

## INTRODUCTION TO ADVANCED PROCESS CONTROL

### Introduction

Although many companies around the world are implementing advanced control techniques, the technology itself is still misunderstood. For many in the industry, advanced control means a complete change of field instruments, wall-to-wall computing, pages of complicated equations and algorithms, and certainly substantial cost. As a result there are still managers in the industry who will find it easier to approve major redesign projects than investing in the process control improvements even though the control changes would cost far less and lead to greater improvements in productivity.

To understand advanced control technology let us review the typical traditional process control set up (Figure 1). At the bottom are the field instruments such as sensors valves and moving to digital control units. Each higher level control system passes set points to and receives feedback information from the lower level. Typical set ups use single loop controllers each governing a primary process variable, such as the flow, pressure or temperature based on one or more sensor signals. The next level is regulatory control in which the process is maintained at present conditions primarily through PID devices. This is followed by constrained control in which the operator specifies set points for each variable. The top level is process optimization.

Advanced control comes into play from the level of basic control through that of process optimization. Instead of having the operators manually adjust control units for specific variables, advanced systems provide generalized models that automate regulatory and constraint control as well as process optimization. In regulatory control single loop feedback improvements such as feedforward, cascade control can be used to supplement PID algorithms. Time delay compensation techniques can also be applied to compensate for long delays permitting tighter control. At the level of constraint control, multivariable techniques can be used.

Advanced control technology is therefore a combination of:

- Advanced hardware (on line sensors, pneumatic or electronic analog with digital systems, computer hardware and digital control units)
- Advanced control algorithms at the regulatory, constrained and optimization levels.

### 1. Benefits of advanced control

Studies have shown that advanced process control would save 2-6 % of annual operating costs and is able to generate about 1 % in extra revenue. Payback takes generally less than two years. Advanced process control can be used with any process. However its benefits would not be appreciated and the costs of its installation would not be justified unless advanced control yields some sort of optimization for key

process variables. Hence the processes that are contenders for advanced control should be either:

- Processes that are difficult to control with single loop PID feedback controls. These processes have probably long time delays, changing conditions, frequent upsets or whose variables are measured intermittently or offline.
- Processes with high raw material or energy costs
- Processes with tight product specifications
- Processes where some equipment should run under tight security and safety conditions.

For an automated batch process, an improvement in the regulatory control generates most of the benefits. A well automated batch process will manufacture the product in a repeatable way resulting in consistent quality and allowing operators to experiment with varying conditions. This can shorten batch times, allowing for production increases and flexible change of operating conditions.

In continuous processes, advanced control can better coordinate the interactions that frequently occur in single loop control systems. Advanced control can also reduce the process variability and allows the plants to run closer to their operating constraints. Advanced multivariable constrained control are therefore very useful in continuous processes. This can help in cutting energy uses as well as raw materials and waste processing costs. It can also improve product yield and quality safety and productivity.

## **2. Phases for implementation of Advanced control Technology**

The implementation of advanced control schemes is generally carried out in six phases:

### **2.1 Benefits estimation**

This is probably the crucial part of any advanced control technology project. Over and underestimation of costs and benefits due to misunderstanding or misinterpretation of process economics can have negative consequences on the project. There are however a number of tools that can help assess the potential benefits of implementing advanced control technology. These tools will be discussed later.

### **2.2 Engineering and programming**

Implementing advanced control algorithms such as model based multivariable controllers require modeling the process dynamics and configuration of the real time database and the controller. There exist several technologies to implement model-based control. For multivariable model-based control packages such as Set point Inc. (Houston) SMC-idcon, Dynamic Matrix Control corp.'s (DMCC), Predictive Control Lt' s(Manchester, UK) Shell SMOC and QDMC packages can be used.

Plants tests need to be carried out to obtain a model for process dynamics using the approaches discussed previously. After plant tests have been completed, real time

database is designed and communication with the process is defined. Protocol between workstation and the DCS has to be established and the data link has to support the communication speed required.

The controller is configured by defining the manipulated and controlled variables and constraints and including the process model derived from process identification. Most of the multivariable controller packages have configuration tools that assists the engineer in this task.

The modules designed and programmed are then lined and integrated. All programs are tested together to ensure they mesh with the database, the control language and the real time operating system.

### **2.3 Commissioning**

After interfacing the advanced control system with the existing plant infrastructure commissioning should start. A Step by step approach is more effective. The communication with the existing plant control system is tested. Next the multivariable controllers must be turned on and each controller module tested in an open loop model.

After checking the controller actions and tuning each control loop is closed in an advisory model by the operator. Once each has been shown to work successfully it is then closed on automatic mode. After the multivariable controllers has shown to perform as desired the optimization package can be commissioned.

### **2.4 Maintenance**

Maintenance is required to ensure continuous benefits from the advanced controls. Analyzers and sensors should be checked regularly. Advanced controller algorithms should be analyzed for such problems as overshoot or more aggressive activity which indicate it is time for tuning. Tuning would include correcting process delays, inferring static gains or executing plant test to update the model for process dynamics. Retuning is needed when product specifications and process conditions change or new product specifications are added.

## **3. Steps to Avoid in Advanced Control Project**

As mentioned in the introduction, advanced control technology can be very beneficial to the plants. However unless carefully planned and executed, the advanced control technology may not produce the expected benefits; worse in some cases it may lead to lost of money. Here are some ways that should be avoided in any advanced control project.

### **3.1 Select the wrong operating objective**

If the operating objective is not selected properly then not only advanced control applications can cost money but they will help the plant operate even further from optimum. This can arise from a number of situations. One of the most common is choosing the wrong target variable in constraint control applications. Other examples can arise from a misunderstanding of the process economics. Obsession with energy

minimization strategies may lose money on balance due to their negative effect on yields. For example minimizing the heavy key component in distillation overheads is not the same as maximizing light key in the bottoms.

### 3.2 Choose the cheapest technology for control system

Lowest cost is not necessarily the same as maximum profit. It is easy to seek competitive bids for a system which provides the basic regulatory controls. The bidder basically needs only the I/O list and the console configuration. However, some systems are considerably more powerful and flexible than others. A poorly chosen system will successfully inhibit implementation and support of advanced controls. Application commissioning will be delayed and service factors will be lower.

### 3.3 Forget about the basic regulatory controls and instrumentation

Advanced controls need the basic controls to be effective. Without them service factors will suffer. Advanced controls will need to compensate for the limitations of the basic controls, making them more costly to engineer and support. It may be that a large portion of the benefits could be captured with lower level control applications, at a significantly lower cost-possibly even eliminating the justification for the more costly advanced controls.

### 3.4 Design black boxes

This approach makes the advanced controls difficult for operators to understand and will present support problems when the designer moves on and another engineer take on the maintenance role.

### 3.5 Ignore the process operator

The process operator could end up with multiple interfaces to the plant operation: one for the basic controls, another for advanced controls and yet more for information applications such as process performance monitoring, laboratory information, etc. If not fully trained, the operator could take actions which lose more money in a few hours than the control strategy achieve in years.

| Level of Control |                  |                 |                        |                     |
|------------------|------------------|-----------------|------------------------|---------------------|
| Optimization     | Direct search    | Rule definition | Online simulation      |                     |
| Constraints      | Steady state     | Dynamic methods | Single variable        | Multivariable       |
| Regulatory       | Signal condition | PID algorithm   | Dead time compensation | Feedforward control |
| Basic            | Analog control   | PLCs            | DCS                    | Process computer    |
| Field            | Valves           | Transmitters    | Smart transmitters     | Onstream analyzers  |

Traditional Control

Figure 1: Traditional Control versus Advanced Control

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