White Paper

Real-Time Profit Optimization

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What's Inside:

1. Introduction

Distributed Control Systems (DCS) have been successfully utilized to help control manufacturing and production processes since the late 1970s. The primary function of these DCS systems has been the automatic feedback control of the various process loops across the plants and the human interfacing with plant operators guiding the production from control rooms. Although these systems have proven to be very successful at improving the efficiency of industrial operations as compared with earlier control technologies, the state-of-the-art has not grown significantly since their inception. Most plants still operate exactly as they did 40 years ago.

Considerable research and development has been invested in expanding the functionality of DCS's in the areas of advanced controls and advanced manufacturing execution software. Numerous industrial plants have started to employ advanced controls in critical or high-value process operations, with some venturing into the use of advanced application software packages, each typically designed to address a specific issue or challenge within the industrial operations. Entrepreneurial software companies typically developed the software at this level of operation, essentially between the automation and business levels, often referred to as the manufacturing execution software (MES).

Although some industrial operations implemented advanced control and advanced MES software, the vast majority of processes are still controlled by simple automatic feedback control. The efficiency and effectiveness of most plants is a function of the installed feedback control systems. As a result, many industrial managers have expressed concerns that, in spite of the huge investments made in automation systems and software, plants do not appear to be operating better than they had been 30 years ago. In some cases, the plants actually appear to be operating less efficiently, possibly due to the reduced and inexperienced work forces and aging equipment.

2. Real-Time Feedback Control Applied to Industrial Businesses

The good news is that the lack of progress in the advancement of production efficiency and effectiveness has recently begun to turn around, and the software solutions leading the charge are much simpler and familiar than expected. Plant engineers and operators have long been familiar with how to apply feedback process control techniques to the control of the primary industrial processes, such as flow, level, temperature, pressure and speed.

Each feedback loop involves the following:

- Measurement of the process variable of interest
- Transmission of a signal representing the measurement to a controller
- Comparison or that measurement to the desired value (the set point)
- Calculation of an appropriate adjustment to ensure the measured variable is at the set point
- Transmission of a signal representing the appropriate adjustment to a valve
- Corresponding adjustment to the valve (see figure 1)

By controlling each of the key process variables to their desired set points, somewhat independently, the plant will produce its products with reasonable efficiency.

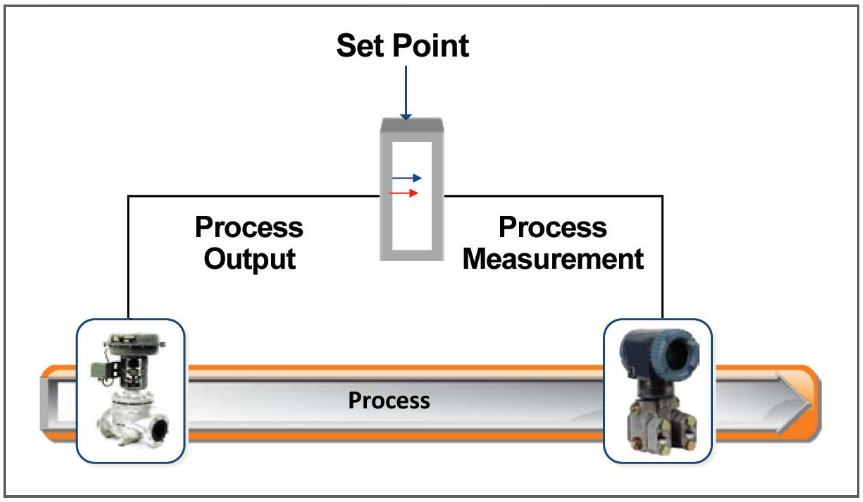

Figure 1: Automated Process Control Loop

At this point, you may be wondering why a primer in the feedback process control has been included in a white paper that is dedicated to moving to the next generation of advancement in the effective automation of industrial plants. Sometimes it is very helpful to remember what we do well in order to move to the next horizon. People have a tendency to take what they know well and are very good at for granted. Feedback control is one of these disciplines that has been commonly and effectively deployed throughout many operations that, as we will try to demonstrate, offers great potential for increased application that leads to large gains in business performance and profitability.

The earliest industrial plants were manually controlled. Gauges were installed to make the critical variables associated with the operation visible, and operators were stationed at manual valves. The operators would watch the gauges and based on the value displayed on the gauge would turn the valve to adjust the process. This was essentially a manual feedback control system. Automatic controllers eventually replaced many of the operators, resulting in fewer operators required to oversee banks of controllers. With the introduction of computer-based control systems, such as DCS's, the banks of controllers were replaced by CRT screens.

The advantages of going from manual feedback control to automatic feedback control included cost reductions associated with fewer operators and better control of the industrial processes. Automatic controllers did not get tired or bored and performed their rather mundane tasks very efficiently. In addition, some processes, such as flows and pressures tended to change very quickly and automated technologies performed better than human operators. Finally, though you can view a plant as a number of independent processes, those processes are actually not independent and must be carefully coordinated to obtain the greatest efficiency from the plant. These key reasons made the automatic feedback process control very popular.

Over the past decade, the industrial business environment has begun to exhibit similar challenging demands that the process environment endured that led the need for automatic process control. Business variables, such as the cost of energy, which had traditionally been a constant value over extended periods of time, have recently started to become almost as volatile as the real-time process variables commonly found in industrial operations. Just ten years ago, most operations had been able to establish contracts with their energy suppliers for periods of six months to a year that effectively relegated the price they were paying for energy to a constant over that time period. However, with the opening of the power grids in many parts of the world, the price of energy has become so variable that industrial plants find the price they are paying changing as many as 24 or even 48 times a day. This variability does not only apply to energy. The pricing variability of energy pricing has had a domino effect on other business variables, such as the price of feedstock and the finished product. These business variables may not experience the same level of variability as energy, but there variability is much higher than ever before. This transition of business variables of industrial operations from a highly transactional to almost a real-time has introduced a significant business control problem.

Business professionals in industrial companies have been hindered on how to deal directly with a real-time business environment and have been reviewing numerous areas to try to respond. Because professionals are used to dealing with the business software and systems installed in their enterprises, they would initially look at these systems. However, these systems were designed to operate on transactional business cycles and were often tuned to monthly reporting. The necessary real-time characteristics were unavailable.

The answer to meeting this difficult business challenge was staring them right in the face. Rather than looking for new, more advanced technologies to address this new real-time control problem, why not apply the real-time control technologies that we are very familiar and have been very successful – feedback control?

One reason engineers do not tend to look to feedback control to help solve the real-time business problems is their lack of familiarity with the business issues. Sometimes when we are unfamiliar with a discipline it can appear to be much more complex or difficult. In evaluating a process control problem, engineers typically start by measuring the variables that must be controlled. This same approach can be taken for the key real-time business variables around industrial plants. The primary business objective in operating a plant is to maximize the production value of the products produced while minimizing the variable cost of the operation. The primary variable costs are the cost of energy and the cost of the materials. Therefore, the business variables that require real-time feedback control are the production value (in economic terms) of the plant, the energy cost and the material costs. These three business variables are constrained by the physical design of the plant, which is not adjustable in real time, the safety of the people and equipment in the plant and the environment around the plant, all of which vary with plant operations – in real time. Figure 2 shows this business relationship.

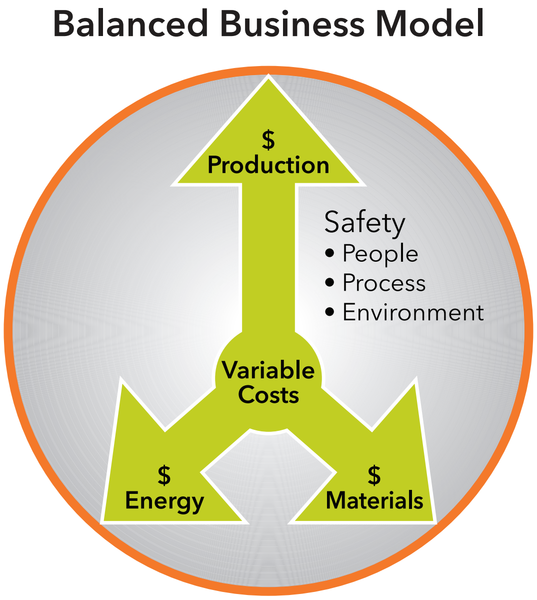

Figure 2: Balanced Business Model

The business control problem associated with an industrial operation is not as intimidating as it may initially appear. The critical business variables are production value, energy cost, material cost, safety and environmental sustainability. In order to control these variables, whether manually or automatically, the first step is to measure them in the time frame in which they are likely to change – real time. It is interesting to note that most industrial operations are not measuring the critical business variables at any greater frequency than once a month. This is entirely inadequate for variables that change multiple times a day. It is no wonder that plant managers often feel their business is out of control. It is!

The tough question is, how can we measure these variables in real time when they are stored in the corporate ERP system only on a monthly basis? The answer is not to rely on the data in the data in the ERP system. Industrial processes are among the most measured processes in the world. There are hundreds of flow, level, temperature and pressure measurements indicating everything the plant is doing and every change taking place in the plant second-by-second. The key is to use this huge database, along with key business values accessible from other sources within and outside of the operation, to model the key variables at every impact point in the plant. These models should include real-time key performance indicators as well as real-time accounting metrics to provide a comprehensive view of both the business and the operation.

Once the measurement models have been developed and implemented, the first step is typically to enable manual feedback control of the business in a very similar manner to the earliest manual feedback process control systems of last century. This can be accomplished by providing business "gauges" on operator dashboard displays. Effectively accomplishing this requires that the objectives and performance measures associated with each person in the operation are identified and prioritized and the resulting contextualized dashboards are developed for each person. These dashboards, correctly developed, provide the ideal manual feedback business control loops.

As with process control, some business variables may move too quickly for effective human response. In these cases, automatic feedback control approaches are required. In feedback process control, most control loops are automated by the application of the common proportional, integral and derivative (PID) control algorithm. Automating business control loops may require uniquely designed control algorithms that are dependent on the specific requirements of the business control problem, but they essentially perform the same function as the PID controllers in process control situations. As with process control loops, operators are tied into the control environment through displays that empower them to take supervisory action over the automated business control loop (Figure 3).

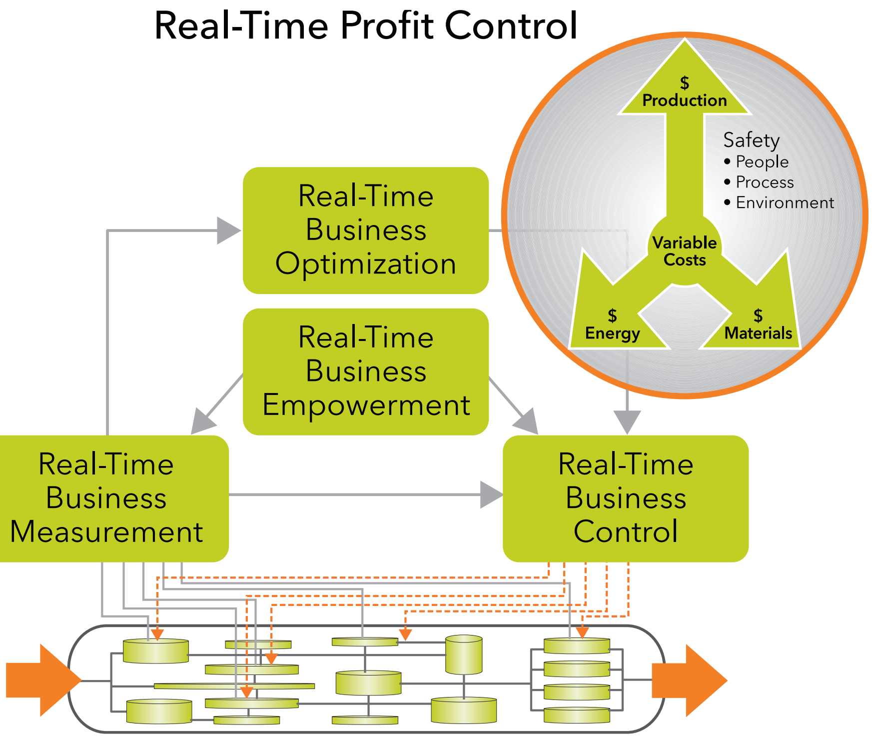

Figure 3: Real-Time Profit Control

One interesting aspect of feedback business control are some business variables are so slow in responding and present control problems for human operators. For example, if an operator changes the temperature set point, it may take 4 to 5 hours before the process measures the true financial impact of the changes. By this time the operator may be off shift and at home. Optimizing these slow reacting variables can present as much, or even more of a problem to operators than the fast responding variables. In these types of cases, technologies such as first principle model simulators can be used to "fast forward" time to the point at which the financial impact will be realized and the operator can predict the impact of an action even though the impact has not yet been realized. This can serve to provide immediate feedback for variables that do not immediately change, which can help significantly improve the effectiveness of the operations staff.

3. Summary

Once each of the individual business variables has been brought under feedback control, the overall profitability of the plant can be optimized by balancing the three critical business variables, production value, energy cost and material costs within the constraints of environment and safety. When this is accomplished within the real-time business environments of today's industrial operations, the profitability of these operations can be effectively maximized through the application of traditional feedback control and optimization techniques to the business variables. Realizing maximum profitability is much simpler than initially conceived and much easier in that it involves intellectual capability that is already abundant in industry.

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