CHEMICAL PROCESSING

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Control systems promise a tighter grip on managing energy

By Moin Shaikh, Siemens

SQUEEZE MORE FROM YOUR MOTORS

FIERCE GLOBAL COMPETITION OVER FOSSIL fuels is driving the process industries to rethink the way their businesses will operate in the future. U.S. manufacturers will have to develop strategies to conserve energy.

Typically 64% of the energy consumed in a process plant today is used by electric motors; energy is the second largest expense after feedstock. In the very near future, energy conservation will have more of an effect on economic success than in the past. Your operation could well depend on how successful you are at reducing energy consumption.

By integrating smart motor control centers (MCC) that will monitor energy consumption a plant can remove wasteful energy expenditure, prevent unplanned downtime, and improve overall operational efficiency. Recent tax code amendments make these improvements inviting.

A closer look

Distributed control systems (DCS) were designed to provide regulatory control. They were based on proprietary components such as operating systems, networks, hardware, and configuration tools. In a typical DCS, communication was slow and methodical, carried out within a circumscribed system boundary using discrete and analog signals. Programmable Logic Controllers (PLC) were designed for high-speed control of discrete devices like motors, pumps and drives.

In the traditional process plant, PLC managed the electrical infrastructure such as motors, drives and MCC, while regulatory control was left to the DCS. Only critical motor performance data was passed along to the plant's DCS because of the cost of field wiring. It was virtually impossible to

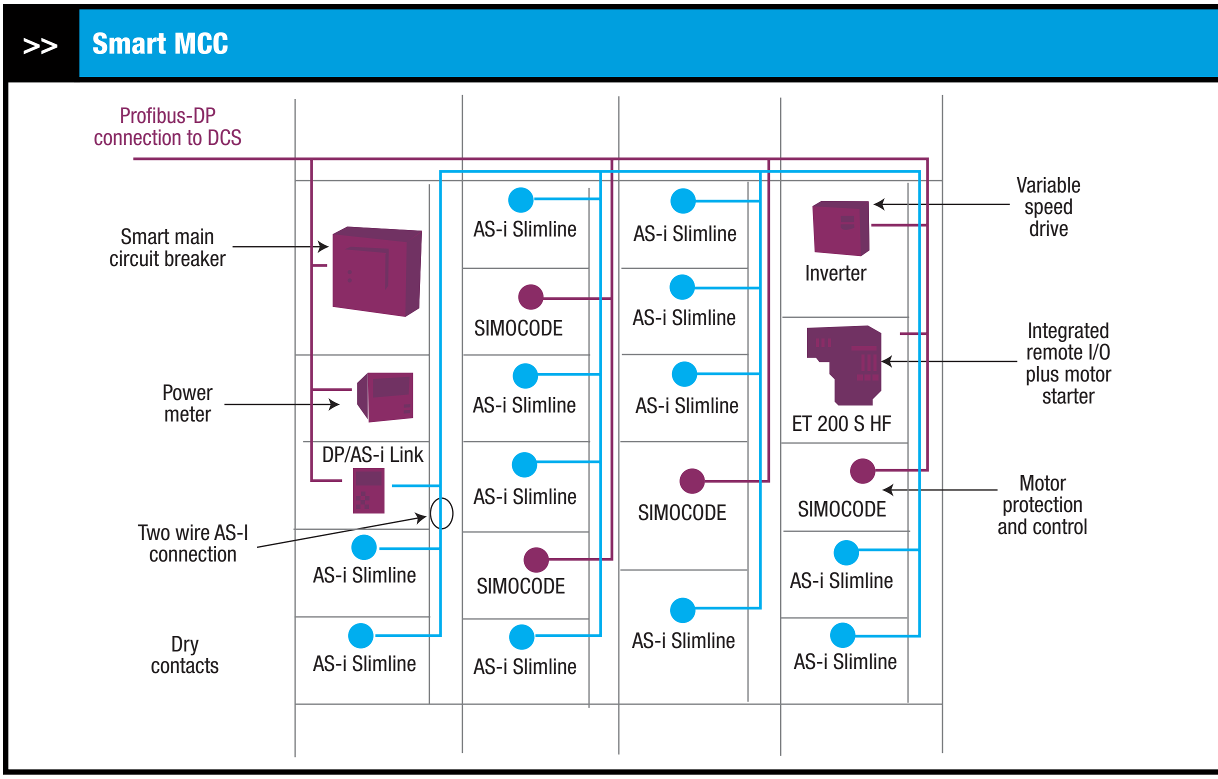

Figure 1. Fieldbuses such as PROFIBUS and the actuator sensor interface (ASI) are the backbone of the smart MCC.

determine the energy consumption for individual processes within a business unit. Plants were limited in their ability to schedule partial shutdowns to improve energy efficiency or reduce energy consumption during peak demand.

Today, a new class of DCS has emerged that can integrate and control high-speed discrete devices like MCC, drives, soft starters, breakers and power metering devices. These new DCS enable dynamic monitoring of motor performance, offering the potential for a leap forward in improving energy management and operational efficiency.

Motor operations

The integration of motor management data directly into the DCS allows the device to communicate its operational condition and status. This can be used for real-time monitoring of motors to detect motor problems before they occur. Maintenance is no longer reactive. Predictive and preventative measures can now be performed to prevent motor failure and damage, allowing plant operators to extend the life of their motors. Because motors consume the majority of the energy in the plant, monitoring the operating condition is an essential aspect of any energy conservation and maintenance program.

Up to 40% of a plant budget goes to maintenance. As much as 60% of scheduled maintenance checks on valves and motors prove unnecessary. The largest cost associated with this support is maintenance labor, which is wasted on false alarms. A secondary cost, often unnoticed, is fatigue and having these people unavailable when you need them. Monitoring motor operations can help plant management develop an effective predictive and preventative maintenance program focused on maximizing operational efficiency.

Motor efficiency

Over the past two decades, significant improvements have been made to increase motor efficiencies above industry averages. Electric motors consume 10 to 25 times their purchase price in electricity each year, so even a 1% increase in motor efficiency can mean thousands of dollars worth of savings in the operation of the motor. Premium efficiency motors cost a little more because of the superior material that goes into them, but the higher cost typically can be recovered in 12 months or less. Implementing a plant-wide replacement strategy — as motors burn out — can significantly reduce your electrical bill over time.

Variable frequency drives (VFD) are a popular approach for matching electrical draw to actual need. VFD are often superior to the traditional choice: a fixed-speed motor plus regulatory control valve. By regulating the speed of a drive to directly control flow rate, a 50% energy reduction can often be achieved in fluid flow control applications.

The motor control center

Motor control systems have a prominent role in industrial processes. These systems are often housed in an MCC that contains a comprehensive array of control and monitoring devices. Advances in technology and decreased cost of electronic devices have led to a boom in the inclusion of various controls and monitoring devices into the MCC. These devices, like relays, VFD, and soft starters, are capable of providing a wealth of data back to the control system regarding the condition of the motor. This information can be presented in the DCS in a clear and easy-to-read format that can be used to increase productivity, minimize downtime and energy consumption, and improve personnel safety. Figure 1 shows the network view of a typical smart MCC. Each combination motor control unit is called a motor bucket. A bucket is an integral part of an MCC.

In a conventional installation, increasing a motor size means moving to a larger bucket. Besides requiring larger cables, this means the physical components inside the bucket could get substantially bigger. More horsepower means more current, which means a larger contactor and breaker. This is where the similarity between the conventional bucket and intelligent bucket ends.

In the current bucket design, an electrical overload switch and a combination of relays control the power to the motor via a contactor. The relays are usually controlled by the outputs from the PLC, and the feedback is provided via auxiliary contacts to the digital inputs on the PLC. Given the limits of space inside a bucket, this design allows limited capacity for monitoring motor performance.

>> Current trend data

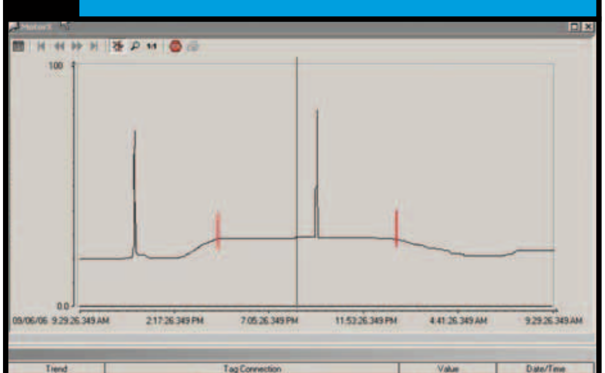

Figure 2. Motor trend data can be archived in a DCS permitting evaluation of starting characteristics and other behaviors and how they relate to production.

Making MCC "smart"

An intelligent motor management system can be added to the motor bucket to make it "smart." For instance, SIMOCODE from Siemens boasts motor protection relay controls and protects the motor and acts as an overload switch. The relay has a built-in current and potential transformer, allowing measurement of line current and voltage. It is capable of sending all information on the motor's operating condition directly to a DCS via a digital fieldbus, such as PROFIBUS. The advantage of using fieldbus versus hardwiring of the signals is that it enables all the data about the motor operation to be transferred into the DCS in a cost-effective manner. For example, a single cable (fieldbus) can be used to transfer data that would have required six to 12 separate wire pairs per conventional MCC.

Information on motors can be communicated via the PLC directly to the DCS or throughout a data network. With this transfer possible, plants will have the capacity to collate these data with production data for analysis and future improvements in reliability and energy consumption.

Power monitors can simultaneously record power consumption and power quality data. This will allow detection of many power quality problems such as voltage sags/swells, harmonics, fast impulses, sub-cycle impulses, and neutral to ground high frequency noise. Knowing when and how these quality problems occur, and how they relate on a timeline with production data, can help you eliminate motor problems. First, it is important to understand how these factors affect reliability.

Motor reliability and performance

The five most important factors that affect the motor performance in any process control system are:

1. Power quality;
2. Motor operation;
3. Motor condition;
4. Load and power consideration; and
5. Operating efficiency.

Monitoring the quality of the incoming power is very important for maximizing the lifespan of the motor and for ensuring that it continues to operate efficiently. Some examples include:

- Monitoring voltage fluctuations to limit degradation in motor winding;
- Ensuring that maximum voltage isn't exceeded to avoid iron saturation; and
- Avoiding voltage drops.

Voltage inconsistencies can be caused by harmonics introduced VFD that are being used within the plant or in nearby facilities. A small amount of voltage distortion causes a large current distortion, which in turn will lead to excessive motor currents and the potential for damage to the windings. Excess voltage applied to the motor causes it to waste energy and operate inefficiently; in this state, iron saturation will occur as the coil will take no more current. The long-term effects of iron saturation are degraded (overheated) insulation winding and motor efficiency. Drops in voltage have a similar effect as current rises to maintain the same power draw as before. Data logged in the DCS can help operators identify these situations.

A DCS that can monitor, log and notify operations when conditions require attention can be used to improve the overall efficiency and performance of the motor. To do predictive maintenance on the motor, it is necessary to be able to measure all of the line currents in the motor. Since the heat in each motor winding is a function of the amount of current that flows through it, the motor's potential weakest point is contained in the phase with the largest current.

Motors typically draw six to 10 times their rated current when they are started. A high current causes the windings to heat up, eventually leading to degradation. It's necessary to limit the number of motor starts. An effective predictive maintenance strategy will ensure that the number of hot starts is limited to protect the motor winding. A smart MCC allows trending and alarms for detecting this problem. In Figure 2, the large amplitude spikes indicate when the motor was started. The area on the motor trend marked by the red lines shows a 25% jump in motor consumption. This increase is either an unusual process condition or a problem with the motor.

Load, percentage of load, horsepower demand, kilowatt usage, and

CHECKLIST FOR IMPLEMENTING A SMART MCC

By Don Kazak, Siemens

1. Be sure your DCS control network supports all devices implemented in your Smart MCC configuration. Some of the attractiveness of implementing a Smart MCC solution is in the cost savings achieved by networking the devices together and bringing the data back to the DCS. All smart devices in the MCC area — motor overloads, variable frequency drives, power meters, protective relays, etc. — should be capable of communicating data back to the DCS on the same network.

2. Choose smart devices that will cover all of your motor needs. For example, when using intelligent motor overloads your device should support direct starting, reverse starting, star-delta starting, soft-starters, and valve/positioner motor control profiles. This way all motors used in the plant are serviced by the same type of device.

3. Avoid monitoring only "important" motors! By choosing a system that is both flexible and modular, it will be cost effective to monitor all motors in the plant. It would be reasonable to monitor basic functions — overload, phase failure, phase unbalance, earth fault, diagnostic data — on non-critical motors; and monitor additional functions – temperature, voltage, power, cosine-phi, phase sequence — on motors deemed more critical due either to function or repair cost. A flexible system allows you to monitor both scenarios using the same device but perhaps with add-on modules to perform the extra functions. This allows a consistency of control across all motors that's very beneficial to both the maintenance personnel and from a spare parts perspective.

4. Parameterize the smart devices before installation in the field! Devices implemented in Smart MCC require configuration parameters for proper operation. That's why they're "Smart!" Whether it is a variable speed drive, intelligent overload device, or power meter, basic configuration data such as network address, motor full load amps, and operating profile are required. Avoid configuration in the field as much as possible by doing this work in the factory or during a factory acceptance test. This will generally assure a smoother start-up of the smart MCC in the field. And while we're speaking of parameters, now would be a good time to mention that you should advise your installers in the field that this is a smart MCC system being installed. There will no dials to tweak or knobs to turn during startup — the parameters are digital and if changes are necessary they will likely be via a PC and software.

5. Strictly adhere to network wiring guidelines! Assure cable shielding, network terminations, data cable routing, bending, and separation from power leads, and other pertinent network rules are followed. A Smart MCC is a unique mix of high power bus bars, high voltage motor leads, variable frequency drive harmonics, and a digital data bus communicating to the DCS. The people terminating the motor leads in the MCC may not have experience wiring to digital-based systems or be aware of the close proximity of the data bus. Make them aware!

6. Make use of the data available! Now that you've invested in a smart MCC be certain to set up a monitoring program to utilize all of the newly available data. During conception of the project there are often grand plans for use of the smart MCC data, but once installation begins the focus reverts to "let's just get this running." Don't fall into this trap. Be sure to use the running hours and number of starts of your motor in a preventive maintenance program. Track the number of overload trips and use this information to catch a problem before a major failure occurs. Save trend data of the normal running current of your motors and watch for a rise from typical – it is probably an early warning of an imminent mechanical problem. Configure reports to capture the data. Your DCS is now collecting data that previously was not available — use it!

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power factor also are important factors related to a motor's long-term performance. Significant load fluctuations might indicate a potential process-related problem. Motors are optimized to be run most efficiently at a specific load condition; operating the motor above or below that point causes it to run less efficiently. Motors asked to operate above their nameplate horsepower ratings will suffer high torque demands that can damage their rotors. By monitoring the power factor and other parameters problems such as this can be avoided (Figure 3).

Motors are often oversized or undersized during design or from post-commissioning modifications of a process. These conditions can be monitored with a smart MCC. Oversized motors have higher initial costs and are typically more costly to repair and operate. Undersized motors perform poorly and suffer from higher energy losses, which can lead to premature failure. Improperly sized motors are less efficient and, therefore, are more costly to operate.

Benefits of integration

The two most tangible benefits of integrating your motor data into your control system have already been described, i.e., improved reliability and the capability of reducing electrical costs. There are other, perhaps less tangible, advantages:

- Faster access for maintenance;
- Quicker detection of faults for scheduled service;
- Lower installation cost;
- More reliable communication; and
- Safer maintenance.

Engineers can access the parameters of the individual motors directly from an engineering station in a central location. They can modify operating parameters, analyze performance,

>> Bringing it together

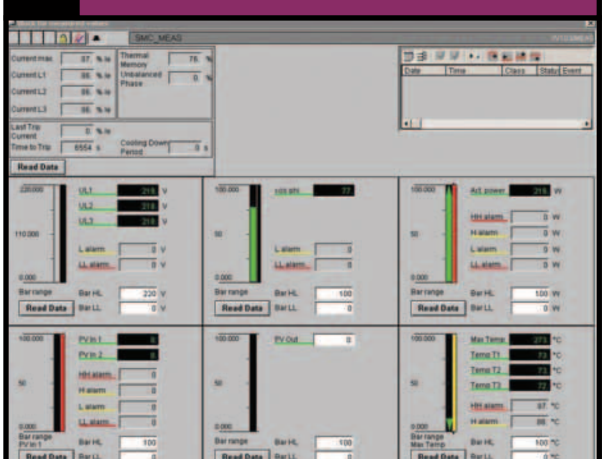

Figure 3. A smart MCC allows the operator to view critical data on a motor from a DCS faceplate.

>> Asset management

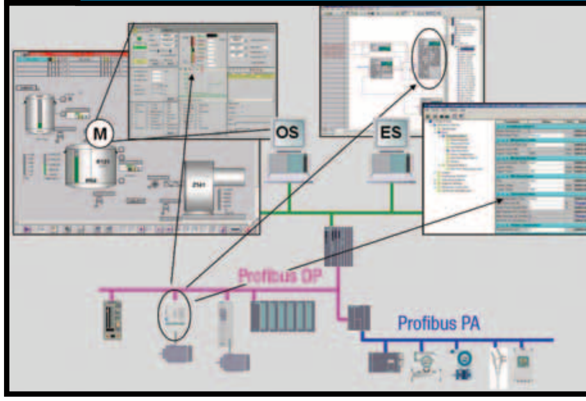

Figure 4. Central access to all devices improves process visibility and helps you create an effective maintenance program.

and reset faults from the control room. Asset management software, such as SIMATIC PCS 7 from Siemens, allows parameterization and diagnostics information to be accessed at the DCS, reducing the risk to maintenance personnel from entering an MCC (Figure 4).

Implementation of an effective predictive maintenance program is critical to avoiding unscheduled downtime. An estimated more than $20 billion is lost annually due to unplanned downtime, with 38% caused by preventable equipment failure. With a smart motor starter any unusual condition, like phase unbalance or loss and excessive current draw, is reported in the DCS. This allows the operator and/or maintenance personnel to take corrective action by quickly identifying the cause and location of faults.

Using a digital fieldbus like PROFIBUS, motor buckets can be connected to the DCS using a single or redundant cable that is daisy-chained between motor buckets. This allows tremendous reduction in the cost of field wiring, terminations, and PLC hardware. Based on actual project implementation data, reductions in engineering, installation, and maintenance costs by 30% or more aren't uncommon.

Another benefit of smart controls is that communication is robust. Fault-tolerant communication architectures can be designed to ensure a high degree of availability of the communication between the DCS and MCC. Different physical media, such as copper or fiber, can be used to connect the digital fieldbus. For example, a fault-tolerant, redundant, fiber-optic PROFIBUS ring can be used between the DCS and MCC that are positioned in remote locations.

Every time a motor bucket is disconnected from the control system for repairs or maintenance, the change in status of the motor bucket is logged in the DCS. The operator initiating the request can write comments in the operator request area or alarm comment field to inform other operators and maintenance personnel. There's always a central place for operators to look for this information, thereby reducing confusion and improving safety.

Smart MCC enable the power consumption of different parts of the plants to be collected within the DCS. This information can be displayed for the operator to monitor the KWh consumption of the manufacturing process alongside other key process parameters. The information can be further passed into an historian or elsewhere in the system for reporting purposes.

Doing it smart

During the initial design and engineering phase, invest in technologies that will enable the optimization to be performed in the later stages. This will include the installation of premium efficiency motors and integrated power monitoring and switching systems. Pre-engineered libraries of software function blocks allow easy integration of power control devices in the DCS.

The most significant gains in energy efficiency are seen during the operation and maintenance phase. An inefficient motor can be identified from the DCS. Another benefit is that operators and processes can be evaluated for their energy efficiency. Best practices can be communicated to other operators and within other units. Energy conservation can be incorporated in decisions of which products can and should be produced on which production lines.

Technology, such as the smart MCC, is expanding the capabilities of process control. Now, it's possible to realize the dream of reliability engineers and production managers alike by providing real-time motor performance data. By adopting these smarter technologies, manufacturers will not only save energy but also become more competitive. **CP**

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