Knowledge management to improve performance

Preserving within the company the expertise that has been acquired by its operators, technicians and managers after they have moved on is the subject of this article, which describes a reliability and operations management system

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Holding on to the expertise of valuable staff is becoming increasingly difficult in today's business environment, culturally and economically. Operations staffs (operators, technicians, engineers, managers, etc) are maturing to a point where significant retirements are imminent. In addition, over the past 20 years, employee/employer loyalty has changed to a point where employee turnover is an expected event. Employers need to take measures to retain knowledge from their critical staff members rather than watch this expertise leave along with the employee.

There are, however, field-proven methods offering just this capability to companies who recognise the differentiating value of their know-how.

There are a number of reasons for companies to adopt a philosophy of knowledge preservation and online diagnostics:

—Loss of corporate knowledge caused by turnover of operations staff (retirements, layoffs, transfers, etc)
—Standardisation on best operating practices
—Active method of sharing knowledge among staff members
—Proactive means of monitoring equipment health
—Method of cataloguing knowledge
—Method of propagating knowledge corporate-wide
—Efficient use of available technical support staff in view of reduced staffing levels industry-wide
—Effective management of career progression for employees.

To facilitate career development and maintain employee interest, employers are often willing to rotate staff through different assignments. Although this benefits the development of the employee, their expertise is no longer available to the team they have left. A new person is brought in and must begin the learning process on the same area again.

By recording and maintaining the knowledge base of those employees rotating through job assignments, an employer is also able to capture and reuse the expertise of all of its employees to the benefit of the company.

By cataloguing the knowledge in a reliability and operations management system, the knowledge and best practices of the most experienced operations and engineering staff are available to all and used on a regular basis while interacting with the operating unit. Over time, this knowledge can continue to grow as new operating characteristics are identified and incorporated into the application. Once deployed, this knowledge can be shared within the corporation on similar equipment or on other similar operating units.

Above and beyond the normal operating practices and procedures, a reliability and operations management system should also include features which diagnose the condition and performance of critical process equipment. The system will inform operations staff of equipment which may not be performing as expected. Such online monitoring will enable operations to schedule maintenance prior to catastrophic equipment failure, which would lead to unscheduled plant down time.

R/OMS

A reliability and operations management system (R/OMS) goes far beyond the capability of the traditional distributed control system (DCS). The R/OMS will provide the ability to improve plant performance, on-stream factor and profitability by:

Reasoning on multiple events occurring simultaneously in the plant (process values, set points, controller outputs, controller modes, etc) and identifying the root cause.

Associating messages with DCS schematics and specific objects appearing on these schematics.

Navigating via messages through relevant DCS schematics with a single touch to access recommended action(s). This approach facilitates quick, consistent actions by operators.

Monitoring process equipment performance and informing operations when a specific piece of equipment is in need of maintenance (such as cleaning a fouled heat exchanger).

Monitoring the unit performance against expected or modelled values.

Providing messages, explanations and a logic tree of suggested responses to the operator.

Referencing up-to-date electronic documentation (health, safety and environmental, operational, maintenance, etc) during actual plant operations.

Providing early warning of a pending problem, which can be resolved at a more leisurely pace than during alarm flooding of the DCS.

Providing very specific process and plant operations diagnostics to the end user.

An R/OMS should include tight integration to the end user's DCS system. Given an industry standard OPC interface, integration is far simpler than via a custom application-programming interface (API).

R/OMS benefits

Depending on the nature of the rules and logic incorporated into the system, a broad range of disciplines will benefit from an R/OMS application. The application will provide benefits to:

—Operators
—Reliability engineers
—Maintenance engineers
—Instrument technicians
—Tech support engineers
—Environmental engineers
—Process control engineers
—Process engineers
—Operations planning and scheduling.

Other disciplines will also benefit as additional opportunities are identified and the logic continues to expand.

Inter-application

The R/OMS application will require data (process value, set point, controller output, controller mode, etc) from the DCS to perform its analysis. There are two common approaches to retrieving data, each offering benefits with some 'cost'. The objective is to compare benefits to costs and decide, in each specific project, the most beneficial approach. The two approaches are described as follows.

A traditional approach is to retrieve data directly from the DCS on the process control network. The advantage to this approach is that the data is truly real-time, providing the most current data available. However, with the R/OMS connected directly to the DCS, many data points will poll the DCS twice for the identical information – once for the DCS and a second time for the R/OMS.

The additional network loading may be tolerable under typical operating conditions, but may prove to be unacceptable during abnormal conditions when system response time is most critical. The additional loading on the process control network could eliminate this as a practical approach.

However, in most process control system installations, the end user will already have a data historian connected to the control system. The data historian probably polls the DCS database for the same data required by the R/OMS application, and much more. By retrieving data for the R/OMS application via the data historian, any potential impact on the process control network is eliminated at the expense of using data that would be at least 10–20 seconds old.

Sound engineering judgment is required to determine if such a time delay is acceptable to the end user (for example, this may be acceptable when considering tank liquid levels, but may be unacceptable for compressor applications).

The ability to support both interfaces simultaneously, a data historian and a DCS, provides the maximum flexibility to the end user and maximises the efficient use of all application computer resources. It should be noted that once the R/OMS application is field verified, end users might decide to make the application "closed loop". This requirement would make some level of communication directly to the process control network (and to the DCS) imperative.

In summary, each end user must take into consideration their own circumstances and requirements in order to select the most effective approach to retrieving data for the R/OMS.

Figure 1 is an overview of the hardware integration of an R/OMS system with an existing DCS. The R/OMS server can retrieve data via OPC directly from the process control network or from the data historian.

Early attempts at rules-based R/OMS have provided limited functionality and were difficult to implement. Improvements in software and hardware technologies in addition to the experiences of many applications have enabled the R/OMS now to be not only viable, but an expected and valued application at many operating companies. Operating companies should be mindful of certain indicators, which will offer a very high probability of success in deploying such an application.

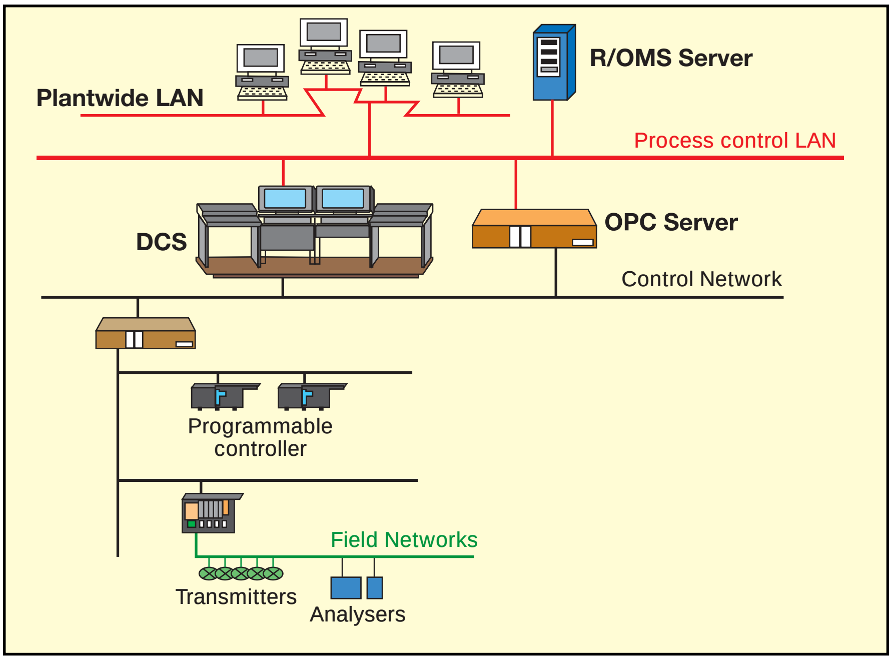

Figure 1 *Hardware architecture of reliability and operations management system*

System architecture

Countless operating companies and contractors have made their best efforts at implementing R/OMS on expert system software platforms. Of those installations, which have not fulfiled expectations, nearly all have at least one thing in common: the lack of an R/OMS software framework on which to deploy the application. Invariably, the end user will cite problems such as "difficult to develop", "difficult to tune", "difficult to enhance" or "difficult to maintain" as the primary reason for their lack of success.

In settling on an approach, an application framework should be a major determining factor in the decision making process. The correct application software will simplify project execution and provide the framework for long-term application support by the operating company or the application developer to keep the application evergreen. Simply bringing the application on line should not be the end user's sole objective – proper care and maintenance will ensure that the end user will experience the sustained benefits the application offers.

An appropriate software framework will offer:

Configuration tools capable of importing multiple databases (DCS configuration database, multivariable controller database etc).

Maximum reuse of features which will be used repetitively throughout the application, eliminating the need to recode for each instance; this is a library of diagnostics which have been precoded into the product.

Full use of default configuration parameters so that initial commissioning requires minimal configuration.

Ease of modification and customisation so that the flexibility exists to configure a very unique instance, if so desired by the end user.

Configuration should be intuitively obvious so that detailed application specific expertise is not required in order to support the application during commissioning and post-commissioning support.

In addition, the software framework will also provide the ability to integrate multiple software technologies on an open architecture operating system. An open architecture design, employing industry standards such as OPC to retrieve process data and XML to interact with business-based applications, will facilitate integration with most state-of-the-art plant software applications without developing custom, project-specific application programming interfaces.

The software framework should also be field-proven well beyond the proof of concept stage. There are a significant number of scale-up issues between proof of concept and a commercially viable application. Field-proven software will eliminate this uncertainty and risk during project execution and commissioning, increasing the likelihood of efficient, trouble-free project execution.

In addition, consideration must be given to a software framework that is commercially maintained and enhanced as opposed to those that are not supported or stagnant with respect to new product features.

These are some of the key features that should be considered for an R/OMS application:
— Quick application deployment and easy to customise
— Documentation
— Custom logic
— Cost of downtime/process upset
— Message suppression
— Sensor validation
— Shift change reports
— Verification of valve line-ups
— Monitoring.

With the benefits of an R/OMS application typically paying back the investment in less than six months, initial focus must be on speed of deployment, which is facilitated by a field-proven software framework for the application. An R/OMS with an application development tool kit is essential to short project execution cycles.

The ability to reuse existing software components, characteristic of a true software product, enables the application to be developed efficiently. This leads to shorter project cycles allowing the application to be placed on line more quickly after project inception. The end user will be able to capitalise on benefits sooner as a direct result of efficient application development.

The fact that the application is based on a product will also make it easy to customise. The ability to easily customise an application is critical to end user acceptance. Beyond the generic R/OMS features, this makes it possible to incorporate both process and plant specific characteristics into the R/OMS application, further enhancing its value.

An application which is self-documenting will facilitate application maintenance. This will eliminate the possibility of misplacing documentation or creating transposition errors often found in manually generated documentation; in this case the documentation is built right into the application and is generated directly from the application code and configuration.

Above and beyond the standard features of the R/OMS, significant value-added can be derived from developing process specific and/or plant specific rules into the system. This “customised” logic can only be achieved by active participation from the operations and engineering staff of the end user. To help operators understand the relative costs associated with upsets or equipment being out-of-service, the application can calculate the lost profit margin associated with specific failures. Over time, operating staff will develop practical business knowledge of where and how profits are made and lost in day-to-day operations. One real example of this cost is to continuously compare the production costs for actual operating conditions relative to optimum operating conditions as determined by an online optimisation application.

An R/OMS may generate a significant number of erroneous messages during atypical yet “normal” operating practices. Therefore, the application framework must be designed to identify and manage the interactions between diagnostics to eliminate misleading messages. For example, in an ethylene plant, an ethylene furnace would typically undergo decoking approximately once every 60 days. During the decoking process, it would be possible to generate “spiked” alarms as coke is burned off the tubes.

Dynamic suppression of these types of message based on line-up of the steam valves to the process tubes will eliminate false R/OMS messages. The value of message suppression cannot be overemphasised; operators will quickly lose faith in the R/OMS application if obviously false messages are generated on a regular basis. Sensor validation applies to all DCS instruments. The baseline product should be looking for problems such as, but not limited to blip, operational high/low, runaway, rate of change, failed high/low, oscillation, dead, sticking valve, etc. The basis for many of these diagnostics is the application of statistical equations including the simplest ones such as standard deviation. These features then become part of the application with nominal configuration, yet have the potential to yield huge benefits to the end user.

Equipment diagnostics evaluate equipment performance based on DCS mounted instrumentation. For example, if sufficient instrumentation is available, heat exchanger performance may be monitored continuously by the R/OMS to determine if a specific heat exchanger has fouled to a point where overall plant performance has been compromised. An R/OMS message of this type is generated automatically, so that plant maintenance can schedule equipment service and minimise overall impact on production.

In the absence of sufficient DCS instrumentation, some end users collect plant data manually and transfer the information to the plant control network via wireless handheld devices to facilitate interaction with the R/OMS application in real time.

Shift change reports will summarise key events on the prior shift(s) for review at the start of a new shift. The report can be exchanged in hardcopy form or electronically via e-mail. This report will reduce the likelihood of miscommunication during shift change.

Verification of valve line-ups evaluate them and inform operations when a specific valve lineup exists. This is generally used in delivering product to specific storage tanks and can help to prevent contamination of different products and/or product grades.

Monitoring the frequency of intermittent pump starts determines if current operations are atypical. For example, an atypical pump start frequency (infrequent or excessive) could indicate problems with the pump start/stop mechanism or a change in upstream process conditions. Providing operator advisory messages will alert the operator to a potential problem so the root cause can be resolved as soon as possible.

Equipment monitoring of spared equipment, depending on operating philosophy, may be desirable for the operating company. This will facilitate balancing in-service time between spared equipment and swap equipment periodically to ensure that equipment is available for service at times when it is needed most. For emissions monitoring, plant-operating conditions can be monitored to determine when excessive emissions have begun and to integrate the quantities released until the condition has subsided, alerting health, safety and environmental personnel in real time. A form or e-mail message can be "populated" to facilitate reporting according to government regulatory requirements.

From time to time and for a variety of reasons, control may be transferred from the DCS to the field. This lockout from the DCS can be monitored by the R/OMS. Repetitive or extended lockouts can be an indication of repeated use of incorrect procedures or outdated control strategies. Further investigation can resolve the problem and/or correct the control strategies and create more reliable operations.

Monitoring of switching to field control will generate a report (in the form of a text file) of all objects in Red Tag state over a specific time interval (such as a one month period). This will identify points or equipment being transferred from DCS control to local control and could serve as an indication of repeated use of incorrect procedures or the need to alter control strategies. As R/OMS becomes mainstream, the list of monitoring features and strategies continues to grow. Maintaining an awareness of the technology and taking advantage of all of the features will serve to enhance plant performance through an ongoing improvement process.

Resources

The project should be staffed with a combination of engineers and operators having process expertise and, ideally, also having experience in software application implementation. This combination of skills will allow the project team to communicate with end users and at the same time, configure operating concepts into a software application.

While it may be difficult to provide resources having such a skill set, it is critical that, as a minimum, both application developer and end user utilise resources having a complementary combination of these skill sets to facilitate communication and to implement the application as efficiently as possible.

Plant experience is a particularly critical end user contribution. Any operating expertise provided by the application developer will be general in nature and not usually specific to the end user's plant. It is the plant-specific characteristics, which often lend themselves to rule-based applications. In the absence of actual plant experience, the operating company's assigned resources should be sufficiently familiar with operating staff to know where the domain expertise resides at the plant.

Finally, a genuine resource commitment is needed to fulfil application implementation and technology transfer from the application developer to the end user. Most often, the expectation of an end user is to be able to support and maintain the application post-installation and commissioning.

The number of staff members on a project is dependent upon the size of an application and project duration. As an example, a typical chemical plant would likely require a part-time project manager and two process/applications engineers/operators full time (each, for the application developer and the end user) in order to deploy a reasonably comprehensive application. This would also provide very effective technology transfer to the end user, thereby enabling the end users to assume lead support of their own installation.

A lesser commitment by the end user will require additional post-installation maintenance support from the application developers to capture all of the benefits the application is capable of delivering.

Sustainable returns

Once the product's capabilities are well understood by the end user, the possible rule and logic applications are nearly without bounds. Most end users will find this to be true during project execution. Once the application is deployed, the end user must not lose sight of the routine maintenance required to keep the application current. It is during maintenance and enhancement that the end user continues to learn more about their operations while defining additional diagnostics to be incorporated into the system.

To put things in perspective, consider that the project is placing a tool into the hands of an end user. It is up to the end user to take advantage of the tool to capitalise on the benefits it offers. The maintenance process takes on several steps as follows:

1. Analyse the operator advisory messages to determine what they are recommending. Are the messages appropriate and correct? Were other messages expected which did not appear?
2. If problems are encountered with the above analysis, it may be necessary to tighten or loosen tuning parameters associated with specific rules.
3. Finally, it is very likely that operations will identify new rules and/or logic, which should be incorporated into the application. With the tool in place, incorporating additional logic will be a nominal effort offering instant payback. This once again raises the concept of the evergreen application.

With proper care and maintenance, the initial benefits on which the application was initially justified, will become a small fraction of all of the benefits the application could provide over its lifetime. The platform independent architecture will enable the end user's intellectual property to be managed and migrated to other units and control systems, even as other control technologies are upgraded or replaced.

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