

This under-utilized approach can enhance operations and the bottom line.

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Plants often overlook their automation system as a resource for improving overall equipment effectiveness (OEE). They generally treat the system only as a tool for process operators to interact with valves, motors, control loops and other devices. However, a different approach can lead to significant progress in the quest for operational excellence.

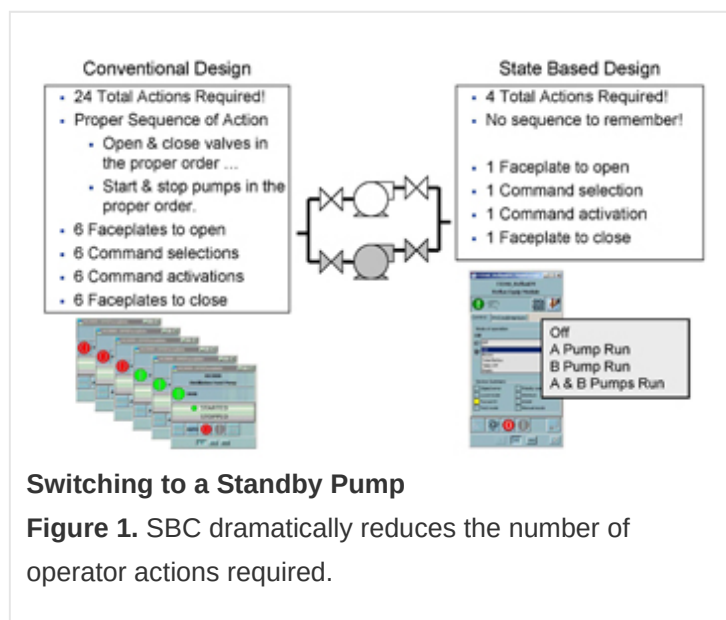
Using a conventional control design, when changes to process conditions are needed an operator interacts with a series of faceplates to manipulate necessary control devices to a set of conditions dictated by immediate manufacturing requirements. This might be as simple as switching to a spare pump with only a few actions -- 24 are typical (**Figure 1**) -- or as complex as starting up or shutting down the entire process with hundreds or even thousands of actions.

If you operate a continuous process, chances are this describes how you use your automation system.

What's often misunderstood about continuous or even semi-continuous operations is that they never completely stay at one set of conditions. All processes operate in "states." Some processes have only a few but most have a wide variety of state conditions. Examples of states that generally apply include:

- **Maintenance.** This often isn't considered a processing state but frequently you must monitor and alarm some measurements or some equipment remains running.

- **Process wait.** Equipment isn't currently involved in production but is at or near operating temperatures and pressures and needs monitoring and alarming.



- *Starting.* You are transitioning from process wait to steady-state operation.
- *Running.* This is the normal state of the process. It frequently involves many states, defined by product grades, production rates or a variety of other factors.
- *Shutting down.* The process moves from a running state to process wait conditions.

Many other states might apply to your process.

The State of Most Plants

Consider the number of actions that your operators must flawlessly execute to move between any of these states. How well do individual operators perform those actions? How much training do your operators need to learn and carry out all the individual actions? How often are these procedures executed? How frequently are they updated? How much effort is required to provide the appropriate level of detail for those procedures? If you're facing a pending shutdown, how many operating team members have been on site long enough to have taken part in the previous cycle, perhaps four or five years ago? Does process productivity decline with the loss of a senior shift member? Do some operators control the process better than others?

Can Your Process Benefit from SBC?

Consider state-based control if your process experiences:

- complete shutdowns and startups (regardless of their frequency);
- equipment changes during production due to feedstock, fouling, regeneration, etc.
- output rate variations exceeding $\pm 15\%$ of normal;
- changes in raw materials, equipment configurations, control setpoints, etc., with product grades;
- nuisance alarms or alarm floods when operating at conditions other than normal;
- actions or conditions in one part of a facility that require other parts to compensate, usually through extensive

If your facility isn't using state-based control (SBC) then you probably don't have acceptable answers for most of these questions. Even worse, your business is missing an opportunity to achieve potentially large improvements in OEE and return on net assets (RONA).

SBC is an automation design philosophy that recognizes processes have identifiable states and the control system nearly always can be the best operator to keep the plant running within those states and during state transitions. It isn't a new concept — it's long been implemented for batch production. Indeed, the ability to use logic to sequentially control a complete series of plant operations has been available in many process controllers for several decades. At the core, that's what underlies SBC. Dow Chemical has applied SBC techniques for many years and has documented a two times better RONA for processes that use SBC versus

operator communication and interaction;

- performance variability linked to operator experience and training; and
- need for frequent attention to automation configuration to maintain process performance at high levels.

those that rely on conventional automation designs (**Figure 2**).

However, in most automation systems designing, coding and maintaining this type of logic has been costly as each piece of logic usually was a unique code block with nearly no reuse of code between applications.

Now, adoption of concepts for developing reusable code modules as presented by the ISA88 standard is increasing. While basically developed to deal with batch processes, the standard never was limited to them. ISA88 is being expanded and this should make even clearer that the principles apply across nearly all industries and not just to batch producers.

In addition, the latest generations of automation systems and their modern tools lower the hurdles to using SBC designs. Some automation systems now utilize object technologies that can significantly reduce initial engineering and lifecycle maintenance costs.

Visibility of information in the control hierarchy is a key feature operators need in a SBC design. Additionally, they must be able to easily view the active state logic to do troubleshooting. This is far different from today's conventional applications where operators only interact with control device faceplates and alarm lists.

Major Benefits

SBC's advantages stem from two main features:

1. Fewer interaction sites for an operator to deal with; and
2. Situational optimization that can be driven from the state control engine.

In SBC, an operator controls just units (larger equipment groupings like a distillation tower and its associated vessels, pumps and instrumentation or perhaps a complete boiler) or equipment modules (smaller groupings of equipment like the distillation tower's overhead section or the boiler superheater section). The operator can change a unit state, e.g., from process wait to starting, merely by selecting the new state. The state control engine configured in the automation system performs all actions needed to make the unit start up. This is more efficient than having the operator execute the necessary sequence of dozens of faceplate access actions and data entries — and avoids the risk of mistakes. A unit faceplate should contain access and interaction points to every equipment and control

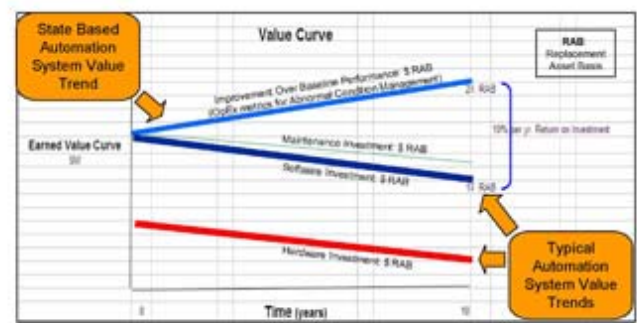
module grouped within the unit, should individual access be required (the visibility relationships). The unit faceplate should be able to call up an interactive view of the state diagram without using engineering tools or licensing. That diagram should allow easy display of the logic behind the steps and transitions — offering the operator an initial level of troubleshooting when things go wrong.

Even more important than significantly reducing interaction sites and potential mistakes that can be made is the opportunity for situational optimization. This isn't the model-based PhD-in-mathematics optimization of years past but rather a conditional-based optimization that's much simpler, perhaps more extensive, and thus more valuable.

Consider two units, for example, a mixing tank and a three-bed dryer. The dryer's throughput sets the tank's output. Normally the dryer uses two beds while regenerating the third — this allows the mixer to operate at full capacity. What happens when the dryer suddenly requires one of the operating beds to be regenerated even though the bed in regeneration isn't finished or needs maintenance? <

In a conventional automation design the operator must reduce output from the mixing tank. The operator must devote attention to the mixer until all necessary changes are made there, rather than address the root cause of the problem on the dryer. This extends the mean time to repair (MTTR) for the dryer and impacts first prime production and OEE. When a second dryer bed finally is available the operator needs to be aware and return the mixer to full production rates — perhaps dealing with many faceplates and many changes. This delays the time to return to normal and once again affects

performance, first prime and overall unit availability, the three cornerstone OEE factors. At the same time, it's likely the mixer's reduced production conditions made control loops not perform optimally, raised energy usage per unit of product and triggered alarms. The dryer probably also had unnecessary alarms because it was operating with only one bed. Failure to provide adequate alarm management in abnormal situations and resulting nuisance alarms or alarm floods have been shown to significantly reduce overall operator performance and contribute to errors and safety risks. (For more on alarm management, see "Adroitly Manage Alarms," www.ChemicalProcessing.com/articles/2009/074.html.)



Demonstrated Benefit

Figure 2. Better abnormal condition management with SBC provides cumulative 10% per year improvement over baseline for 10-year project life.

Source: Dow Chemical.

SBC provides situational optimization directly through state engine functionality and coordination control. First, it automatically would make the mixer turn down from full production without any operator intervention. The operator's attention would remain on correcting the root cause problem at the dryer, improving MTTR. When the dryer returns to normal the mixer, again automatically, would return to full production without operator intervention.

The state engine design also can automatically make many environment changes during the different state conditions -- e.g., implementing optimal loop tuning factors and appropriate active alarm and interlock conditions for each operating state. It can set the right limits to avoid nuisance alarms as well as loop setpoints to make the unit as energy efficient as possible.

Taking advantage of SBC can measurably enhance OEE.

SBC also may improve human asset utilization. In most facilities today the individual loop designs of systems lead to operators being overwhelmed with the amount of information they need to manage. SBC's lower number of interaction points can significantly reduce the effort operators need to keep track of everything. This can free time to work on improvement projects and other value-added activities. Fewer interface points also mean there're fewer things to learn, decreasing necessary training and generally boosting its effectiveness and retention. Additionally, SBC eases moving operators between units because the control environment is nearly the same in each — only actual states and conditions of the states differ.

Engineering staff also may benefit. The same tool used to create the specification and verify final implementation during system test can remain as a live tool to check system performance over time or to amend configuration as the plant evolves. Many of the engineering hours that now go into creating, tracking and maintaining specification and configuration information on the automation system now become available to focus in other improvement areas that will positively impact OEE and RONA.

State-based control is a design philosophy whose time has come. New automation platforms and their software features and tools provide a real opportunity to use SBC to improve OEE and operational excellence.

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