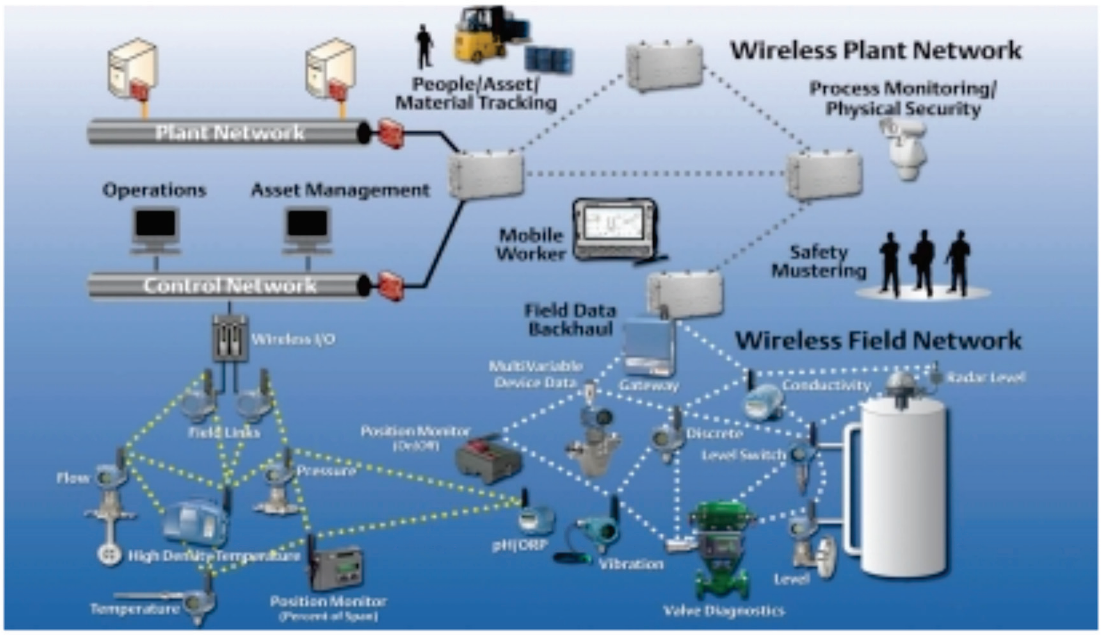


Figure 1 – Example of Wireless Network
In a wireless mesh network small (generally battery-operated) devices communicate with each other and with a central station. They organise themselves into a self-healing network that can pass messages over considerable distances

So pervasive sensing comes down to the use of multiple sensors everywhere, often (but not always) wireless. There are sensors being installed to monitor temperature, pressure, valve position, steam trap opening, liquid hydrocarbon spills, safety showers, pressure relief valve opening and corrosion and erosion. Wireless sensors are used in gas leak detection - both wide area and point - and for flame and smoke detection.

Pervasive sensing in process-critical applications

In manufacturing, pervasive sensing helps in both process-critical and business-critical applications. Process-critical means process control and process safety. Process-critical data requires immediate response to prevent off-spec product or even a plant shutdown. It requires maximum focus; fortunately, much of the equipment and operations involved are already automated, as the new sensors generally connect to an existing process control system. One possible drawback, however, is the possibility of information overload; most of the information gathered by pervasive sensors does not act to close process loops, but to keep plant operators informed, and if designers do not apply human-centred design principles there can be so many alerts and alarms that operators cannot keep up with them.

Pervasive sensing in business-critical applications

Business critical means site safety, reliability and energy efficiency. Business-critical data requires a timely response, rather than the immediate response needed by process-critical data. Failure to act on it can lead to things like a plant slowdown or increased energy usage. Because it is generally of lower priority, business-critical data may receive limited attention. The data gathered was previously obtained by making manual rounds, and in some cases was never gathered: hard information simply did not exist, and was replaced by assumptions, estimates or simple guesswork. Pervasive sensing corrects this.

An example:36% of a typical refinery's maintenance budget is spent on corrosion remediation and repairs[1]. And until recently just keeping track of corrosion was a labour-intensive undertaking, with technicians making manual inspections using handheld analysers and detection coupons. But today's wireless corrosion monitoring transmitters (Fig. 2) allow for continuous, on-line monitoring at previously inaccessible locations and at an affordable cost.

Figure 2 - Wireless corrosion sensors allow continuous, on-line monitoring

Examples of advanced sensing

There are many examples of companies that are putting advanced pervasive sensing in place. One next-generation process plant is currently deploying wireless infrastructure to grow measurements by 60% for critical applications. It uses 20 000 wired I/O points, including 12 000 business-critical applications: 2 000 for site safety, 8 000 for reliability and 2 000 for energy efficiency.

An example of advanced sensing for process-critical applications

A gas storage facility in the southern United States injects natural gas into a salt cavern to take advantage of changing gas prices. In order to do that, they need to monitor the status of the injection wells, but there are dozens of these, spread out over several square miles. In the past monitoring meant sending someone to look at each well, but because the wells are spread out over such a wide area, it was impossible to check each one every day. If there were a leak, they might not know about it for two or three days. The company installed close to 500 wireless monitoring devices that gave them the ability to monitor each well in real time. This increased the ability to efficiently utilise the storage capacity and reduced monitoring costs. It took just 100 man hours to commission all the sensors, which is less time than it used to take to go around and monitor them. This saved the company close to a million dollars on installation costs alone, and helps them operate their field more effectively.

Advanced sensing for business-critical applications

Site safety can be considered a business-critical application because while process safety is really about containment, site safety is typically about worker safety or gas detection. One example is monitoring of safety showers; many of the safety showers in today's plants are not monitored. Another example would be safety and environmental compliance, like leak detection. It is dangerous to have people around the sites/areas where there are gas leaks, and leaks are often associated with compliance issues associated in North America with the agencies like the EPA.

Business-critical application example: site safety and compliance

A Canadian facility for underground storage of hydrocarbon gases had used shelters (essentially simple shacks) to cover wellheads, but these had created difficulties with maintenance activities, and most were scheduled for removal. This created a problem: the legacy single-point catalytic bead detectors that monitored each wellhead for dangerous gas leaks worked well enough when enclosed, but in the open air the wind dilutes any escaping gas and tends to blow it away from the sensors. The sensors must also be protected from the weather (they don't work when buried in snow), some types can become saturated and require replacement when exposed to high concentrations of gas, and they must be recalibrated at regular intervals.

Figure 3 - Escaping gas can be detected more than 10 metres away, regardless of wind or weather

The company decided to try ultrasonic leak detection, as shown in Fig. 3. Gas escaping under pressure produces an ultrasonic whistle in the range from 20 to 100 kHz that can be detected instantly at distances in excess of 10 metres, regardless of wind or weather. The detectors work even when everything is covered with snow, and once set up do not require periodic recalibration.

The company measured the background noise at 55 dB, and set the detectors to trigger at 70 dB. Several test scenarios were run and the units responded to even the slightest leak, with no false alarms. Periodic testing consists of venting some high-pressure air or nitrogen in the area, and the detectors have functioned flawlessly.

It is worth noting that ultrasonic leak detectors are not low-power devices, and must be supplied with power from outside.

Business-critical application example: pump health monitoring with wireless vibration sensing

The operators of a refinery in India wanted to prevent inadvertent surprise failure of pumps which could lead to Process slow-down or shutdown. They were monitoring the health of pumps manually on a periodic basis. With a need for more robust and effective monitoring system, they opted for wireless infrastructure with plantwide network (Fig.4) to monitor online health of the essential Pumps.

This eliminated the manual rounds previously used at one tenth the cost, and completely eliminated the fires and resultant shutdowns.

Business-critical application example: Energy efficiency

A steam trap has three possible states:

1. Operating correctly, opening and closing as it should;
2. Failed closed, which keeps water in the steam

system and can create a water hammer and damage equipment;

3. Failed open, blowing steam into the atmosphere or a condensate recovery line, which is a waste of energy.

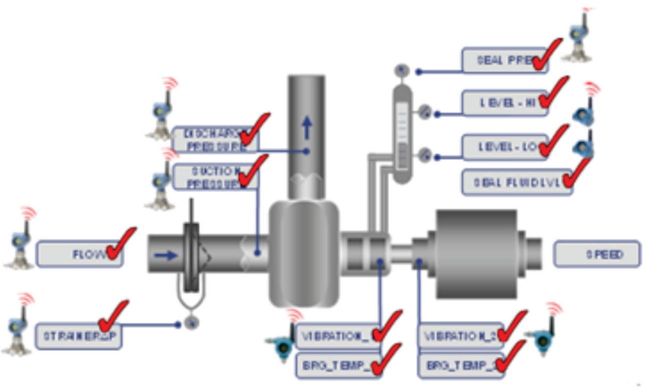


Figure 4 – Monitoring of various parameters to ensure smooth running and reliable operations of pumps.

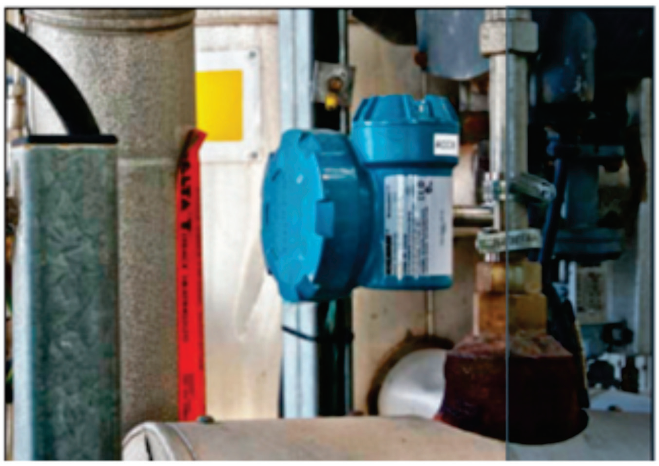


Figure 5 – Acoustic monitors mounted next to steam traps took less than ten minutes per trap, and the system paid for itself in energy savings within a year

Operators of a plant in the process industry had concerns about steam traps and Pressure Safety Valves. A survey found that 25 per cent of the steam traps in the plant had failed. The company installed nearly 100 wireless acoustic transmitters at steam traps and PSVs (Fig. 5) - which took less than ten minutes per trap - all providing instant alerts of failed traps, plus several dozen more at pressure safety valves. The system paid for itself in energy savings within a year.

Summary

In the past, pervasive sensing for business-critical applications was impeded by the cost and difficulty of deployment, the complexity of the technology, and the difficulty of accessing and using the resulting data. The cost was high and the information benefit was low. Improvements in instrumentation and analytic software have changed that equation. Pervasive sensing can have profound effects on reliability, safety, efficiency and environmental compliance, and it makes possible analytics-driven predictive maintenance. There is every reason to believe that pervasive sensing will continue to spread through industries of all kinds, where it will have positive impacts on productivity, environmental compliance and profitability

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[7] Environmental Expenditures by the U.S. Oil & Natural Gas Industry (1990-2012). [Page 4: Figure 4]

Biography

Anupam Srivastava Joined Emerson Process Management, India in 1996 and presently leading Business Development for Rosemount Measurement Business, India. He has worked with various Process Industry Customers to offer solutions on Field Instrument Applications.

Anupam has over 20 years of experience in Instrumentation Industry, holds a Bachelors in Instrumentation Technology from Mysore University.

Anomaly Detection – Going beyond condition monitoring

Ramakrishna Commuri
Technical Consultant – Meggitt India Pvt. Ltd.

ABSTRACT

As Power and Process Industries move up the ladder of automation, a unique challenge emerges out of the enormous amount of process data that gets generated continuously by various equipment. This paper discusses proven modelling techniques that can be used to digest huge amounts of data and detect anomalies in critical equipment at the onset to reduce forced outages.

INTRODUCTION

Plant operating profits are a function of Thermal Performance & Reliability. Incorporating best practices into Operations and Maintenance and following reliability centered maintenance programs help in maintaining overall plant reliability to some extent. However, operating schedules of many industries are dictated by market requirements and many machines operate for long durations without outage. In such cases, it becomes extremely important to monitor and understand equipment health and detect any changes in the equipment behaviour that may lead to performance degradation and (or) forced outages.

KEY WORDS

Anomaly Detection, Reliability, Artificial Intelligence, Statistics, Thermodynamic modelling, Process Data Analytics, Condition Monitoring

NEED FOR ANOMALY DETECTION - COST OF FAILURE

Cost of failure of critical equipment in any industry is typically very high and is due to the combination of various following factors –

- Cost of replacement of parts
- Loss of output\production
- Missed commitments
- Non availability of spares\Delay in restart
- Safety of manpower and equipment
- Increase in insurance premium

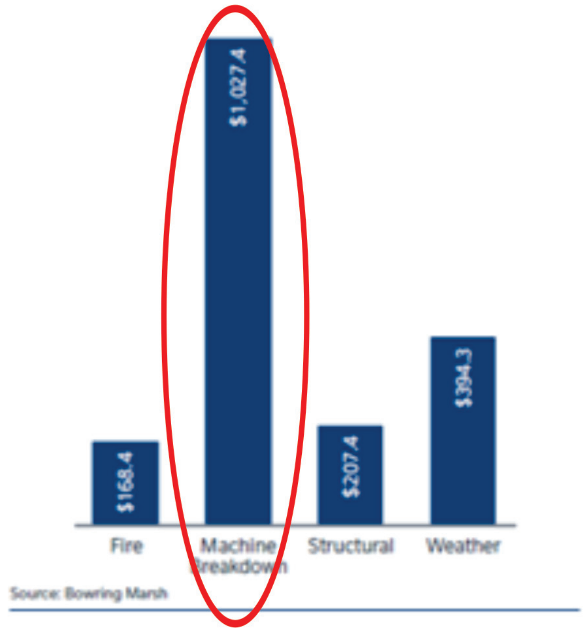


Figure 1: Loss value (US$ million) during 2005-2012 (source Bowring Marsh)

Please note that losses indicated in Figure 1 are for Power industry and represent the claims managed by Bowring Marsh. Losses would be much higher globally.

DATA ANALYTICS – PROBLEMS FACED BY THE INDUSTRY

- OEMs often limit data analysis to their own equipment
- Most DCS are currently not equipped to understand complex correlations that exist between process variables
- Most Reliability Centered Maintenance programs in the market do not look at live data on a continuous basis
- 'Condition monitoring' is often assumed to be limited to rotating equipment
- Setup of dedicated 'Reliability and Performance Analysis' centers are too expensive for individual plant owners

With advances in technology and data analytics, monitoring systems have matured from simple measurement of parameters to automated diagnostics with advisory capability. However most advisories in the market are standalone systems and lack a holistic approach to asset\plant\process reliability. While these available advisory systems can help with some actionable information, there are many instances where anomalies occur and propagate unnoticed resulting in equipment failures.

The path for increased reliability lies in having an integrated approach to the asset management i.e., Integrated Condition monitoring, Performance analysis and Anomaly detection.

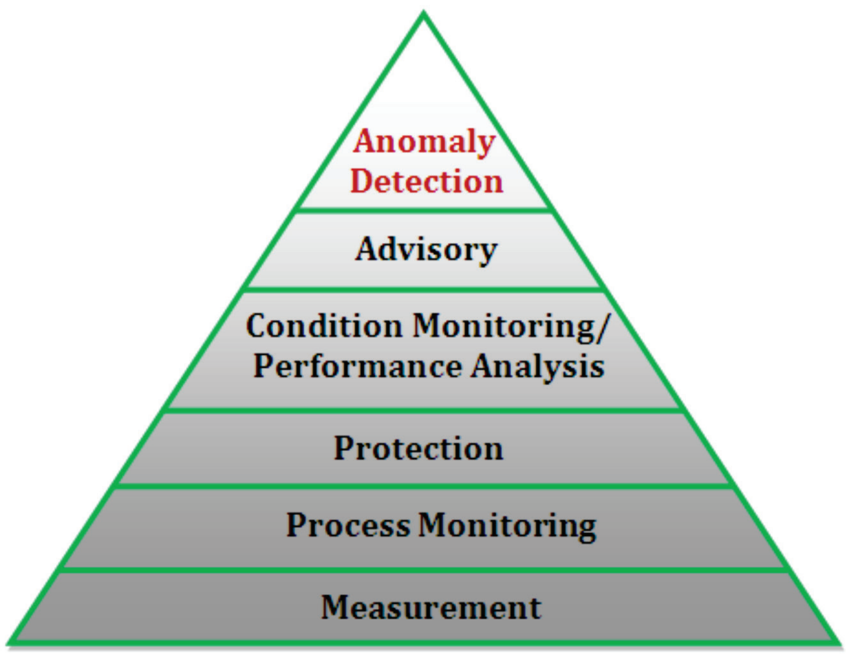


Figure 2: Monitoring and Diagnostic Pyramid

ANOMALY

Anomaly can be described as a discrepancy or deviation from an established rule or trend. In every critical process or equipment, various parameters are measured and monitored. Every parameter has a unique operating profile or signature. This signature is the response of the machine\process to various internal and external forces\factors under a given set of conditions. Various instruments mounted on machines to measure process parameters (like temperature, pressure, vibration, flow, current, voltage etc.) indicate the response of the machines to such conditions.

TYPES OF ANOMALIES

- Equipment Anomalies

– Any variation in machine behaviour due to a physical change ex: high vibrations, temperatures (hotspots), currents, emissions etc.

- Process Anomalies

– Bypass stack leak, Bleed valve leak, Recirculation valve leak etc.

- Instrument Anomalies

– Sensor issues

- Data Anomalies

– Data drops from PLCs\DCS to Historian

ANOMALY DETECTION – PREDICTIVE ANALYTICS

Predictive Analytic methods employ Thermodynamics, Artificial intelligence, Statistical methods to build process "signatures". These signatures in turn are used to "predict" various process parameters. These models are very sensitive and are extremely accurate at modeling even complex processes. They often find problems that go undetected by normal procedures.

A significant deviation between "predicted" and "measured value" indicates a deviation in its behaviour. This deviation usually is the onset of an anomaly. Proprietary algorithms differentiate between sensor issues and real anomalies and also calculate the "confidence level" of prediction to reduce false positives.

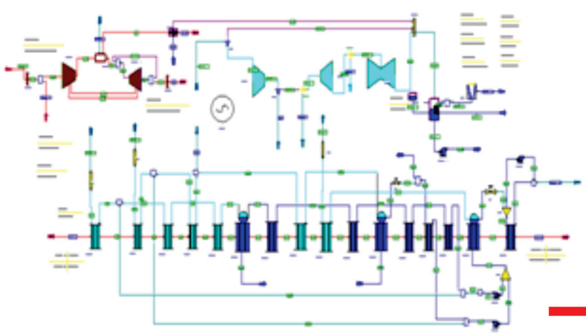


Figure 3: Thermodynamic models

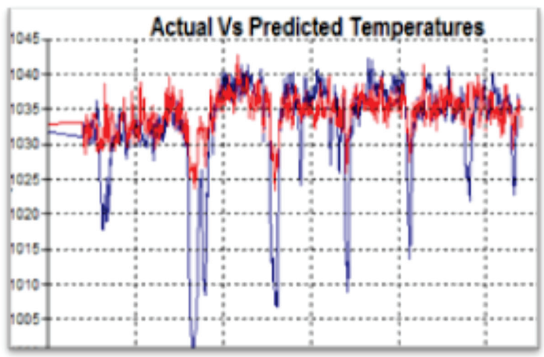


Figure 4: Actual Vs Predicted values

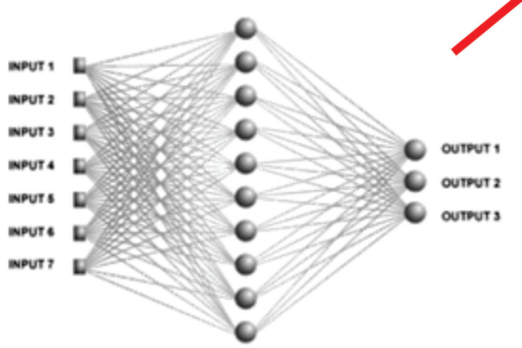


Figure 5: Neural Networks

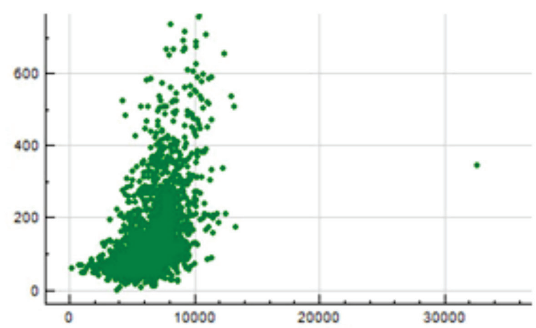


Figure 6: Statistical Methods

CASE STUDY – ANOMALY DETECTION IN GAS TURBINE EXHAUST TEMPERATURES

Exhaust temperature thermocouples in a gas turbine provide valuable information regarding thermal performance of gas turbines and also present a good picture of the degree of uniformity in the combustor. A large spread (max – min) among the array of thermocouples indicates that some combustor section is running hotter or colder than the rest. Operating a gas turbine for extended periods in such conditions adversely affects the life of hot gas path components. It also results in higher NOx and CO emissions.

Most gas turbine control systems provide basic protection against high exhaust spread. However, "alarm limit" for high "spread" in is high (typically ~150-200 deg F). This limit is "static" and does not take into account various factors that affect the combustion process and exhaust temperatures (like load etc.) With such a limitation, in many cases it is observed that serious damage occurs to the hot gas path components before spread reaches "alarm" level.

To demonstrate the effectiveness of model based systems in predicting such anomalies, temperature signatures of an aero derivative gas turbine exhaust thermocouples were built using Neural Networks and Statistical methods.

Measured (Actual values) and Predicted values of exhaust temperature are plotted on the primary Y axis. Secondary Y axis shows the deviation (Measured – Predicted). As you can see in the graphs below, predicted values match the measured values at various conditions for thermocouples T48B, T48C. This indicates that there is no change in equipment behaviour from their known "signature behaviour". Thermocouple T48A data has high variance and is eliminated from the predictive loop.

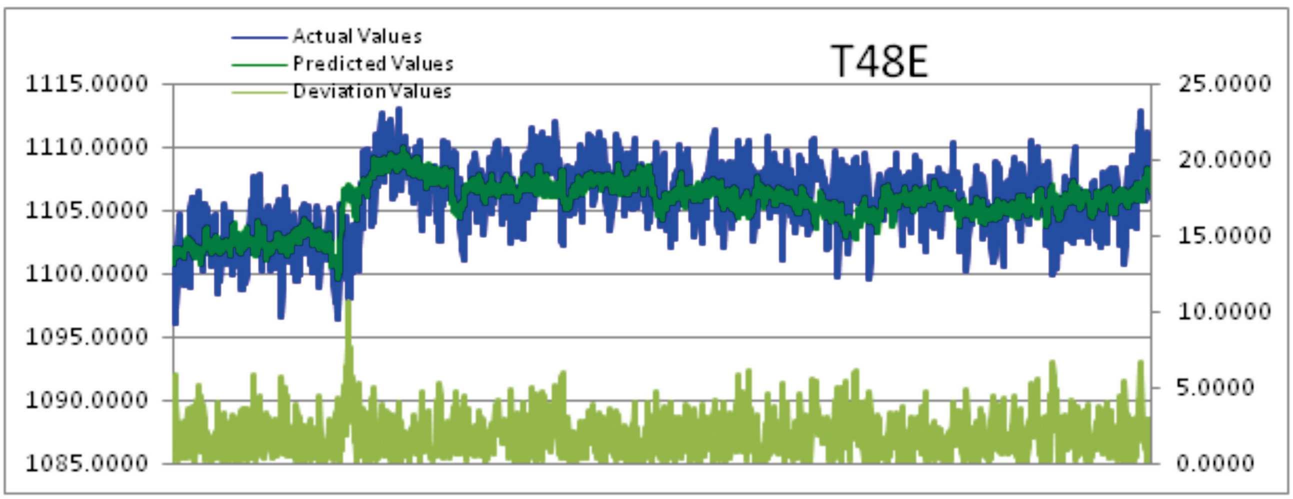


Figure 7: Thermocouple T48E – Measured Vs Predicted values

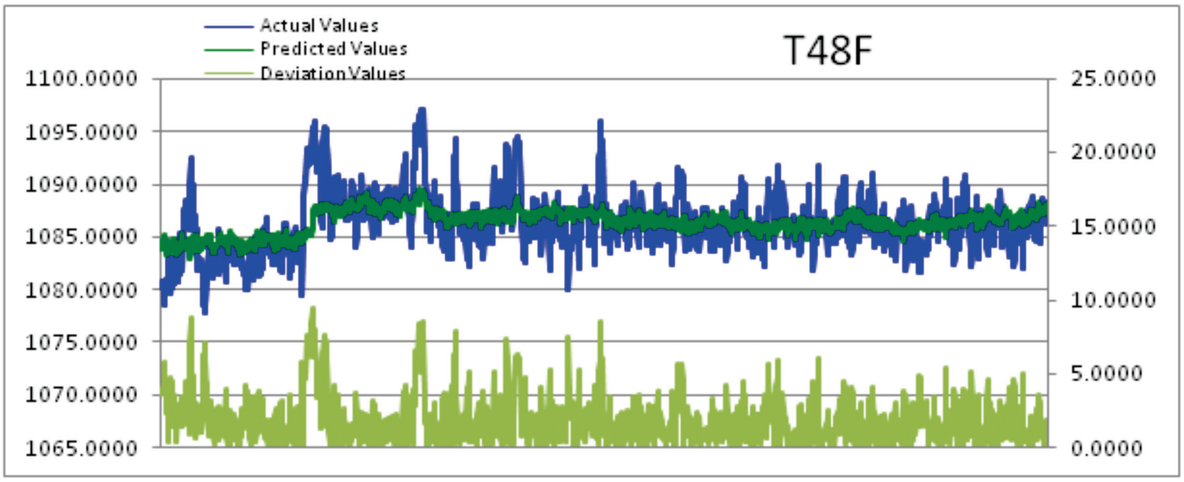


Figure 8: Thermocouple T48F – Measured Vs Predicted values

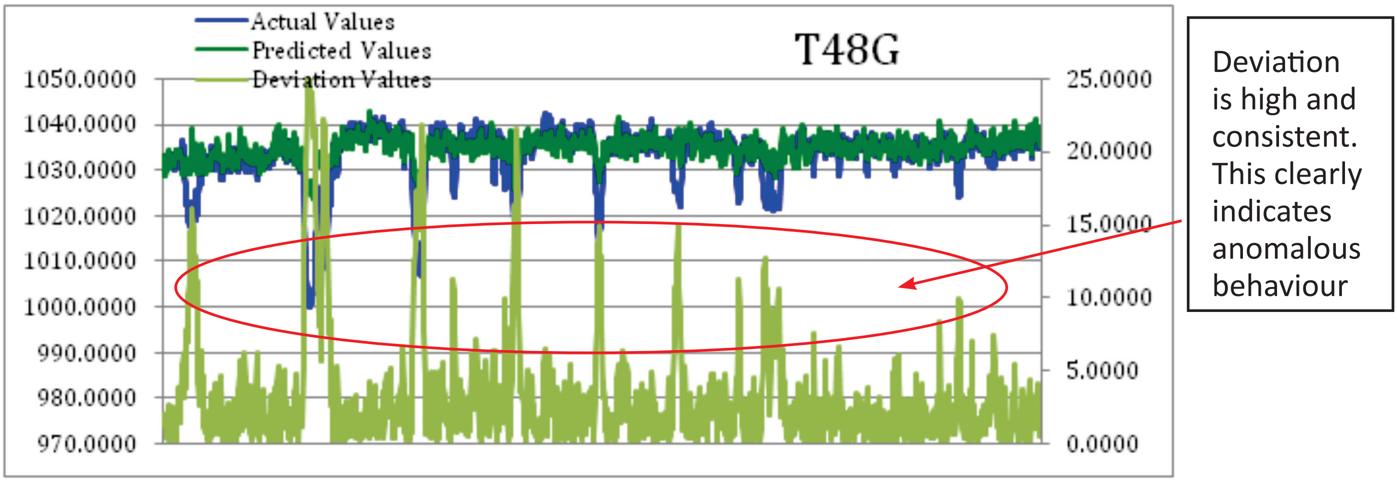


Figure 9: Thermocouple T48G – Measured Vs Predicted values

However significant difference is seen between “Actual” and “Predicted” temperatures in thermocouple T48G

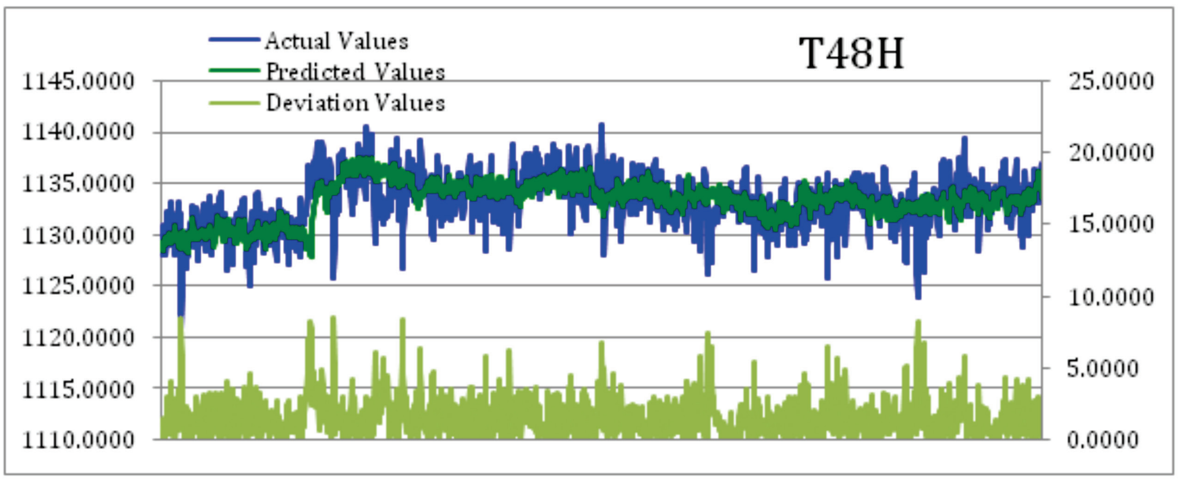


Figure 10: Thermocouple T48H – Measured Vs Predicted values

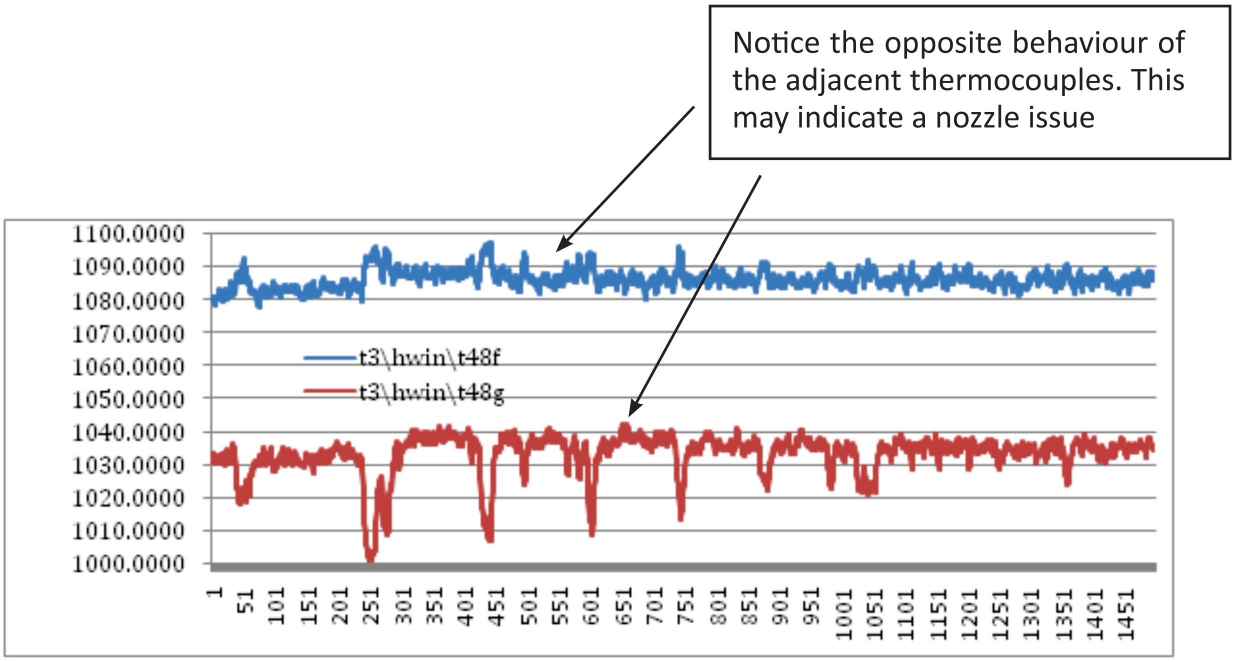


Figure 11: Deviation between T48F and T48G Thermocouples

As seen in Figure 9, thermocouple T48G is showing a significant and consistent deviation from its predicted behaviour. A deviation, although to a lesser degree is seen in T48F (Figure 8). This rules out the possibility of such behaviour in T48G happening due to an "instrument error" and clearly indicates an anomaly. It is to be noted that in the above case, the actual "spread" of exhaust temperatures is well within alarm limit. So there was no alarm from the control systems.

CASE STUDY - CONCLUSIONS

Deviation between actual and predicted values of T48G is consistently high. Spikes in exhaust temperature of T48F were also observed at the same time. This behaviour indicates an anomaly and is possibly caused due to clogged fuel nozzle. Operating the machine for extended periods in such conditions may result in hot spots and may have an adverse effect on the thermal barrier coatings of hot gas path or even the first stage gas generator nozzle.

Even with the above anomalous behaviour, the calculated spread is much below the alarm limit. So without a model based alert system, such a condition would go unnoticed as the control systems would not have alerted the operators.

ADVANTAGES OF ANOMALY DETECTION

1. Identify problems that go undetected by normal procedures
   - Reduce forced outages
   - Improve safety

2. Helps plan maintenance actions in advance
   - Man power planning
   - Procurement of Spares

It is to be noted that even if a single anomaly is detected in its entire life time, such an anomaly detection system would have paid for itself many times over!

APPLICATION OF ANOMALY DETECTION IN POWER / OIL & GAS INDUSTRY

Predictive Analytics can be used on any data where correlations exist between variables. This means the technology can be applied to ANY power or process industry. Some examples of systems related to Power, Oil & Gas plants that can be modeled are -

1. Anomalies in Gas turbines and Compressors
   a. Bearing vibrations
   b. Exhaust Temperatures (combustion related anomalies)
   c. Disc cavity/Wheelspace temperatures (cooling flow related anomalies)
2. Heat Exchangers (Lube oil, cooling water etc.)
3. Boiler Feed pumps
4. Anomalies in Major Fans / Motors
5. Anomalies in Generators
6. Anomalies in Transformers (subject to availability of online instrumentation)
7. Detecting Process issues (bypass stack leaks, bypass valve leaks, pressure, temperature control and recirculation valve passing etc.)
8. Condenser and ejectors issues
9. Instrument & service air Compressors
10. De-mineralized water system etc.

ACRONYMS

OEM	- Original Equipment Manufacturer
DCS	- Distributed Control Systems
PLC	- Programmable Logic Controller

REFERENCES : [1] Figure1: Bowring Marsh "http://usa.marsh.com/Portals/9/Documents/5399%20MA13-12605%20MRMR%20Power%20Generation%20Losses%20ISO%2008-2013.pdf"

[2] Figure 3: Thermodynamic model of a single shaft combined cycle plant built using GateCycle Software: http://site.ge-energy.com/prod_serv/products/oc/ja/opt_diagsw/gatecycle.htm

BIOGRAPHY

Ramakrishna Commuri graduated in Mechanical Engineering from Regional Engineering College, Tiruchirappalli in 1995. During his 20 year career in Power Industry, he was involved in Commissioning, Operations and Maintenance, Thermal Performance Analysis, Training and delivered numerous online performance monitoring systems around the world. He currently works as an engineering consultant specializing in process data analytics.

MULTI-POINT DENSITY ARRAY

SOLUTION FOR INTERFACE APPLICATIONS WITH VARYING EMULSION PRESENT

BACKGROUND

Over the years many different measurement technologies have been used to measure interface in a vessel. Depending upon the characteristics of the interface (clean and well defined, small rag layer, large emulsion layers, number of interfaces being measured, etc.) these technologies may or may not be successful. Many times the end user may be completely unaware of the characteristics of the interface they are trying to measure, especially if the process does not support the use of sight glasses on the outside of the vessel. Based upon a lack of information, end users will progress from the least expensive to the more expensive technologies with each change being prompted by the previous unsuccessful results.

VEGA can measure interface using DP, capacitance, guided wave radar, and nuclear technologies. When the application is qualified as an interface application prone to have a large emulsion layer that may vary over time, then nuclear technology is the recommended solution. The nuclear solution can possibly be a mechanically moving detection system such as the SmartScan or the VEGA Fixed Multi Point Density Array (MDA) System. Disqualification of the SmartScan or MDA will be based upon the vessel size and configuration, customerdesires related to maintenance, process description, number of interfaces, resolution, etc. Manyapplications with smaller vessel dimensions, high temperature, one varying emulsion layerthickness, and low maintenance requirements will be better suited for the VEGA MDA System.These applications would include oil and gas industry desalters, free water knock-out drums,separators and treaters where today's sour crude being processed creates more emulsion inthese vessels. Other industry applications are applicable where interface measurement withemulsions is desired.

SYSTEM COMPONENTS

The attached provides the basic components of the MDA system. Each system is designed around the specific vessel and application requirements of the end user.

7 MAIN BENEFITS OF VEGA MDA SYSTEM :

1. Gives a fixed density profile of the process over the measurement span. Each measurement point is an independent density measurement (in the horizontal plane) of the process between the source on the inside of the vessel, in a drywell, and a density detector.

2. Processes higher temperature as the detectors mount on the outside of the vessel and not in contactwith the process.

3. Conveys independent 4 … 20 mA dc HART signals from each detector monitored to show changing emulsion, upper or lower process densities to indicate emulsions growing, or interfaces rising or lowering to unacceptable elevations in the vessel.

4. Allows higher immunity to changing processes parameters such as capacitance, dielectric constants, and coatings that may change and cause measurement error with mixing of various process fluids as input to the vessel.

5. Offers higher reliability and uptime because there are no moving parts and the detectors are mounted outside the process and readily available for maintenance. One single detector failure does not affect the other detectors making measurements.

6. Displays a density profile even when no clear interface exists (process is a complete emulsion).

7. Provides custom designed flexible mounting bracket assembly and dry wells for ease of installation.

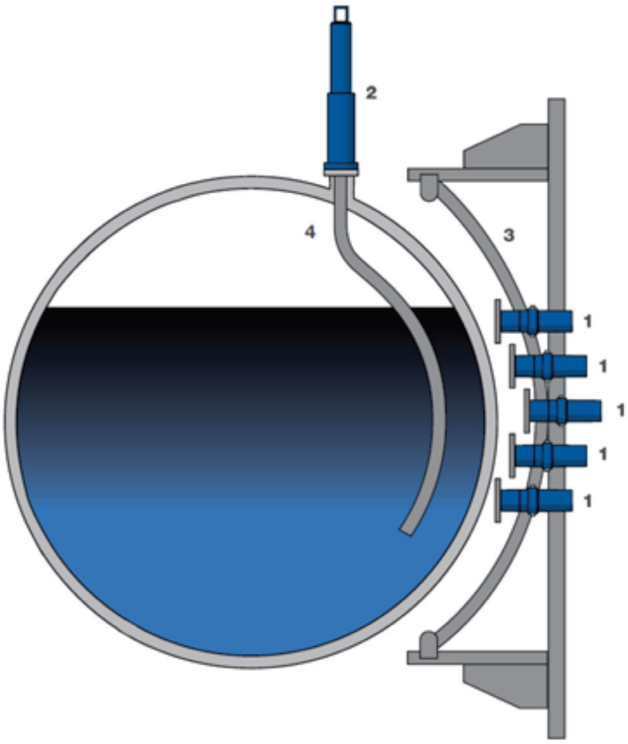
VEGA MDA COMPONENTS

1: High sensitivity scintillation density detector

2: SHLM source holder

3: Flexible detector mounting bracket system

4: Dry well



Note : The number of sources,source holders, detectors,and the location of detectorsis application dependent

AUTHOR

Abhijit Sarathe

VEGA India Level & Pressure Measurement Pvt. Ltd.

OPC Integration with IEC 61850 for Powering Smart Power Systems

Saroj Chelluri AGM (PE-Elect) NTPC Ltd

R.Sarangapani, AGM (PE-C&I) NTPC Ltd

Abstract:

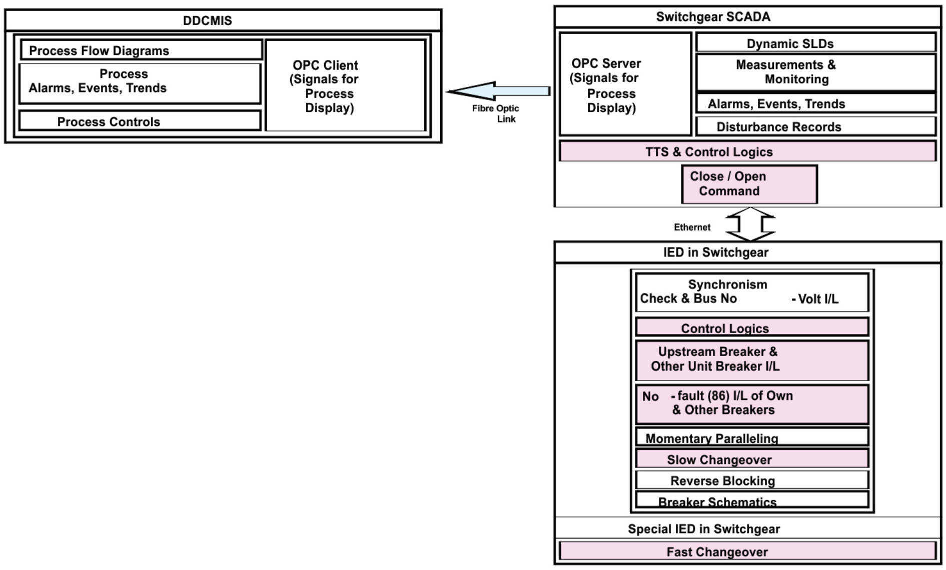
The very existence of the smart Grid concept is based on real time data connectivity of the generation systems, the grid, the distribution system and the user. Communications standards are evolving and there is lot of work going on for the unified architecture. The participation of various stakeholders in the future energy systems through standard communication standards is being deliberated and discussed. The two radical standards IEC 61850 and the OPC, are being seen as the most promising for future smart Grid concept. The technical paper examines the various aspects, data models and integration considerations of IEC 61850 with OPC for achieving data integration for the upcoming smart energy systems. The authors have put forward the real examples of data integration of IEC 61850 with OPC DA 2.0 in different projects. The authors have also put forward the integration study of OPC UA with IEC 61850 which shall prove to be an enabler for new vistas for smart systems having multi-agent systems with hierarchical controls, diagnosis and monitoring. OPC UA which can run on multiple systems with remote access across the cloud and supporting complex data structures can be integrated with IEC 61850 to actualize the Smart Electrical Systems.

A. Introduction

The advent of communicable numerical relays with IEC 61850 in electrical auxiliary power systems had thrown in many options of data connectivity. Many of the electrical data, which were traditionally shared with the plant automation systems only through hardwiring, could now be exchanged through a soft link, resulting in less cable. More importantly, this enabled exchange of vast amounts of data between the two systems; not only for monitoring but also for diagnostics of electrical faults from the comforts of the control room.

The electrical SCADA system has a typical network architecture as shown in Fig 2. The Data Concentrators communicate with the Numerical Relays on IEC61850 Protocol over a secured Process LAN Network. The workstations depend on the Data Concentrator(s) for acquiring data and communicate on the redundant Station LAN network. Data from the electrical SCADA system is linked to the DDCMIS system through the OPC DA gateway. The electrical data then integrated to the Plant DDCMIS system and thus the electrical parameters are displayed in the control room mimics the same way as the native parameters of the DCS. The data interface is as depicted in the Figure 1.

Typically for a power plant application, about sixteen data points per feeder/drive are mapped from the plant SCADA system. A comprehensive list of inputs for motor drives, transformer drives are as exhibited in the Figure 2.Considering about five hundred (500) such feeders on MV and LV systems a huge amount (data of about 9000 to 10,000 digital/analog tags), is being mapped from the plant electrical IEC 61850 SCADA system to the Plant DCS on OPC DA.



INPUT/OUTPUT SIGNALS for Motor Feeder (Feeder Type - DAX)

Sr. No.	Input Description	ON State Description	OFF State Description	Signal for DDCIMS
	Status Signals			
1	Breaker Close Position	Close	Open	✓
2	Breaker Service Position	ON	OFF	✓
3	Breaker Test Position	ON	OFF	✓
4	Reverse Block	Operated	Reset	✓
5	86 Trip	Operated	Reset	✓
6	Under Voltage trip	Operated	Reset	✓
7	Trip Circuit Healthy	Healthy	Unhealthy	✓
8	Numerical Relay	Healthy	Unhealthy	✓
9	Thermal Overload Alarm/Warning Element	Operated	Reset	✓
10	Thermal Overload Trip Element	Operated	Reset	✓
	Analog Inputs			
12	Current R (Ir)			✓
13	Current Y (Iy)			✓
14	Current B (Ib)			✓
15	Current N (In)			✓
16	Active Power (P)			✓
17	Reactive Power (Q)			✓
18	Energy Kwh			✓

INPUT/OUTPUT SIGNALS for LT Incomer Feeder (Feeder Type - DAI)

Sr. No.	Input Description	ON State Description	OFF State Description	Signal for DDCIMS
	Status Signals			
1	Breaker Status	Close	Open	✓
2	Breaker In Service	ON	OFF	✓
3	Breaker In Test	ON	OFF	✓
4	Realy 86 Opearted (LED-1)	Operated	Reset	✓
5	Trip Circuit Healthy(LED-13)	Operated	Reset	✓
6	25" in Sync Prem to DDCMIS(LED-14)	Operated	Reset	✓
7	Numerical Relay Healthy	Healthy	UnHealthy	✓
	Analog Inputs			
8	Voltage R-Y (Vry)			✓
9	Voltage Y-B (Vyb)			✓
10	Voltage B-R (Vbr)			✓
11	Current R (Ir)			✓
12	Current Y (Iy)			✓
13	Current B (Ib)			✓
14	Current N (In)			✓
15	Active Power (P)			✓
16	Reactive Power (Q)			✓
17	Power Factor (Pf)			✓
18	Frequency (Hz)			✓
19	Energy Kwh			✓

INPUT/OUTPUT SIGNALS for Transformer Feeder with Diff (Feeder Type - DBF)

Sr. No.	Input Description	ON State Description	OFF State Description	Signal for DDCIMS
	Status Signals			
1	Breaker Status	Close	Open	✓
2	Breaker in Service Position	ON	OFF	✓
3	Breaker in Test Position	ON	OFF	✓
4	Bucholz Trip	Operated	Reset	✓
5	Winding Temp High Trip	Operated	Reset	✓
6	Oil Temp High Trip	Operated	Reset	✓
7	PRV Trip	Operated	Reset	✓
8	(86 Trip (LED-1)	Operated	Reset	✓
9	Numerical Relay Healthy	Healthy	Unhealthy	✓
10	TRF DIFF(87T)	Operated	Reset	✓
	Analog Inputs			
11	Current R (Ir)			✓
12	Current Y (Iy)			✓
13	Current B (Ib)			✓
14	Current N (In)			✓
15	Active Power (P)			✓
16	Reactive Power (Q)			✓
17	Energy Kwh			✓

INPUT/OUTPUT SIGNALS for Motor Feeder With Diff (Feeder Type - DAF)

Sr. No.	Input Description	ON State Description	OFF State Description	Signal for DDCIMS
	Status Signals			
1	Breaker Status	Close	Open	✓
2	CB in Service Position	ON	OFF	✓
3	CB in Test Position	ON	OFF	✓
4	3 Ph Inst O/C (LED-2)	Operated	Reset	✓
5	Under Voltage (LED-9)	Operated	Reset	✓
6	Time Between Starts (LED-12)	Operated	Reset	✓
7	Trip Coil Healthy(LED-13)	Healthy	Unhealthy	✓
8	Major Relay Failure (LED-23)	Operated	Reset	✓
9	Thermal Over load alarm/warning element	Operated	Reset	✓
10	Thermal Over load Trip element	Operated	Reset	✓
	Analog Inputs			
11	Current R (Ir)			✓
12	Current Y (Iy)			✓
13	Current B (Ib)			✓
14	Current N (In)			✓
15	Active Power (P)			✓
16	Reactive Power (Q)			✓
17	Energy Kwh			✓

Fig 1: Electrical Data Interface

The two systems being evolved from different genres could not be directly integrated seamlessly, as the distributed control systems (DCS) always worked on typically MODBUS or OPC for communication between different systems, while the electrical auxiliary systems has IEC 61850 SCADA for communications between various Intelligent Electronic Devices (IED)s. This resulted in creation of an additional & different layer of data exchange in the electrical system, the OPC. As depicted in Fig 2, the OPC server at the data concentrator in the numerical relay system typically sends data to an OPC client in the DCS. Hence, effectively, this an example of classic OPC data exchange (DA). The OPC DA information model typically uses name, quality, value & stamp for data exchange.

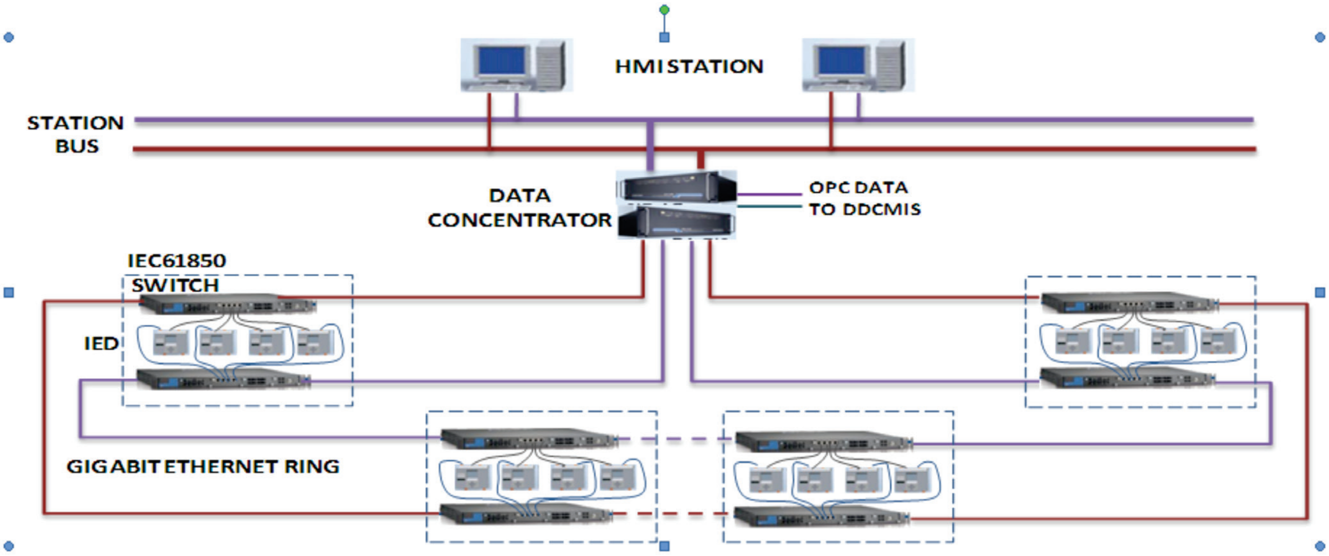


Fig 2: Electrical SCADA Configuration

B. Data Exchange from Numerical Relay Network on IEC 61850 to OPC DA

IEC 61850 Server functions supported via OPC Client DA interface Involves the configuration of IEC 61850 server via SCL (IEC 61850-6-1). Then the mapping of IEC 61850 objects to external OPC server for dynamic data is done. The fixed value initialization is achieved via SCL or mapping file for static data. Read/Write of any IEC 61850 Object, Buffered and Unbuffered Reporting and Controls (Direct and SBO via Normal Security) are also mapped. Full support for object discovery and automatic configuration of data by clients using ACSI services is provided.

The IEC 61850 OPC Server supports the OPC Data Access v. 1.0/2.0 and OPC Alarms and Events specifications. Other features include communication diagnostics, IEC 61850 data modelling, system supervision and IEC 61850 device communication. The IEC 61850 OPC Server supports the IEC 61850 command services, file transfer and OPC alarms and events. The IEC 61850 OPC Server can act as an SNTP client and server for time synchronization. When the IEC 61850 OPC Server is configured for receiving time synchronization, it updates the operating system time.

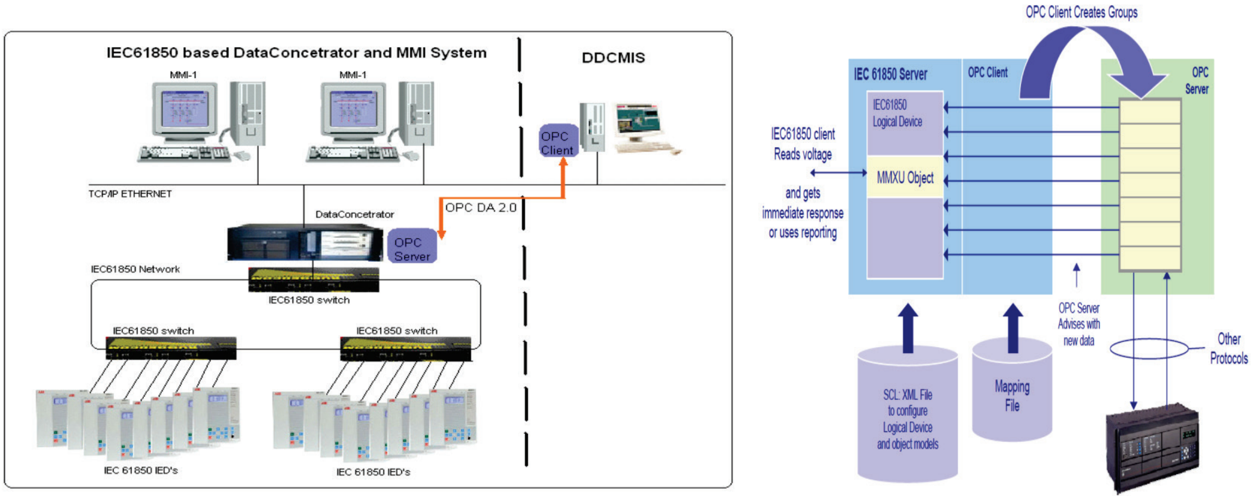


Fig 3: Electrical Data Mapping on OPC DA

The data exchange between Electrical & C&I systems has been implemented in many of the DCS of many leading vendors like ABB, Emerson, BHEL, Invensys in NTPC projects. The data methods, polling as well as change based on data value at server end, have been implemented & are running successfully. In order to minimise problems during commissioning, automation engineers have created an elaborate testing mechanism at the DCS FAT stage to check the data communications between the two systems. At NTPC many a time, actual configured communicable relays are being used in the testing. With many third party connections from the plant HMI and Station LAN on OPC, the scene at the DCS FAT is very much similar to an interoperability workshop.

C. Limitations and Challenges being faced with OPC DA

Classic OPC is based on Microsoft DCOM which sometimes becomes unstable at the layers where data exchange takes place at enterprise level or between systems on station LAN systems. DCOM security configuration is generally error prone and the results fragile to operating system updates and patches. OPC DA has no intrinsic security and mostly it is delegated to the COM/DCOM layer. OPC DA provides a simple address space in a tree structure of branch nodes containing branch nodes and leaf nodes. Many systems are now migrating in favour of .NET's Windows Communication Framework which the OPC DA may not be able to support such transmission systems. At NTPC the major issues being faced are:

a) Penetration with Firewall: During commissioning of the OPC data exchange during the initial projects, a major challenge faced was communication through a firewall. Classic OPC uses DCOM & since DCOM uses dynamic port addresses, communication was getting affected. This was overcome by the DCS vendors either through supply of tunneller software or a predefined static port.

b) Redundancy of the soft link: In case of any problem, hardware or software, data was not available at the DCS. Since important electrical system alarms like motor overload was coming through this link, non-availability of the link was leading to loss critical actionable information.

c) Response: Even though it can be argued that classic OPC link response depends on the software implementation of the OPC server & client; by & large the automation industry does not rely on OPC when it comes to mission critical response times. As an example, we had an inter HMI communication link to be designed by the vendor between two DCS systems. While the annunciations & events were handled by OPC A&E, the designers chipped in MODBUS links for drive operation.

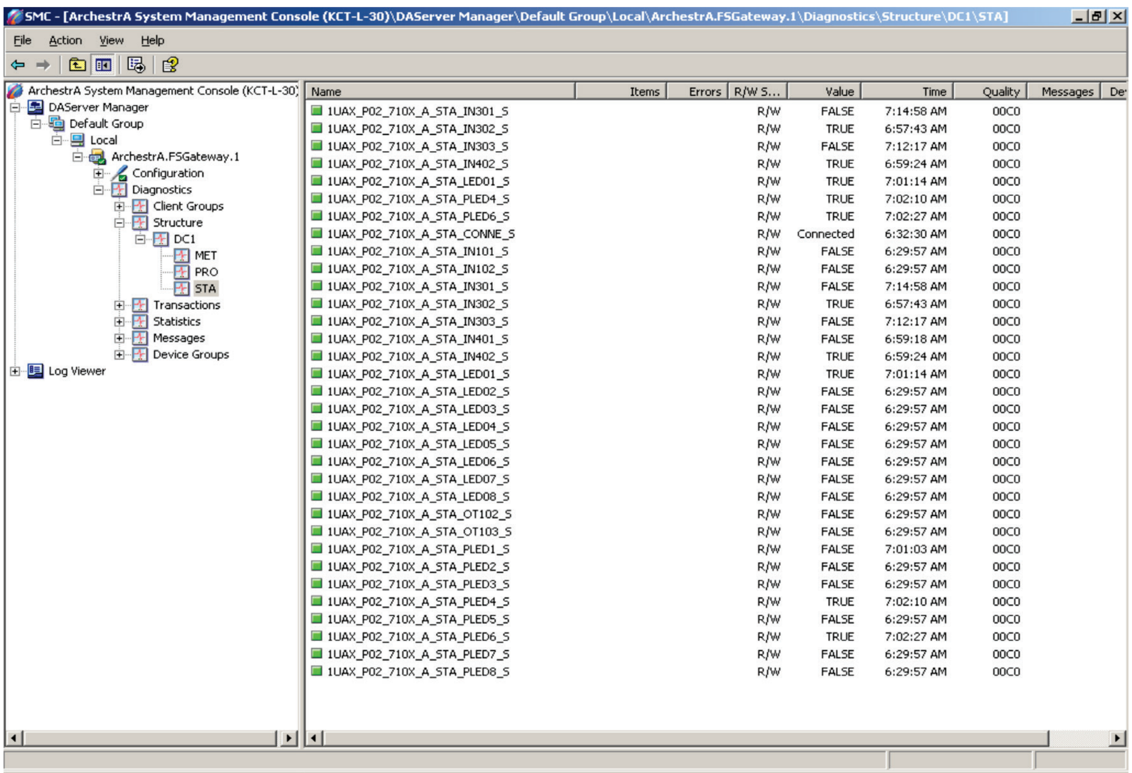
d) At NTPC elaborate data connectivity testing during FAT is done to ensure the two systems i.e. the electrical SCADA on IEC 61850 and OPC DA and DCS systems are communicating. A typical set up for NTPC Simhadri Project is illustrated as below:

M/s Emerson: EDS Server (Installed in Emerson) and ZD OPC ZP OPC Client (Installed In ABB SCADA 800 XA system)

M/S ABB: ABB AfwOpcDa Surrogate.1

The ZD OPC ZP OPC client installed in SCADA server acts as a tunneller which feeds the data from the ABB OPC Server and passes it to EDS server through a fire wall. The test results from a typical test set up for data connections between ABB 800 XA system and Emerson EDS server is as seen in the results below.

In the above testing it was observed that EDS server was listing all the available tags in the OPC server from SCADA. It was required to write codes to filter required data in DCS from the server. Further during the testing it was observed that on forcing values from SCADA Server, the required values updated in the DCS server but the time response was as high. In an another testing between SCADA system from SEL, USA and DCS system from M/s Yokogawa, communication could be demonstrated between FSGateway from SCADA OPC system and Maricon OPC data manger as client in DDCMIS system. Some snapshots of the test are as illustrated in fig 4.



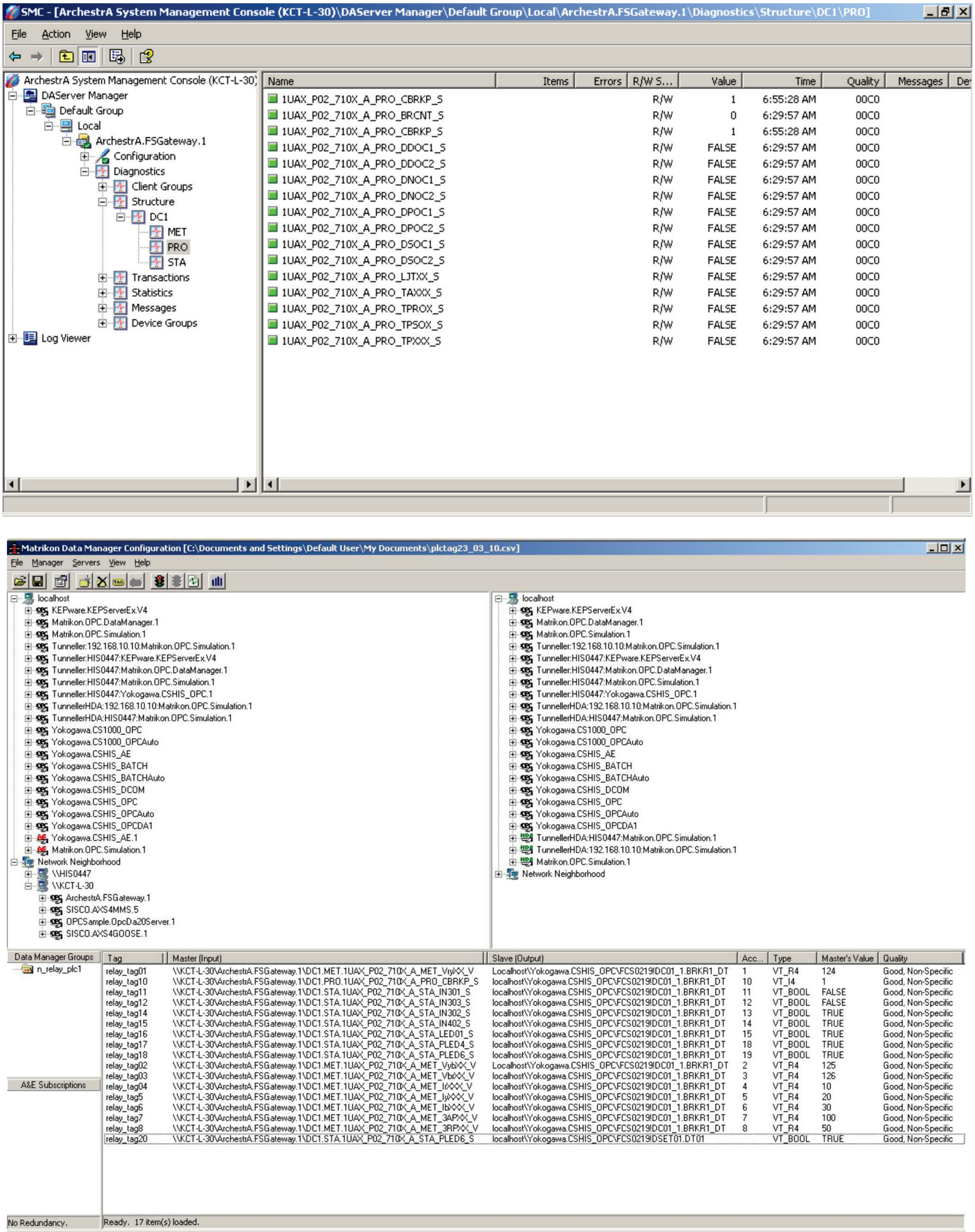


Fig 4: Electrical Data Mapping Sample for a typical Power plant application

D. Standards for Integration and Data connectivity for Unified Data Models

Highly interoperable communication between all the components is the backbone of the smart power systems. In today's Power Utility enterprise information exchanges between the various generation, transmission and distribution management systems and other IT systems is not only desirable but necessary in most cases. That means that both data semantics and syntax need to be preserved across system boundaries, where system boundaries in this context are interfaces where data is made publicly accessible to other systems or where requests for data residing in other systems are initiated. In the energy sector the core standards emerging for standardization are

– TR 62357: Reference Architecture

– IEC 61968/61970: Common Information Model for EMS and DMS

– IEC 61850: Intelligent Electronic Device (IED) Communications at Substation level and DER

– IEC 62351: Vertical security for the TR 62357

– IEC 60870: Telecontrol protocols

– IEC 62541: OPC UA – OPC Unified Architecture, Automation Standard

– IEC 62325: Market Communications using CIM

Until now, the data interface between plant DCS system and Electrical SCADA through Classic OPC was considered and implemented only for data exchange of soft data. OPC UA throws a very bigger possibility for automation & electrical engineers to explore & benefit from direct integration with IEC 61850. The mapping of the OPC UA with the IEC 61850 is promising and will open new vistas of collaboration between the plant automation & electrical systems.

Many standardization efforts are going on for creating harmonization and enabling interoperability of systems in terms of communications. IEC TC 57 has identified IEC 61850 and CIM models as core standards which shall play key roles in the seamless integration for smart electrical systems. OPC Unified Architecture, which is also a core standard specifying a server-client-architecture, is also used to harmonize the two mentioned data models based on a common access layer for higher interoperability of Power plant electrical and DCS systems and also for the management of SCADA systems.

I. IEC 61850

IEC 61850 which primarily focuses on protection equipment and substation automation, is finding use far beyond electrical systems for information exchange like switching commands, status information and measurements, within the utility domain. By integrated communication architecture, IEC 61850 covers the information exchange among and within the three typical layers: process level (transformer and switch), field level (protection and control) and substation level (operation terminal and remote control).

IEC 61850 communication uses standardized information, e.g., for circuit breaker, measurements, control and Meta data, including self-descriptions, specified in IEC 61850-7-4. These information are based on a set of about 20 basic data types (status, measured value, etc.), defined in IEC 61850-7-3.

IEC 61850 places significant emphasis on data modelling. The standard builds up complex data structures from simpler data types in order to describe substation functions and equipment in a standardized way. Types of equipment, such as circuit breakers, transformers, tap changers, earth switches, and cooling systems, are described by the standard using object-oriented techniques.

IEC 61850 standardized naming conventions is applied to the device application definition (known as a logical device) and individual application function descriptions (known as logical nodes). Logical nodes used to define the data models related to protection functions for instantaneous over current also exist, including timed over current, distance, and protection-related functions, such as auto reclosing. The standard therefore defines a consistent way of describing the information related to a significant number of system functions and substation devices and equipment. The process of defining a data model for a substation application requires flexibility within devices, allowing the data model to be defined within the device ICD (IED capability description) file and mapped accordingly to the internal data references of the device.

The information can address both, substation-specific and general aspects. For the communication, certain services for accessing, reporting and archiving values, and controlling devices etc. are standardized in IEC 61850-7-2. Standardized communication networks and systems can be selected to exchange the standardized information by the standardized services as specified in IEC 61850-8-1, -9-1 and -9-2.

The main objective of the IEC 61850 is supporting interoperability in terms of communication among control system devices. IEC 61850 stores its configuration in an open format (ICD, CID [configured IED description], and SCD [system configuration description] files use industry standard XML [Extensible Markup Language]), it is easy to integrate the configuration into existing configuration management systems already being used by engineers. Configuration information is thus readily and easily obtained. Many tools exist to take XML configuration files and perform configuration revision (also built into IEC 61850), alterations, storage, distribution, and many more functions used by engineers.

II. Concept of OPC UA

Targeting simplicity, maximum interoperability, and security, OPC has created a unified method of data communication for parts of the existing OPC specifications for DA, HDA, A&E, and Security known as OPC UA. While conventional OPC (known as classic OPC) solved the device interoperability problem at the Control level, there was the demand of the same level of standardization at the Enterprise layer. Classic OPC is based on the Microsoft DCOM, which can introduce vulnerabilities at these layers. OPC UA was designed to deliver a true Universal Connectivity based on a secure and simple platform to address Enterprise level challenges.

OPC UA is designed on the principles of

Unified Access: OPC UA integrates existing OPC specifications DA, A&E, HDA, commands, Complex data, and Object Types in one specification. This reduces system integration costs by providing a common architecture for accessing information. Access via Firewalls and across the Internet OPC UA uses message based security which means messages can be relayed through HTTP, UA TCP port or any other single port available.

Reliability: OPC UA implements a configurable timeouts, error detection, and communication failure recovery. OPC UA allows redundancy between applications from different vendors to be deployed.

Security OPC UA is Secure-by-default, encryption enabled, and uses advanced certificate handling.

Platform neutrality OPC UA is designed to be independent of the platform. Using SOAP/ XML over HTTP, OPC UA can be deployed on Linux, Windows XP Embedded, Vx Works, Mac, Windows 7, and Classical Windows platforms. OPC Unified Architecture extends the highly successful OPC communication protocol, enabling data acquisition and information modelling and communication between the plant floor and the enterprise reliably and securely

Future-ready and Legacy-friendly: OPC UA uses binary encoded data; hence the response issue in Classic OPC is expected to be addressed. The scalability offered is tremendous; OPC UA can work on embedded devices which also will address the response issue.

Easy configuration and maintenance: As it does not use DCOM, it is fire wall friendly. The OPC client design in case of UA is much simplified since the entire information modelling is done in the UA server.

Higher Performance: Being platform independent, it is the niche solution as many DCS vendors are also expected to go non-Windows platforms. OPC UA supports redundancy although many of the implementations are yet to add this feature. In addition, mechanisms like failover & heartbeat will make the communication more robust than its classic counterparts.

OPC UA has already found its place in some of the latest DCS systems of NTPC going to be commissioned around 2016-17. FAT of some of these will be in the pipeline this year & will surely provide the opportunity to witness these prominent changes. The expectation is for lesser problems, both at the testing as well as actual site stage.

E. OPC UA Integration with IEC 61850

OPC UA can be applied almost in every domain facing challenges in automated control. Besides communication services, information modelling is the key concern of OPC UA. For adopting OPC UA in the context of smart electrical systems and grids, three important data structures—the CIM, the IEC 61850, and IEC 61131-3 for industrial control programming—have been identified to be integrated into OPC UA communication.

OPC UA information modelling capabilities can be used for the electrical integration, by mapping the CIM as well as the IEC 61850. This shall lead to a harmonized access layer for various data sources providing not only a standardized protocol accessing data, but also allows accessing the metadata and thus, understanding the semantics of the provided data. And thus making IEC 61850 easily understandable and interoperable to the world of OPC UA providing access to HMI, historians, MES (Manufacturing Execution System), and connecting the industrial world and the power domain.

The basic principles of OPC UA information modelling are:

a) Using object-oriented techniques including type hierarchies and inheritance. Typed instances allow clients to handle all instances of the same type in the same way. Type hierarchies allow clients to work with base types and to ignore information that is more specialized.

b) Type information is exposed and can be accessed the same way as instances. The type information is provided by the OPC UA server and can be accessed with the same mechanisms used to access instances.

c) Full meshed network of nodes allowing information to be connected in various ways. OPC UA allows supporting various hierarchies exposing different semantics and references between nodes of those hierarchies. The same information can be exposed in different ways, providing different ways to organize the same information depending on the use case.

d) Extensibility regarding the type hierarchies as well as the types of references between nodes. OPC UA is extensible in several ways regarding the modelling of information. Besides the definition of subtypes it allows - for example - to specify additional types of references between nodes and methods extending the functionality of OPC UA.

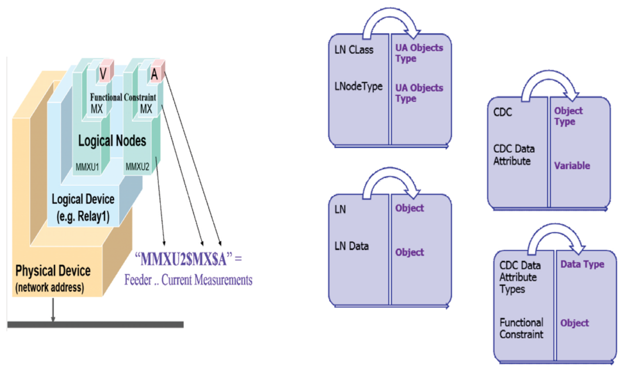
e) No limitation on how to model information in order to allow an appropriate model for the provided data. OPC UA servers targeting a system that already contains a rich information model can expose that model ”natively” in OPC UA instead of mapping the model to a different model.

f) OPC UA information modelling is always done on the server-side. OPC UA information models always exist on OPC UA servers, not on the client side. They can be accessed and modified from OPC UA clients. An OPC UA client is not required to have an integrated OPC UA information model and it does not have to provide such information to an OPC UA server.

F. Mapping OPC UA and IEC 61850 by Experts

The IEC 61850 abstract model works on various layers of communications. The physical layer being the Fiber/twisted pair layer with link layer as Ethernet. As IEC 61850 includes both data and functions, the mapping is complex. IEC 61850 part 8.1 maps the objects and services to MMS (manufacturing Message Specifications). IEC 61850 application layer has MMS i.e core ASCI services, Samples values (SV), GOOSE, and SNTP. MMS operates over TCP/IP where the session layer and presentation layer is connection oriented.SV and GOOSE data map directly to the Ethernet data frame directly providing fast response. GOOSE data is peer to peer communication over Ethernet. SNTP operates directly on TCP/IP.

There have been continuous efforts and studies to map IEC 61850 to OPC UA. Experts have demonstrated an application of the OPC UA Binary serialization and mapping for the 61850 logical node models, namely the most used logical node MMXU for measurements. A demonstration by Sebastian Lehnhoff and coauthors for mapping is presented in their papers. ‘*IEC 61850 based OPC UA Communication - The Future of Smart Grid Automation’ and ‘ÓPC unified Architecture: A Service Oriented Architecture for Smart Grids’*



Mapping IEC 61850 data structures onto OPC UA address space

Fig: 5 Mapping IEC 61850 data structures to OPC UA by experts

It has been illustrated that the base concepts of OPC UA are nodes that can be connected by references. Each node has attributes like a name and id. There are different node classes for different purposes, e.g. representing methods, objects for structuring the address space or variables containing current data. Each node class has special attributes based on their purpose. The variable, for example, contains a value attribute.

Now, the development of the OPC Unified Architecture (UA) enables a new and very promising opportunity to harmonize data models. The UA specifies an abstract server-client-architecture based on a defined information model and services. The architecture provides that a domain specific information model is used to represent certain objects. Hence, a UA-server can be run with an IEC 61850-based model.

The example mapping by the above experts shows that it is possible to expose the IEC 61850 model in OPC UA. With its information modelling capabilities OPC UA offers a high potential for becoming the standardized communication infrastructure for various information models from different domains. Several information models are already defined based on OPC UA making use of the generic and powerful meta-model of OPC UA. An OPC UA server might provide a very simple model or a very complex model depending on the application needs. An OPC UA client can make use of the model or only access the data it needs and ignore the metadata accessible on the server.

IEC 61850 is also discussing the introduction part 8-2 to define mapping of IEC 61850 to Specific communication service mapping (SCSM) for mappings to web-services (Document 57/1181/NP).OPC UA can be a suitable candidate for such interface. The OPC Foundation is also currently investigates the creation of two new working groups, one providing a general mapping of UML models to OPC UA, which can be applied to the CIM, and another, defining a standardized mapping of the IEC 61850 model to OPC UA.

G. Conclusion and future recommendations

In NTPC the data connectivity of OPC DA 2.0 with IEC 61850 has been successfully done but with restraints. There is a need for integrated controls of plant process and electrical controls for reliable and optimized plant operations. Integration of OPC UA with IEC 61850 shall provide the required system connectivity and not just the data connectivity.

The OPC UA, the successor of Classic OPC and also now termed as 'IEC 62541 - OPC Unified Architecture 'shall bring the required system connectivity, interoperability and integrated solutions required for the smart systems. With continual progress in the digital world, the need for higher levels of automation and intelligence built in systems and data integration from various systems is imminent. As OPC UA standard becomes more popular and with devices available it can be seen as a potential driver for integration of Plant DCS and Electrical SCADA systems at control level thus achieving a total integrated Plant controls. The main prerequisite shall be development of DCS systems with OPC UA and standardized mapping of IEC 61850 with OPC UA and inclusion of the same in the IEC standards.

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3) OPC Unified Architecture: A service Oriented Architecture for smart Grids by Sebastian Lehnhoff, Sebastian Rohjans, Wolfgang Mahnke. and Mathias uslar

4) IEC 61850 Standards

5) Smart Grid Road map SG3

6) OPC UA Specifications

About The Authors:

Saroj Chelluri is presently working as Additional General Manager in Project engineering division of NTPC Limited. She has about 28 years of experience in Electrical design department of NTPC Ltd. She has been involved extensively in electrical systems automation, design of Protection and Controls for auxiliary power supply systems in power plants, including concept designs, preparation of technical specifications, tender engineering, detail engineering, testing, and execution. She has introduced the numerical relay technology and SCADA systems on IEC 61850 in the medium- and low-voltage system automation designs, a first in India. She has authored international papers titled 'Integration Considerations for Large-Scale IEC 61850 Systems' presented at Western Power Delivery Conference conducted by Washington State University at Seattle, USA and "Edifying the Smart Future of power Utilities by analysing the benefits of Generation side Virtual Power Plant" presented at the ISA meet at Charlotte, NC, USA and technical paper titled 'GOOSE Controls for a 3x 800 MW Power Plant' at POWID organised by Washington State University, Seattle , USA. Saroj is an active council member of ISA Delhi chapter and is holding 'Membership Chair'.

R. Sarangapani works for the largest Power Generation Company In India NTPC Ltd. and serving as Additional General Manager (Engineering. In a career spanning 23 years in the Power Sector, he has mainly worked in the Engineering of Coal fired power Plants from Concept to commissioning. His areas of work broadly include Engineering & Design of Power Plant Control & Automation Systems - For coal fired stations, Engineering of solutions for Renovation & Modernisation of Coal Fired Power Plant I&C Systems, Engineering Management & Project Administration for Power Plant Projects, Business Planning, Monitoring & staffing functions etc. His areas of specialization include Engineering of Thermal Power Station Control & Instrumentation Systems including Plant wide IT integration systems and Renovation & modernisation solutions for such systems, Engineering of Training Simulators for Fossil Power Plants and Engineering of Performance Analysis Diagnosis & Optimisation (PADO) systems for Power Plants.

3D VOLUMETRIC ANALYSIS FROM BUNKERS AND SILOS TO OPEN STOCKPILES

Dr. Abhishek Goyal and Mr. Rajat Goyal
Director

EIP Technologies Pvt Ltd

Email: abhi@eiplevelcontrols.com
rajat@eiplevelcontrols.com

KEYWORDS

Coal fired power plant, Steel Plants, ESP, Mining Industry, Petrochemicals, PP, LDPE Plants, Volume measurement, bulk solids, Instrumentation, 3D profiling, acoustics, lasers array of antennas.

ABSTRACT

Large-scale manufacturing industries ranging from power industry to cement to steel, plastics, foods, fertilizers and others must overcome challenges of accurately assessing and controlling inventory in order to successfully manage the entire production process. Hundreds of different kinds of storage bins and silos around the globe of different shapes and sizes store materials with widely varying basic characteristics – dielectric constants, particle size, particle type, chemical make-up of particles, and more. Conditions inside bins and silos are often harsh: they are dusty, impacted by extreme temperatures, and subject to anomalies of irregular surfaces and unbalanced filling and emptying. To name some of them are ESP Hoppers, Coal, Limestone, Cement and Fly Ash Silos. They all present a great Challenge in knowing the its true level and volume, thus challenging the management in assessing and controlling it inventory, improve efficiency and preventing over spilling.

In this paper we will introduce a technology which employs an array of low frequency transducers to measure and map the entire surface area, and a patented algorithm that processes the information to generate a 3-dimensional map. The technology enables to measure the volume and mass of materials in new applications that other technologies cannot reach. It enables measuring practically any kind of material stored in an almost unlimited variety of containers, including large open bins, bulk solid storage rooms and warehouses. It enables mapping loads that randomly form over time inside silos, and many other previously inaccessible applications.

Providing much greater accuracy in its measurements and significantly enhanced overall performance, the technology represents very attractive solutions to continuous level & volume measurement challenges. The technology translates into major cost savings and faster returns on investment, and allows managers to make informed decisions that go right to the bottom line throughout the entire supply chain

INTRODUCTION:

FEW SUCCESS STORIES

- 4 X 210 MW Power Plant with 4 boilers and 24 numbers of Coal Bunkers and 8 numbers Fly Ash Silos providing Level, Volume, Mass and 3D Profile of the Coal and Fly Ash for accurate inventory management
- 5 X 660 MW Power Plant with 40 Coal

Bunkers and 8 numbers of Fly Ash Silos

- Many more success stories in Power Plants
- Successful installations and Solutions for PP, LDPE, HDPE Silos
- Calcine and Alumina Silo inventory management is now an easy task with continuous and flawless measurement capabilities of 3D Level Scanner

The technology relates to monitoring of inventory and to process measurement, and, more particularly, to a system and method for measuring the content of a bin. The monitoring of liquid inventory generally is straightforward. By contrast, the monitoring of bulk solid inventory that consists of particulates piled up inside a bin such as a silo often is very difficult. Examples of such bulk solid inventory include cement, coal, fly ash, etc. The measurement of the level of bulk materials inside a bin is a problem that has not yet been solved adequately. The conditions inside bins typically are unfavorable (dust, extreme temperatures, etc.) and the contents of the bulk material stored in the bins often do not have a flat surface and are not always isotropic. Other difficulties arise from the wide variety of bin shapes in use and from the explosive atmospheres inside some bins.

The scope of the term “bin” as used herein includes any storage container, for bulk particulate solids, whose structure defines an interior volume for receiving and storing the solids. Such a bin may be closed above, below and on all sides, as is the case when the bin is a silo, vessel or tank, or may be open above or on one or more sides. The example of a “bin” that is used in the detailed description of the present technology below is a silo; but it will be obvious to those skilled in the art how to apply the principles of the present technology to any type of bin.

Four principal methods are known for continuous measurement of the content of a Bin/ Fly ash silo/ ESP Hoppers

(1) An electromechanical (yo-yo) level sensor consists essentially of a weight at one end of a reel of tape. The weight is allowed to descend in the silo to the depth at which the top surface of the content is situated. When the weight settles on top of the content, the tension in the tape slackens. The weight then is retracted to the top set point. The height of the content is inferred from the time required to retract the weight or from the measured tape length. Mechanical devices such as yo-yo sensors are unreliable. They tend to get clogged by dust and to get stuck on obstacles such as pumps and rods inside the silos.

(2) Ultrasonic level sensors work on the principle of sound wave transmission and reception. High frequency sound waves from a transmitter are reflected by the top surface of the content to a receiver. The height of the content is inferred from the round-trip travel time. Such sensors have limited range and work poorly in the presence of dust. In addition, such devices need to be custom-designed for different types of silo.

(3) Radar level sensors work on the principle of electromagnetic wave transmission and reception. Electromagnetic waves from a transmitter are reflected by the top surface of the content to a receiver. The height of the content is inferred from the round-trip travel time. Such sensors are still based on a single continuous sample point and are therefore not accurate enough for bulk solid applications.

(4) Capacitance sensors measure the capacitance between two metallic rods or between a metallic rod and the ground. Because the silo content has a different dielectric constant than air, the capacitance changes according to the level of the top surface of the content between the two rods or between a rod and the ground. Such sensors tend to be inaccurate and are sensitive to humidity and to type of material stored in the silo.

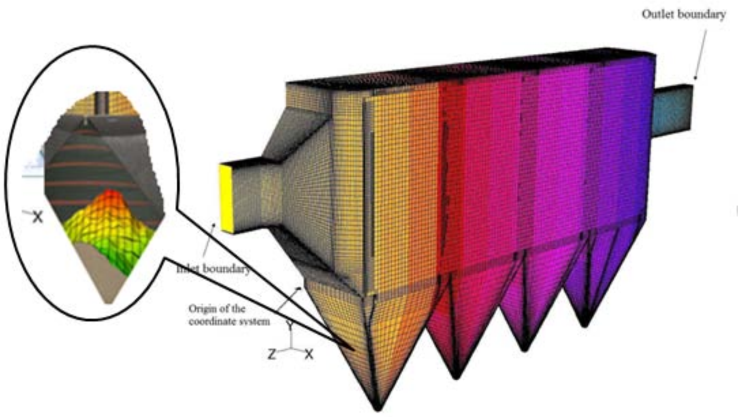
All the prior art sensors discussed above are insensitive to the shape of the contents, and so are inaccurate in the presence of a common phenomenon called “coning” that occurs as bulk particulate solids are withdrawn via the base of a bin: an inverted conical hole, whose apex is directly above the point of withdrawal, tends to form in the bulk particulate solids. A similar phenomenon occurs as bulk particulate solids are added to a bin from the top: the solids tend to pile up in a cone whose apex is directly below the point of insertion of the solids. These sensors also work poorly in bins with complicated geometries and in the presence of obstacles.

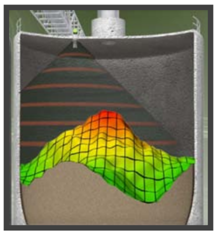
There is thus a widely recognized need for, and it would be highly advantageous to have, a method and a technology of measuring the content of a bin such as a silo that would overcome the disadvantages of presently known methods as described above. In particular, it is not known in the prior art to map the upper surface of the bin contents in three dimensions.

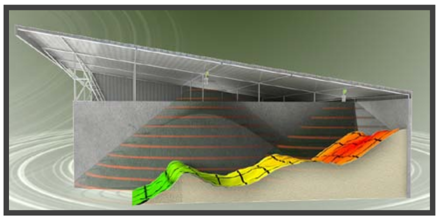
METHODOLOGY/SUMMARY OF THE INNOVATIVE TECHNOLOGY – VOLUME MEASUREMENT

The technology employs a 2-dimensional array beam-former to send low frequency pulses and receive echoes of the pulses from the contents of the silo, bin or other container. The device’s Digital Signal Processor samples and analyzes the received signals. From the estimated times of arrival and directions of received echoes, the processor generates a 3-dimensional image of the surface that can be displayed on a remote screen.

The 3DLevelScanner is unaffected by the type of materials being stored, avoiding the need







for special calibration, or by environmental conditions, such as dust, filling "noise", humidity, or temperature.

Three factors combine to make the technology an innovative one and the best-of-class solution for accurate measurement of bulk solids, particularly those in dusty environments:

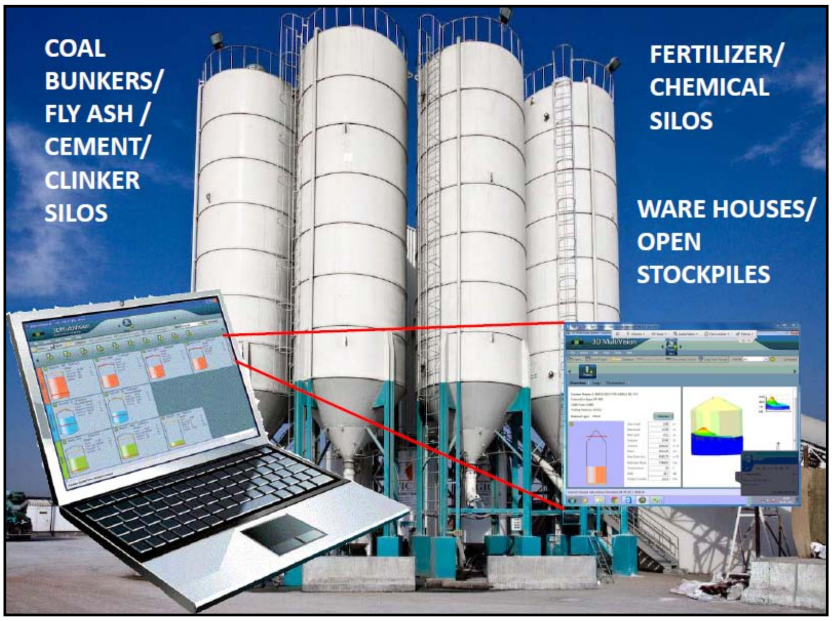
1. Low frequency of transmitted signals (under 4 kHz)

2. A 3-antenna system that measures not only elapsed time between transmission and receipt of acoustic echoes but also the phase between the echoes

3. Proprietary algorithms enabling precise 3-D mapping of the contents inside the silo or storage bin

APPLICATIONS

- Coal Fired Power Plants
  - o Fly ash Silos
  - o Coal Bunkers
  - o ESP Hoppers (Typical Application)
- Steel Plants
- Cement Plants
- Fertilizer Plants
- Food Industry/ Storage Silos
- Alumina industry
- Chemical and Powder Industry
- Minerals industry
- Mining Industry
- Petrochemicals
- Bio energy
- Plastics manufacturing
- Paper and Pulp industry
- Warehouses
- Open Stock Yards



TYPICAL APPLICATION: FLY ASH LEVEL DETECTION IN ELECTROSTATIC PRECIPITATORS (ESP) HOPPERS

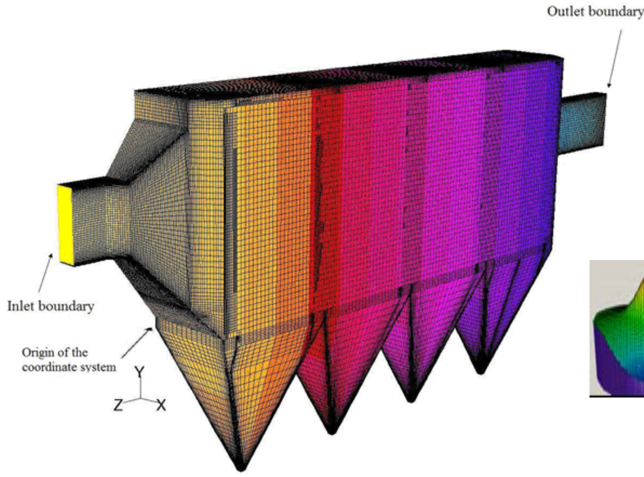
In recent years the particle emissions from process industries have been attracting more attention because of the anticipation of upcoming strict U.S. Environmental Protection Agency (EPA) regulations. Although electrostatic precipitators generally capture 99.5% of the particles from the flue gas in terms of mass volumes, the anticipated regulations on PM2.5 (particulate matter with particle sizes of 2.5 microns and less) have led power stations to explore improvement options to control the emissions of the fine particulate at a minimal cost.

Electrostatic precipitators (ESPs) are the most commonly used, effective, and reliable particulate control devices (System); they are employed mostly in (coal based) power plants and other process industries. The particle-laden flue gas from the boiler flows through the ESP before it enters the environment (thru stack). The ESP works as a cleaning device, using electrical forces to separate the dust particles from the flue gas.

A set of discharge electrodes is suspended vertically between two collection electrodes in a typical wire-plate ESP channel. While the flue gas flows through the collection area, electrostatic precipitators accomplish particle separation through the use of an electric field in the following three steps. The electrical field does the following:

- Imparts a positive or negative charge to the particles by means of discharge electrodes
- Attracts the charged particles to oppositely charged or grounded collection electrodes
- Removes the collected particles by vibrating or rapping the collection electrodes or spraying them with liquid (applicable only in wet ESP)

That large portion of the Fly-ash (dust) particles (which could not be trapped in the Economizer) are collected in the ESP Hoppers below the Electrostatic Precipitators (ESP) having high peak voltage of 71 KV on the collecting plates to polarize the Fly-Ash (dust) Particles.



To prevent over-spilling of Fly-ash (dust) from these hoppers, de-ashing (de-dusting) is performed after a fixed time interval (even if the hopper is not filled completely with Fly-ash (dust)).

This results in:

- High power consumption as many times as the de-ashing (de-dusting) operation takes place.
- A lot of wear & tear due to moving parts of the de-ashing (de-dusting) system.
- Build-up of the ash particles in the portion of the High Voltage Plates could cause a short-circuit between the collecting plate and the electrode (especially under Humid conditions) thus destroying the plate arrangement and the electrical equipment.

This calls for an Automatic Level Detection System to control the High and Low Level of Fly-ash in the ESP Hoppers and start the emptying process only when the pre-set maximum level is reached.

Fly Ash (dust) Level Control & Detection in Hoppers remains a difficult problem in the industry, presenting the following main challenges of dealing with Fly Ash:

- Has very low density, hard to sense (false alarms)
- Tends to stick to everything particularly when moist. (creates rat holing)
- Has a very low dielectric constant.
- Carries static charge.
- Is at high temperature (Approx. 200 deg. C.).
- Is abrasive in nature.

Due of the above mentioned difficulties, current solutions (such as high and low level alarm switches and other technologies) present lots of operational issues.

Users are looking for a non contact solution that will profile the material and measure the volume continuously and therefore save energy (money), maintenance (wear and tear). Once user gets material profile he can easily:

- Detect rat holes at a very early stage
- Detect buildups so user can clean the hoppers in time
- Prevent false alarms due to build ups

- Prevent damage to the plates due to absence of alarms

And eventually:

- Reduce pollution and allow compliance with the strict EPA regulations.

The solution

Continuous volume measurement, using a 3D Scanner, with real time visualization of the material inside the hopper.

The ability to visualize material surface on line, will provide better monitoring and will reduce the number of failures.

The ability to empty the hopper on time result in less pollution (conformity with EPA regulations) and less short circuiting, hence longer plates life (less expenses and higher efficiency). (Customer quote: "…. no more shut down of plant / generation")

METHODOLOGY/SUMMARY OF THE INNOVATIVE TECHNOLOGY – VOLUME MEASUREMENT

3DLevelScanner's technology actually takes advantage of the large 70-degree beam angle (that results from working at a very low frequency), by using a three-antenna system with proprietary algorithms to add another important dimension, direction. The result is that every 5 seconds the 3DLevelScanner receives a matrix of x-y-z position coordinates that represent the echoes from the surface of the contents in the silo. Connecting these points together generates a highly accurate profile of the surface area, which in turn yields more precise measurement of the amount of materials being stored.

Method of Algorithm: How to find and detect the direction from which the echoes are coming from:

Step1: Every echo reflected back goes through classification algorithm.

The MUSIC (MUltiple SIgnal Clasification) algorithm: is a linear subspace algorithm that achieves performance close to Shanon limit with relatively low complexity cost. MUSIC estimates the frequency content of a signal or autocorrelation matrix using an Eigen space method. This method assumes that a signal, x(n), consists of p complex exponentials in the presence of Gaussian white noise. Given MxM an autocorrelation matrix, R_x, if the Eigen values are sorted in decreasing order, the eigenvectors corresponding to the p largest Eigen values spanning the signal subspace. Note that for M = p + 1, MUSIC is identical to Pisarenko's method. The general idea is to use averaging to improve the performance of the Pisarenko's estimator. The frequency estimation function for MUSIC is

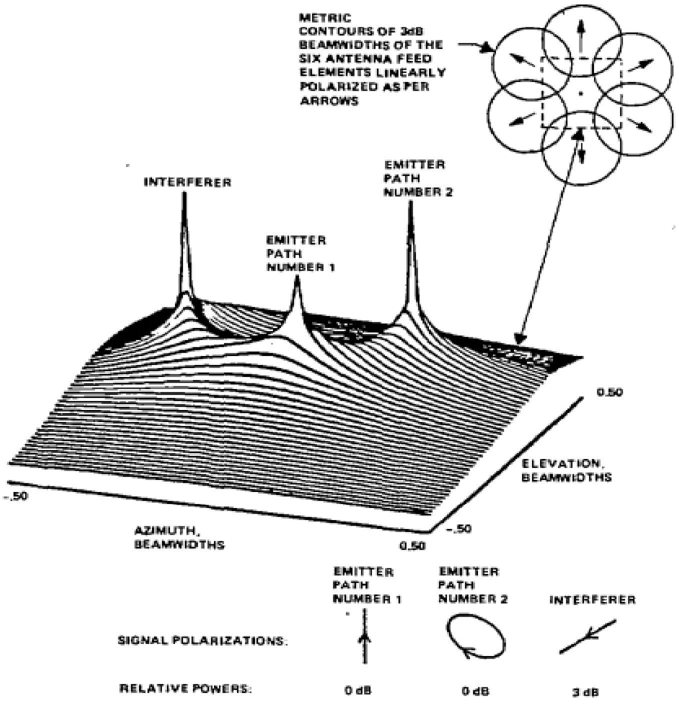
$$\hat{P}_{MU}(e^{j\omega}) = \frac{1}{\sum_{i=p+1}^{M} |\mathbf{e}^H \mathbf{v}_i|^2},$$

Where $\mathbf{v}_i$ are the noise eigenvectors and

$$e = \begin{bmatrix} 1 & e^{j\omega} & e^{j2\omega} & \cdots & e^{j(M-1)\omega} \end{bmatrix}^T.$$

Example of Music algorithm result with 2-dimensional array

1.



1. TOA measurements

The algorithm records the exact time that every pulse is transmitted and the exact time every adjacent echo is received. The difference between these times is the time of flight of signal. The distance is the time of flight multiplayer by half the propagation speed (half because the signal travels forth and back).

The Speed of sound is given by

$$331.3\sqrt{1+\frac{T^{\circ}}{273.15}}$$

T is the measured temperature in Celsius.

For every direction of echo there is a specific set of relative phases induced on the scanner array. However there are some directions that create the same phases on the array even though the directions are not the same.

That effect can be avoided if the spacing between array elements is not more than half wavelength.

Step 2: Angle Calculation

When the spacing between array elements is larger than half wave length there are some different pairs of angles (θ1,ϕ1) and (θ2,ϕ2) that cannot be distinguished physically by the array. The smallest angle θ0, such that for every pair of spherical angles that fulfill θ1<= θ0 and Θ2<= θ0, the directions (θ1,ϕ1) and (θ2,ϕ2) induce different relative phases on the array (thus every two directions with smaller θ can be distinguished) is the maximal angle at which the array can figure direction without aliasing mistake. In triangular array this angle is given by:

$$\theta_0 = a\sin\left(\frac{C}{\sqrt{3}\cdot f\cdot D}\right)$$

Where:

D is the spacing between antenna elements.

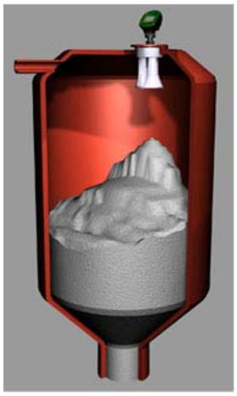
C the propagation speed

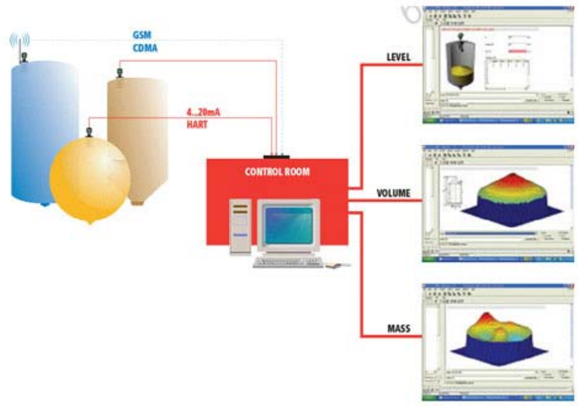
F pulse carrier frequency

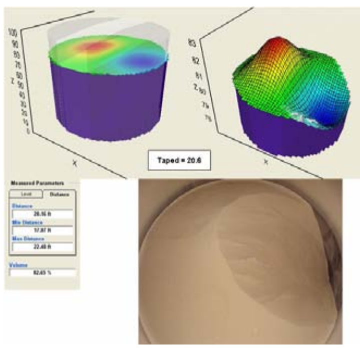
RESULTS

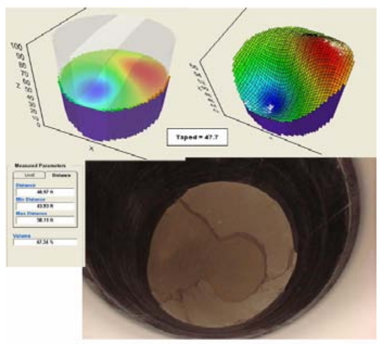
Using the described technology results:

(1) In the ability to profile bulk solid materials in silos such as the below examples:

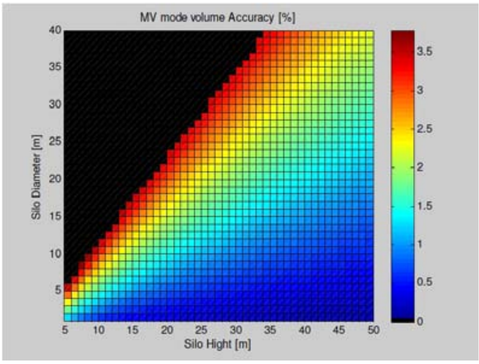








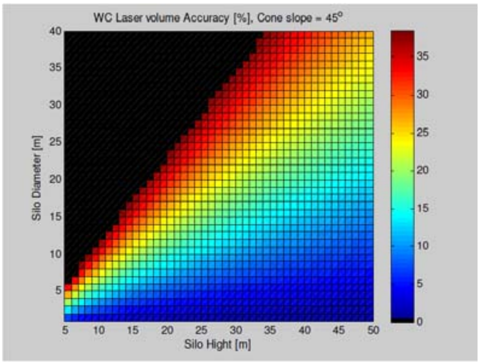
(2) The ability to reach unprecedented volume accuracy. The accuracy reached with the described technology:

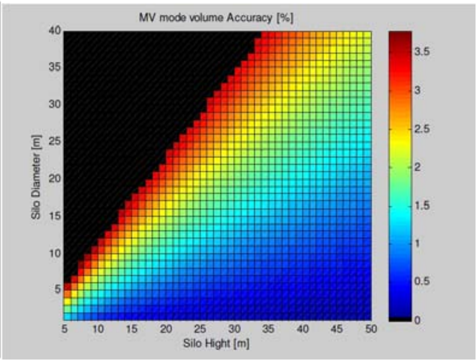


<u>Example</u>:
(1) In a 25 meters high silo and 15 meters wide, it is possible to receive volume accuracy of 1.5% - 2%.
(2) In a 25 meters high silo and 10 meters wide, it is possible to receive volume accuracy of 1%.

CONCLUSION

The results show a great improvement in the accuracy of measurement in bulk solid applications





Comparing today's technologies with the described technology shows an improvement in the volume accuracy by an order of magnitude.

In other words, in applications where the described technology would provide 1% accuracy, an existing technology (yo-yo, ultrasonic, radar) would give 10% accuracy.

Therefore, it is advisable for customers from a variety of industries (steel, power, cement, food, chemicals) who wish to asses more accurately the amount of materials they have in their silos for inventory purposes and optimization of manufacturing process to use the suggested technology.

Providing much greater accuracy in its measurements and significantly enhanced overall performance, the technology represents a revolution to continuous level & volume measurement challenges. This translates into major cost savings and faster returns on investment, and allows managers to make informed decisions that go right to the bottom line throughout the entire supply chain of their pl

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UPGRADING PIPELINE SCADA SYSTEMS WITH MINIMAL DISRUPTION, ISSUES AND CHALLENGES

By Nava Kalita, Deputy Chief Engineer (Telecom), Pipeline Department, OIL

Abstract: Due to changes in business needs, process changes and augmentation, SCADA systems require continuous upgrades. Upgrading SCADA systems of pipeline transportation require exact determination of the needs and changes to be made. It also requires proper selection of technology based on current status, identify components for change and a proper implementation strategy. An operating Liquid hydrocarbon pipeline is never allowed to stop and neither a high downtime is acceptable for most processes considering the safety, security and possible operational excegencies. Under such circumstances, any upgrade undertaken needs to justify the changes done. After identifying the need for upgrade, the likely scenario's of upgrade is to be evaluated. The latest technology available, the degree of automation, existing or upgraded instrumentation and future roadmap is to be fixed before embarking on the changes. Life cycle of the equipment, system and the process as a whole is also to be taken under consideration. Managing change is of outmost importance and the whole idea is value engineering and optimization. As a case study, SCADA upgrades in OIL's crude and product pipeline offers a good example. OIL operates a SCADA system for safe and efficient monitoring and control of crude flow transportation in its 1157 KM long pipeline. When a new product pipeline 654 km long was commissioned to evacuate product from Numaligarh to Siliguri from NRL refinery in 2008, instead of going for a new SCADA system for the product line, the existing crude SCADA system was upgraded to augment and accommodate product pumping process. The upgraded system thus evolved was a combined SCADA system of both crude and product pipeline. This combined system is in its 7th year of operation and has fulfilled the desired targets of safe, efficient monitoring and control and downtime and availability in excess of 99%. Presently with the proposed upgrade of the surface equipment under the NBPL project it is again planned to upgrade the SCADA facilities of the crude oil pipeline along with turnkey instrumentation and is due to be commissioning in March 2015.

Prologue:

Business needs changes frequently nowadays. Along with this process improvisation and augmentation takes place at regular intervals. The days of SCADA system being operated for decades (10 -15 yrs) without any upgrade or change is gone. System improvements in process control, automation and upgrading SCADA is an on going process and needs to be done at regular intervals to cope up with the business needs and changes. It is not surprising that SCADA upgrades nowadays happen in 3 to 7 years.

Points to ponder:

Before embarking on any project to upgrade and improvise operable and running SCADA system the following questions need to be asked to ourselves.

- Can we predict accurately whether it is the right time to upgrade our SCADA system?
- Is it possible to identify with certainty which component are to be upgraded and which are to be retained?
- Do we upgrade just because there is a new technology available?
- Do we imbibe all the advanced features and applications ?

A close look at these questions will give us a common answer and it is 'NO'. If the answer to all the above questions is 'No' then why is there a need to upgrade SCADA system.

Identifying the need to upgrade SCADA:

There is definitely a need to upgrade SCADA systems when the appropriate time comes and hence it is of outmost importance to identify the need to upgrade at the very outset.

Identifying the need to upgrade SCADA maybe due to the following reasons

- System performance has degraded.
- Limitation of resources due to process modification and augmentations.
- Hardware has become obsolete due to old technology and lack of spares.
- Software is no longer supported by the vendor as new advanced versions are developed.
- Enhanced SDADA capabilities and functionalities are required and it fails to deliver.
- Large scale change in the Process takes place due to which changes become inevitable.
- Implement and Integrate new process to the system.
- Cost of maintenance of the system increases and becomes very high.
- Operational efficiency needs to be optimized and existing system fails to achieve the desired target.
- Regulatory requirement

Along with the identification of the need to upgrade and change the system it is also important to access the current reality and the status of the system before embarking on the change. In this regard, it is of great importance to know the present network status and hence go into the steps of evolution of SCADA systems.

SCADA systems over the years have evolved with parallel modern computing technology in three generations. The First Generation Monolithic SCADA system were standalone computer systems which limited its application to scanning the RTU for field data. Equipment and protocols were lean and proprietary in nature with limited connectivity and selective redundancy. The Second Generation, Distributed SCADA systems used distributed processing along LAN to spread over multiple systems. Distributed processors acquired field data in real time thereby enhancing processing power and HMI. It improved redundancy, reliability, accessibility and process optimization. The third Generation Networked SCADA System provided open system architecture with open standards and protocols. SCADA functionality is distributed in not just a LAN, but across a WAN as a whole, using WAN protocol and Ethernet connectivity. Major task can be done at a lower level with advanced RTU and control.

While going for upgrades it is of outmost importance to know which generation the system is and what additional features need to be incorporated.

A modern SCADA system is all about

- Input / Output
- Master Control Station
- Remote Terminal Unit
- DCS
- PLC systems
- HMI & Remote workstation
- Network Elements
- Online Database systems
- Data historians
- Communication media
- Different applications and processes

Likely scenario's of upgrades

SCADA upgrades maybe based on changes in plant Process or maybe based on large scale upgrade of plant equipment or maybe due to addition of a new process to the system, or it maybe neither of all; only a desire to adopt new technology & features. Whatever maybe the case, one or some or all the components of a modern SCADA system may need replacement. Sometimes MCS is upgraded leaving the RTU intact and at other times it is replaced simultaneously. Whatever maybe the scenario it is of outmost importance to divide the tasks into smaller subtasks and take the plunge one at a time. This is more significant in a pipeline scenario, where the process of replacement and upgrade should not have any significant affect on the running of the plant /process. Many processes will not allow high downtime and some process may not allow any shutdown at all. Considering all these factors, it is a prudent strategy to take up the following tasks separately.

a. Upgrading Communication Media to be handled independent of SCADA.

b. Upgrading Field instrumentation should be taken separately.

Even if both are done simultaneously it is a better approach to take this up separately, independent of the main SCADA upgrade.

Features of Modern SCADA system:

In any upgrade job, it is very significant to access the requirement of Modern SCADA systems. Features are as follows

- Flexibility
- Scalability
- Accessibility
- Reliability
- Responsiveness
- Risk assessment & risk mitigation
- Disaster recovery
- Support & serviceability
- Maximize efficiency
- Reduced operating cost

Current focus

The thrust of present day SCADA system is its increased role in the business process, networking for seamless integration of devices & processes, security, merging of Data and integrating SCADA network to Business network / and Enterprise network.

Issues involved in upgrades

1. Locations of SCADA
2. No. of I/O points
3. Size of the Database
4. Type of the database
5. Parameters to be measured
6. Parameters to be acquired online and transmitted to MCS
7. Type of server, its configuration and capacity
8. Selecting the right software & hardware platform
9. Open source software & Proprietary licensed software
10. Data historian
11. Period of data retention
12. Pipeline application software and its requirement
13. Managing interfaces to various applications
14. Managing the web server and web interface
15. Leak detection system
16. ERP connectivity
17. Connectivity to GIS & Asset management system

18. Integrating process KPI management system with SCADA
19. Integrating FFB system
20. MCS & Disaster recovery centre
21. Communication redundancy & standby loop
22. RTU protocols
23. Integration of PLC both process & Safety
24. Emergency shutdown
25. Integrating F & G system / ICSS
26. Network and server configuration of Pump stations
27. MMI & HMI
28. PMR (selecting sampling resolution of database for PMR)
29. Cyber protection
30. Alarm & Event management system
31. Total electrical integration
32. Extended lifecycle

How to go about it

If knowledge is available, in house preparation of specifications is a better option. If it is not, than hire consultants / integrators / specialists to do the job on the customer's behalf. Whatever maybe the case, systematic planning of installation and seamless integration is paramount, so that the changeover is with minimal disruption and downtime, to the existing process.

CASE STUDY ON UPGRADING & INTEGRATING NEW PROCESS (PRODUCT PUMPING) IN OIL's TRUNK PIPELINE SCADA SYSTEM

OIL owns and operates a 1157 km long crude oil pipeline from Naharkatiya in Assam to Barauni in Bihar. Commissioned in 1962, this crude trunk pipeline traverses through the states of Assam, Bengal & Bihar crossing difficult terrain of mountains, hills, marshy, rocky and water logged areas, through thickly populated towns and cities, 21 reserve forests and sanctuary, with 78 rivers on its way including the mighty Brahmaputra. Presently this pipeline transports ONGC and OIL crude to Digboi, Numaligarh, Guwahati refineries and reverse pumps imported crude to Bongaigaon refinery. Since 1962, a telemetry system existed for monitoring & control of flow of crude in the pipeline. The first telemetry system supplied by M/S SERCK control UK was a solid state device system based on registor-transistor logic (RTL) gates. It was world's first solid state telemetry system and at that time south- East Asia's longest & most sophisticated automated pipeline.

The old system underwent a lot of system development during its lifetime and finally in1996 it was replaced with a new state of the art **SCADA SYSTEM** supplied by ABB Energi, Norway.

Old MCS configuration

The networked SCADA system installed in 1996 was configured around the 64bit Alpha AXP 3000/300 LX hardware platform of erstwhile DIGITAL EQUIPMENT CORPORATION (now merged with COMPAQ and HP) USA and ABB's RTU200 and RTU210. The main software used was ABB's SPIDER Pipeline Management System (SPIDER ver. 7.2) based on DIGITAL OSF/1 on UNIX platform. It comprised of Master Control SCADA system at Noonmati and 9 Pump Station SCADA, 15 Repeater stations all interconnected by a UHF radio link through a 12 circuit, medium speed, multipoint data module.

The three DEC ALPHA Server cum workstations in MCS was in triple hot standby mode, with two DEC ALPHA managerial station and one DEC ALPHA Engineering Workstation. All these workstations were interconnected through Dual redundant Ethernet LAN. Four nos. of LAN terminal servers, DEC 90TL provided the means of interfacing the Workstations cum servers to a number of peripheral devices like the Dynamic Mosaic Mimic, Functional Keyboard Controller, Printer, Communication line switching units and Remote terminal Units. Master- remote communication to remote RTU's were handled by two software communication controllers RCS 100 (Remote communication servers) with one RCS100 in online mode and the other in Hot- standby mode. RCS100 used ABB's RP 570 protocol to cyclically request data from RTU's through front end equipment, consisting of LIM cards in daisy chain. The man machine interface at MCS provided interactive support to all SCADA applications through WS400 software. All time tagged and logged, alarm and events, were displayed allowing the operator to call up any process mimic of a pump station in any console and view plant position. Leak detection was achieved in first level through Differential Flow alarm function by monitoring the instantaneous flow rate in and out of sections of pipeline system.

Pump station SCADA configuration

Similar to MCS the Pump station SCADA was configured around two DEC ALPHA 3000LX servers, in dual hot standby mode with ABB's SPIDER PMS software based on DEC OSF1 on UNIX platform, interconnected by dual redundant Ethernet LAN. The network consists of DEC servers, two communication controllers in dual redundant mode and other peripherals. Field data acquisition and control is achieved by two or more ABB RTU200 (Remote Terminal Unit) in all Pump Stations. A fourth RTU is dedicated to refinery terminal where it existed. RTU 200 communicates with the network control system, updates database following event generated by

I/O modules and executes LAF (PLC) program. It also does the tasks of processing, memory management, monitoring, clock synchronization, MMC and NFK interface control, management of database and interaction between different modules and data transmission.

New Process (Product pumping)

In 2008, a new multi product pipeline (NSPL) was commissioned from Numaligarh to Rangapani near Siliguri to evacuate product from Numaligarh refinery to Siliguri. This pipeline shares the same ROW with the crude pipeline and its four IP (Intermediate Pigging) & nine SV (Sectionalizing valve) stations are co- located with crude pump stations & Repeater stations. While designing the SCADA system for NSPL two options were available

a. A separate new system

b. Upgrade crude SCADA system to incorporate NSPL product pipeline monitoring and control

Contrary, to the consultant report, OIL's in-house internal feasibility report and Detailed Engineering concluded that upgrading the existing system to incorporate the product pipeline is a better option. M/S ABB LTD. was found to be technically suitable for the job.

The additional process to be added was 654 Km Product Pipeline monitoring and control with one Despatch Pump Station at Numaligarh, 4 IP Stations co-located with Pump station 4,5,6 and 7,9 SV Stations co-located with Repeater Station 3,4,5,8,9,10,11,12 & 13 and one Receiving Terminal Station at Rangapani

CHANGES DONE FOR THE UPGRADE

1. Major overhauling done in MCS
2. MCS mimic was expanded to accommodate NSPL.
3. OLD front-end replaced with PC based PCU400 system.
4. RTU560 installed in IP stations.
5. Additional remote workstation installed in IP stations for NSPL
6. Existing RTU210 replaced with RTU560 in SV stations.
7. New installation at NRL & Rangapani Terminal with RTU560 & workstations
8. Rockwell PLC installed of at NRL & RPT for local control
9. LIM front-end & Old ALPHA server network retained at crude Pump Stations

Implementation strategy

- Install temporary control desk in existing MCS room
- Shift the existing old servers cum workstations into the temporary control desk.
- Establish the network with the front-end system.
- Transfer Operator controls of crude Pipeline to this temporary network
- Dismantle the old desk and Commission the new desk
- Parallel all signals between old and new control desks till final changeover
- Install the new servers and workstations in the existing control room
- In Repeater Stations dismantle the old Honeywell panel & install the new panel
- Provide parallel connection
- Hook up the network to the communication room using parallel lines from MCS
- Commission in parallel the new combined system
- De-commission and dismantle the old system after the new system has stabilized

New MCS configuration

The new was configured around four IBM 3650 servers based on Xeon processor, with Red hat Linux operating system. ABB's Network Manager SCADA software runs in two IBM servers with real-time AVANTI database in dual hot-standby configuration. The other two servers are UDW (Utility Data Warehouse) on which RDBMS Oracle software runs to store historical data. Database in the four servers are synchronized with the online SCADA server.

Two front-end PCU system installed in industrial PC's with licensed PCU software, performs the master remote communication with the old RTU200/210 of the crude OIL pipeline.

Four IBM operator workstations, two for crude and two for product pipeline on windows based operating system runs ABB's proprietary WS500 HMI display software. A data engineering workstation with IDES (Integrated data engineering system) performs all data Engineering jobs including incremental population for updating the database. The Dynamic mosaic MIMIC of the old MCS was retained and it was expanded to make provisions of display of the new product pipeline. All servers, workstations, PCU systems etc are interconnected through dual redundant Ethernet LAN.

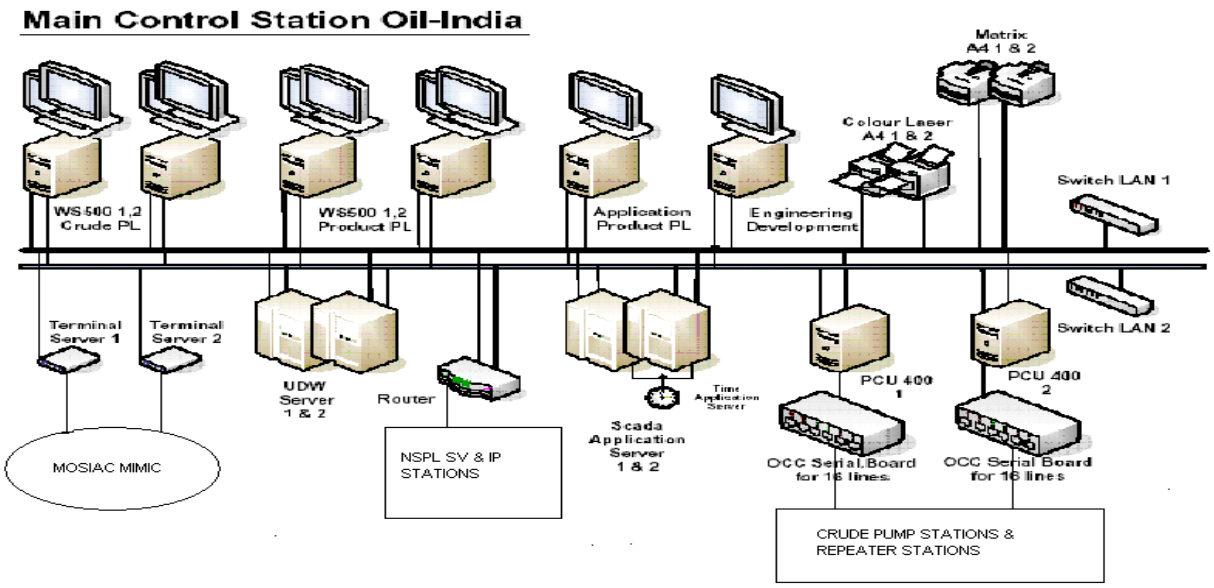

Figure 1: System Configuration Main Control Station (MCS)

NRL Pump station & Rangapani Terminal

At Numaligarh Despatch station and Rangapani Terminal ABB's latest RTU560 is installed for field data acquisition with two Windows based workstations with ABB's WS500 HMI software to perform HMI and display functions for the operator. RTU560 communicates with the workstation with Ethernet LAN using IEC104 protocol. A Rockwell PLC system is installed for local control of the process. Field process data points are interconnected to marshalling cabinet and the Telemetry interface cabinet acts as the interface of the Input/ output points with the RTU560. The local network is connected with the MCS network through a router installed at the communication room at Numaligarh. The product pipeline despatcher monitors and control from Numaligarh where all the authorities of the MCS workstation has been provided.

In the nine SV stations, which are co-located with the Repeater stations of crude oil Pipeline, the old RTU 210 is dismantled and replaced with new RTU560. This RTU is directly connected to MCS LAN through the OFC network. The process data information and instruments of both product and the crude oil pipeline is connected to this common RTU560 and they are telemetered to MCS using IEC104 protocol.

In the four Intermediate Pigging stations, co-located with the Pump stations one additional RTU560 have been installed to cater to the product pipeline process information. Along with the RTU two new windows based workstations have been installed with WS500 software for HMI display as interface for the local operator. This local product pipeline network is connected to the MCS network through router at the IP station communication room. The old ALPHA server network has been retained and the RTU200 performs data acquisition for the crude pipeline.

Major features of the Combined system

a. Single network system with common server for both crude & product pipeline.
b. Common database for crude and product pipeline.
c. A single SCADA software for both crude & product line
d. Separate workstation for crude and product operator
e. Model based leak detection for product line

What we have achieved

- Open system architecture
- Retain Commonality of Equipment
- Modular design with Expandability
- Optimize monitoring & control of flow
- Improved operation
- Improved system design
- Reduced maintenance, cost & effort
- Reduced inventory
- Optimum capacity utilization
- Reduced power and Better energy management
- Less carbon footprint

SCADA UPGRADATION UNDER NBPL PROJECT

In 2012, OIL embarked on a new project to upgrade all the surface equipments, prime movers and pumping facilities. Under this project major changes in philosophy of pumping will take place from tank to tank pumping to tightline pumping. Overall efficiency to be increased using with VFD control motor driven centrifugal pumps.

Although massive changes in the machinery, equipments, instruments are envisaged in this project still it is a brownfield project. The project is undertaken to derive distinct benefits in the whole business process as listed below.

a. Extension of operating life of the system.
b. Optimum capacity utilization by phasing of up-gradation and reduction in three intermediate Pump Stations to 8 nos. from existing eleven.
c. Improvement in overall system efficiency by providing flexibility of handling variable flow through VFD.
d. Reduction of vapourisation loss.
e. Compliance to latest OISD standards.
f. Reduction / mitigation of hazards & risks by performing HAZOP & HAZID during detail design stage.
g. Making the system more environment friendly and earning carbon credits
h. Reduction in OPEX & Maintenance cost.

i. Improved system design with better automation.

j. Reduction in inventory.

The entire instrumentation and piping is envisaged to be replaced. This has also necessitated up-gradation of the SCADA system in Pump stations, Repeaters and MCS. The upgraded SCADA is proposed to have the following

a. MCS at Noomati

b. ECS at Jorhat

c. RTU at Pump stations and Remote station

d. SIL3 PLC at all pump stations

e. APPs system

f. LDS system

g. OPC server

h. Web server

The Future of SCADA system

Widespread use of SCADA systems in more and more industry is anticipated in future. There will be more investment in this system in the coming years with better security and infrastructure. SCADA systems will no longer remain tangential to pipeline regulatory obligations as in the past. It will be the major criteria of how pipelines are operated and maintained. This will further give more importance to the stability and accuracy of SCADA systems.

With this there is a possibility of SCADA evolving as a New data hub. When these traditional control centre become information and data hub, customers expectation need to be met with information and control from the control rooms.

Speed and data storage integrity of SCADA will improve tremendously in the coming days. Information acquired by SCADA system will be used more vigourously as a statistical tool for predictive and preventive maintenance activities. Process optimization, business process re-engineering, reduced downtime of machines is expected to be accrued from it.

As information from these systems will become more important to the overall business processes, backup and disaster recovery system will be more advanced to ensure data protection and data integrity.

SCADA processes in future will not be limited to the traditional delivery system controls. Industry experts and technology experts believe that over the years SCADA use will be widespread in diverse sectors. Wireless technology will be more sophisticated to be integrated into SCADA systems exclusively. Wireless technology will become more prevalent due to the need for remote control operation of plants and more efficient operation. As more and more information will be handled by these systems, there will be an enhanced requirement of bandwidth and data storage. Highly industrialized countries will lead in innovation, in the field of SCADA systems. Stability and accuracy of the system will be more important in future. Statistical assessment and model based diagnostics will be implemented further into the system. SCADA systems in future will be Management information systems, Company's information services, Supply chain management, Enterprise resource planning and Customer relationship management systems all packaged into one. In specific cases, it will be integrated to GIS systems, KPI management systems and asset management systems. Total Electrical integration architecture will also be the order of the day. The overall trend will be to migrate on to HTML format. It will integrate the SCADA system into a complete company wide database.

There will be more use world wide web to access SCADA data from anywhere in the world allowing the flexibility of accessing data. Invariably almost all SCADA systems of the future will be more distributed, with open protocols and networked. Networked SCADA systems will be more vulnerable and its protection from cyber attacks will require tremendous effort. Cyber protection will be a major issue and bulk of the cost maybe borne by user for this. Cyber threats will be more prominent and terror attacks on SCADA networks to disrupt and damage the actual physical process will show an increase in trend. Cyber protection measures will increase many fold.

A SCADA attack crippling major cities will be a very real. Considering the real threat of cyber terrorism, security cracks in SCADA security will increase.

Emerging new technologies like 3G-enabled RTUs will enhance SCADA network level of security. High end routers, managed switches and firewalls will improve network security. Security of location of the SCADA nodes, communication lines and modules of the SCADA system will be of more importance also unused data outlet of the SCADA network have to be protected.

As the mobile workforce concept gains ground in future it will be all the more challenging to deliver field data directly to these people to optimize operations and maintenance. Alarms and alert, events and instruction will be directly routed to the remote personnel directly from the SCADA system in the form of SMS, Mobile call, text message or e-mail via web interface and public network.

Improvement in IED, Smart sensors, plug and play devices, remote calibration will improvise the SCADA system functionality. Protocols will be more universal and Ethernet is envisaged to be the common carrier.

Roadmap Pipeline SCADA upgrades

- Technology changes very fast.
- To keep pace with changing Technology timely upgrades are necessary for optimized & safe operations.
- Keeping in view the future Trends, upgrades should be address

a. Data integrity

b. Threats & vulnerability

c. Bandwidth requirements

d. Open system protocols

e. Reduced gap between SCADA, RTU & PLC

f. Enterprise connectivity

g. Electrical integration architecture

Conclusion

Pipeline operation process needs continual improvement and improvisation for safe and optimized monitoring

and control. With emerging technology in process control, continual upgrade of Pipeline SCADA system is

inevitable. But before embarking on any upgrade it has to be seen whether such upgrades are necessary, what

are the areas to be upgraded and whether the upgrade expenditure will justify the process requirement. All

SCADA upgrades need to be well planned and a strategy needs to be in place to execute the upgrade.

References

a. All open source material in the internet.

b. Manuals and technical sources.

SAVE MY SIL

Amit K Aglave, Meghna Bahl

Fluor Daniel India Pvt. Ltd.

ABSTRACT

The entire process industry has widely adopted the functional safety standards such as IEC61508 and IEC61511 for achieving the functional safety. These standards lay the guidelines and the framework for achieving functional safety throughout the lifecycle of the Safety Instrumented System (SIS). Lot of efforts are put up in the design and engineering of the SIS to achieve the intended risk reduction which is expressed in terms of Safety Integrity Level (SIL) for all the identified Safety Instrumented Functions (SIF). However, the desired focus on ensuring that the achieved SIL is maintained at the desired level throughout the operational and modification/retrofit phases is not given. Post design and engineering, when the SIS is deployed in to the operational phase, testing and maintenance methodologies influence the SIS performance. These methodologies include the human and organization aspects which may affect the SIL of the SIF.

The paper 'Save my SIL' intends to cover some of the parameters that the operating company should focus on during the operational phase to ensure that the concept of SIL is not killed, i.e. designed SIL is not degraded, thereby degrading the safety of the plant.

KEYWORDS

Functional Safety, Safety Lifecycle, Safety Instrumented System, Safety Instrumented Function, Safety Integrity Level.

INTRODUCTION

The process industry has widely deployed Safety Instrumented Systems for achieving process safety for years. Not only do the applied instrumentation and logic solvers have seen enormous changes, the reference and governing standards also has changed. From local standards, the reference has moved to Functional Safety Standards; IEC 61508 and IEC 61511.

These standards address the requirements of the Safety Instrumented Systems which are based on the use of logic solvers those use electrical / electronic / programmable electronic technology. The standards also address the requirements for sensors and final elements which may be based on any of the technologies.

The standards lays down two important concepts; first, Safety Lifecycle and second, Safety Integrity Levels.

Safety Lifecycle

The safety lifecycle as defined in the standard covers the necessary activities which are involved in the implementation, deployment and operation of the Safety Instrumented System. The lifecycle begins with the concepts phase of the project and ends when the Safety Instrumented System is decommissioned. The safety lifecycle approach ensures that the rational and consistent technical policy is applied in each phase. This is necessary as each phase of the safety lifecycle involves different stakeholders and may apply different philosophies.

The phases which are covered by the safety lifecycle are:

- Perform a hazard and risk assessment to identify the overall safety requirements
- Allocation of the safety requirements to the safety instrumented systems
- Design and Engineering of the SIS
- Installation and Commissioning
- Operation and Maintenance
- Modification
- De-commissioning

The standards cover the requirements of Management of Functional Safety necessary in each phase of the safety lifecycle. It establishes the management activities that are necessary to ensure the functional safety objectives are met.

The safety lifecycle phases of IEC 61511 are covered in the figure 1.

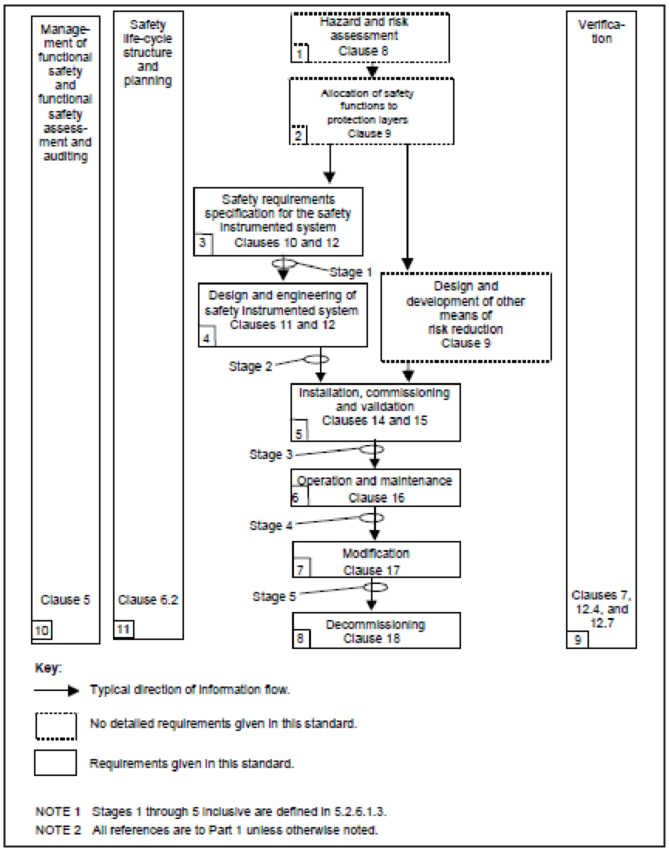

Figure- 1: SIS Safety lifecycle phases

SIS, SIF and SIL

The simple explanation of the SIS is a system that contains Sensor(s), Logic Solver (Safety PLC) and the Actuating Device(s). It is represented as below:

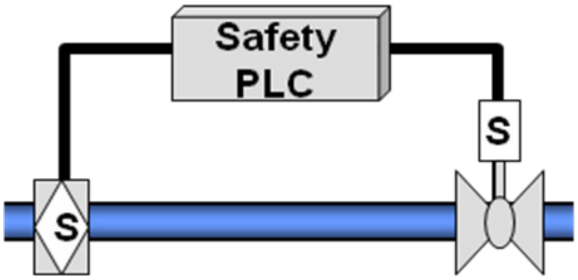

Figure- 2: Safety Instrumented System

The Safety Instrumented System (SIS) implements the desired Safety Instrumented Function(s) (SIF) to maintain the safe state for the Equipment under Control (EUC). The requirements of the SIS are given in IEC61508