Real-Time Process Supervision for the Food & Beverage industry.

How to engineer a supervisory system simply by parameterizing automation software.

Based on the example of a flash pasteurizer.

Contents

Executive summary

This document is intended to demonstrate that automation teams with no software programming know-how can easily and rapidly implement or extend a supervisory and control system for essential production processes. By using the example of a key process in Food & Beverage manufacturing, this document is intended to guide readers through the implementation or extension of a supervisory system.

The example is based on the use of COPA-DATA's zenon software. COPA-DATA's zenon software is ideal for a wide range of users - from experienced Automation Engineers with strong programming skills right through to the novice, or automation staff with little or no programming experience. zenon addresses the needs of automation specialists and software developers by offering the necessary tools for PLC, IEC 61131-3 and VBA/VSTA (.NET, C#) programming and the unlimited extensibility of applications.

However, since this document is concerned with guiding users with little or no programming experience through an implementation, for this purpose we will base our discussions on the use of the zenon Development Environment (Editor) because it is based on the core principle of "parameterizing instead programming".

We will look at various functions of a supervisory system, such as process visualization, online curve trending, alarm and event management and assess their importance for production teams focused on business goals, including regulatory compliance, quality and productivity.

By outlining the main steps involved in the parameterizing of zenon out-of-the-box modules, we will highlight how this easy-to-use engineering approach lowers the costs of implementation and maintenance.

Introduction

The demand for quality in production processes in the Food & Beverage industry is absolute. Food & Beverage production teams share a clear mission to ensure every step of the entire manufacturing process is perfectly executed in order to ensure a product which tastes right, looks good and has the desired shelf-life.

Milk products, juice or beer – what do these products have in common inside their production processes? One frequently used and often vital step is the pasteurization of the product. Pasteurization involves heating a liquid food or beverage to a certain temperature and then cooling it, with the aim of killing the microorganisms which can negatively influence the shelf-life and which can be dangerous for consumers. At the same time, it is very important to ensure the specific product properties, like taste, remain unchanged.

One type of pasteurizing machinery often used in large scale manufacturing plants is the flash pasteurizer. The flash pasteurizer delivers certain benefits in terms of energy efficiency and equipment costs. It is characterized by the pasteurization of the liquid food or beverage taking place in a controlled, continuous flow, usually during the pipe transport to the next phase, typically a packing process using sterile fill technology.

How critical is the pasteurization process?

Once the pasteurization process has started, it is essential the process runs uninterrupted according to strictly controlled parameters - otherwise the quality of the final product could be compromised:

- In the case of insufficient pasteurization, the amount of microorganisms which remain alive will be so high that, due to their further exponential growth over time, they will compromise the product before the end of the “promised” product guarantee term. Such a situation can have dramatic, or even disastrous, consequences if the consumer is exposed to bacteria, such as E.coli, for instance.

- In the case of over-pasteurization, the product can be burned. Brand Managers beware: who wants to order a favourite beer only to be unpleasantly surprised by a strange taste?

The performance indicator for the quality of this process is measured in “pasteurisation units” (PU). This is a non-linear measurement of time and temperature which reflects the kill rate of the bacteria within the product.

How does the flash pasteurizer work?

For simplicity, in this document, we will use the example of a beer pasteurization process using a flash pasteurizer. This involves three main process phases:

- Temperature recovery: the beer which has just entered the equipment takes on the residual temperature from the most recent beer to be pasteurized

- Pasteurization: the beer is heated up to the appropriate pasteurization temperature and, depending to its circulation flow and the volume of the holding cell, remains at this temperature for a designated time

- Cooling: before being buffered and bottled, the beer first needs to be cooled down.

An important factor, which requires monitoring, is the efficiency of the heat exchangers in the pasteurizer, which directly influence energy consumption. Another related performance indicator is heat regeneration efficiency, which details how much of the energy from the pasteurized beer is recovered into the following pasteurization process.

Every flash pasteurizer is typically delivered by the Machine Manufacturer with a certain degree of basic automation, which provides for:

- Equipment operation, including cleaning mode

- Flow and temperature regulation, in order to maintain the target values of the pasteurization units.

The production team expect the equipment to guarantee process quality.

What is required from the supervisory system?

As we have seen already, correct pasteurization is critical to the quality of the end product. The supervisory systems are a tool for real-time control, which allow the production team to react rapidly when intervention in the process is necessary. This is particularly useful in this industry, where late reactions will result in losing a considerable amount of product.

The implementation of ISO 9000, HACCP or ISO 22000 quality standards in the Food & Beverage industry requires strict monitoring and the documentation of pasteurization parameters.

For the maintenance staff, the supervisory system offers valuable information in order to plan actions like the removal of scale and build-up on heat exchangers. This preventive approach supports efforts to optimize energy consumption, can reduce unplanned equipment downtime, and helps to keep Overall Equipment Effectiveness as high as possible.

In the next section, we will look at the functionalities of a supervisory system implemented using zenon, and the benefits it can deliver for the manufacturing company, in more detail.

Parameterizing a supervisory system in 6 steps

1. Get connected

PLC = Programmable Logic Controller

HMI = Human Machine Interface

For the purposes of this paper, we are assuming that the automation of the flash pasteurizer consists of at least a PLC and an HMI system. The availability of a communication interface to external systems is a basic requirement of such an automation system.

With more than 300 communication protocols, zenon ensures a smooth connection to the automation hardware of almost any flash pasteurizer.

The key information which has to be collected in real time is:

- Current equipment status. For example: stopped; pasteurization in progress; or cleaning in progress.
- Temperatures in different sections of the equipment
- Liquid flow

To do this in the zenon Development System, when you begin a new project, there are just a couple of steps to be completed, which require no programming effort:

a) Select and configure the proper communication driver (e.g. Siemens S7 or Modbus TCP, etc.)

b) Create variable tags for each piece of information that is required. This includes address configuration in the PLC, or the direct import of the PLC variable list.

An important additional function offered by zenon's communication drivers is the monitoring of the quality of the communication, in order to ensure the accuracy of the information the user receives.

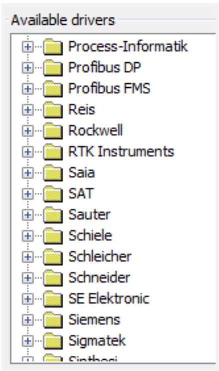


Figure 1: The huge amount of sophisticated communication drivers available in zenon ensures the smooth connectivity to almost any production equipment.

2. Calculate performance indicators

Based on automatically acquired information and other manually introduced equipment parameters, various performance indicators can be calculated in real time:

- The pasteurizing units (PU)
- The regeneration efficiency (R)
- The minimum, average and maximum value of measured temperatures and liquid flow, within the current pasteurization cycle.

How do you implement these calculations in the zenon Development Environment? In two easy steps:

a) Define the variables tags which will contain information, such as equipment constants or indicator values.

b) Using the zenon Mathematical Driver, describe the calculation formulas.

Do you work with other performance indicators or do you use some very specific formulas? zenon gives you the freedom to define the ways the system should process data in real-time.

3. Visualize the process

In the previous two steps you have ensured the availability of the right information to the supervisory system. The next step is to make it available to the production team. To this end, the zenon Development Environment will now focus on the realization of the user interface and the necessary graphics:

a) Create a navigation screen populated with buttons, which will help the user to navigate between the several screens of the application, like process visualization, manual parameter configuration, trend curves, alarm management, and so on.

b) Create a screen dedicated to the visualization of the process.

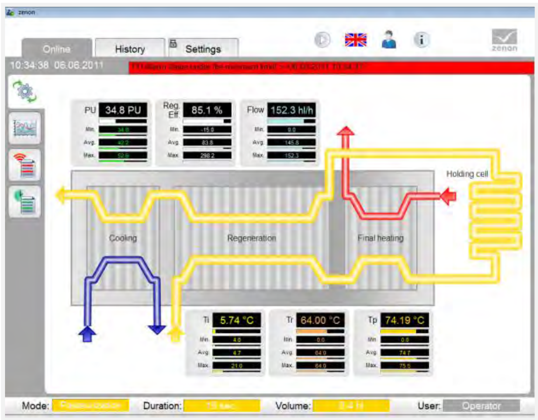
c) Populate the screen with the graphical elements which will display the real time information:

- A schema of the pasteurizing process, which clearly shows the main components and, illustrated as a pipe, the way the beer is following inside the equipment.
- Numeric and/or bar graphs which will display the current values of pasteurization parameters and indicators in real-time.

d) Add functions to visually indicate the current status of the pasteurizer, for example, by colour definition. Setting the parameters of the variable associated with the pasteurizer status and its graphical elements in the zenon Development Environment is all that is required to, for instance, show a pipe to be colored yellow during pasteurization, violet during cleaning, or gray when stopped.

Fig. 2 shows an example of a pasteurization visualization screen that has been created using the zenon Development Environment.

Figure 2: Process visualization in zenon



4. Show real-time trend curves

Displaying only the instantaneous values of parameters and indicators can often be insufficient. The trend evolution - for instance, within the most recent 15 minutes - brings supplementary information regarding the process quality. For example, how stable is the “pasteurization units” indicator? A big fluctuation will bring to light a malfunction in the automatic regulation at a pasteurizer level, possibly caused by big scale deposits. Faster corrective actions could mean avoiding losing control of the entire process.

In the zenon Development Environment this requirement is fulfilled in just a few steps:

a) Create a screen dedicated to the real-time trend curves and populate it with the pre-configured graphical components.

b) In the function created to switch this screen, select the variable tags to be displayed as curves.

c) For every curve, assign the colors and the display scales. The status information can also be very clearly displayed as Gantt chart.

By following these steps to parameterize an existing out-of-the-box module, extra zenon functionalities are immediately available to the user: operators can navigate using the time axis, and available functions include zooming, scanning etc.

If a trend curve analysis is required over a longer historical time, a supplementary configuration of the historian module has to be completed. This is a straight-forward process of simply indicating which variables tags have to be archived.

Figure 3: **Trend curves in a zenon visualization**

5. Alarm and Event Management

An essential functionality of any process supervisory system is its alarm mechanism. In the case of our flash pasteurizer, alarms will usually need to be generated when the PU measurements fall outside the defined maximum and minimum limits. These alarms provide essential support for process control staff. But how are such alarms realized in the zenon Development Environment?

a) To set process parameters or indicators, such as pasteurization units and temperature values, configure dynamic limits receiving values through the recipe mechanism available in zenon.

b) Allow the user, under password-controlled access, to manage these limit values in a Runtime configuration screen.

c) Configure that any change to the pasteurizer status will automatically adapt the minimum and maximum acceptable values to the respective status. For example, when the pasteurizer is in cleaning mode, it is no longer relevant if the PU value remains within the limits specified for pasteurization mode.

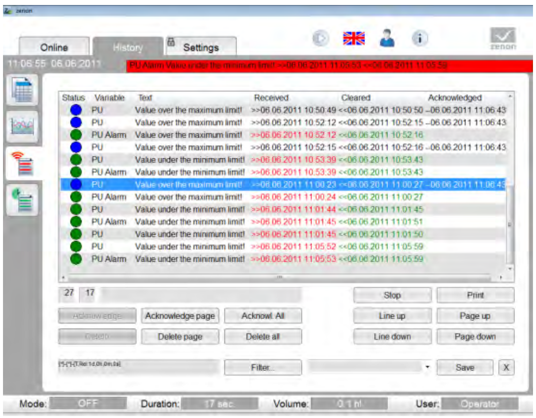
d) Create a screen dedicated to alarm management and populate it, using a simple drag and drop tool, with the pre-configured graphical components.

e) Fine tune alarm management, by tailoring the alarm grouping and filtering according to the needs of the user.

As shown in Fig. 4, the user has permanent access to the alarm list and can interact with it (to acknowledge, delete etc.). The out-of-the-box alarm management mechanism in zenon gives users other sophisticated features, with no additional engineering effort being required.

A similar mechanism is available in zenon for implementing chronological event lists. This enables users to log important events during pasteurization operations, such as the change of the pasteurization status, any manual change to equipment parameters, the start and stop of the supervisory system and so on.

Figure 4: Alarm management in zenon



6. Extend your application

Our example looks at several main functionalities demanded from a supervisory system and how they might be created when automation engineering is based on “parameterization instead programming”.

This is an ideal approach for users with little or no experience of programming, but what happens when the system needs to be extended as user requirements grow or change? In the dynamic environment of the Food & Beverage manufacturing, the system is likely to be subject to continuous process developments. How can our flash pasteurization supervisory system be further extended?

a) **Connect more pasteurizers to the system**. For example, from different beer filling lines. Repeat step 1 for each pasteurizer you wish to connect to. Then reuse the functionality you have created for the original pasteurizer.

b) **Create pasteurization reports**. Using zenon Historian, it is simple to configure the archiving of the all information of interest, including the start and end of pasteurization, amount of pasteurized beer, minimum and maximum values of parameters and indicators, number of alarms etc. then use zenon’s Report Generation module to make this information available to the user in a table format, with a time filter mechanism.

c) **Grant access to the supervisory system to additional members of the production team**. zenon’s network technology means in just a few mouse clicks you can configure client stations which will connect to the initial server station; the application is unchanged, so you completely reuse the previously implemented functionalities over the network. User management is configurable and you can make access to system configuration or system functions password protected.

d) **Inform staff by SMS or e-mail.** zenon’s Message Control module enables you to configure the communication of process and system events and parameters to the appropriate staff.

e) **Connect a new pasteurizer to the existing supervisory system after replacement.** Even when replacing equipment and hardware, you can reuse much of your existing application. You simply need to replace the communication driver and reconfigure the PLC addresses of the existing variables. And if you need to acquire more variables or create new performance indicators you can configure them and their associated functionalities just as before.

Summary and benefits

In our implementation guide, using the example of a pasteurization process, we have described the essential functionalities that supervisory systems should offer for industrial processes in the Food & Beverage industry:

- Connectivity with equipment
- Clear process visualisation
- Real time calculation of performance indicators
- Trend curve analysis
- Alarm and events management
- Data archiving
- Communication over network, e-mail or SMS

These functionalities of the supervisory system decisively support the production teams to reach their goals:

- The strict control and documentation of production process, including regulatory compliance
- The assured quality of final product
- The reduction of downtime
- The elimination of product losses

In this paper, we have demonstrated how all of these functionalities can be implemented without programming; just by parameterizing out-of-the-box modules in the zenon Development Environment.

What are the benefits of this advanced engineering approach for manufacturing companies?

- Versatility in integrating equipment from different suppliers and with different automation components.
- Low cost of integration and system maintenance – no special programming knowledge is required
- Quick and reliable integration – the out-of-the-box modules are already tested and simply setting the appropriate parameters requires much less time than programming to this high level of functionality would require.

- Flexibility to update the application to accommodate any changes in the production environment, regulations or user requirements

- High extensibility of the application over a network or new production equipment.

What are your experiences of using supervisory systems in Food & Beverage production processes? What are your thoughts about adopting the “parameterizing instead programming” approach during the integration of such system? Would you like to know more?

Emilian Axinia, Food & Beverage Industry Manager at COPA-DATA, is looking forward to hearing about your experiences and your feedback. Please email him at EmilianA@copadata.com