

Energy efficiency guidance for the food & beverage sector

Introducing energy saving opportunities in process and measurement control

Process and measurement control

While process control systems directly account for only a small proportion of the energy used on industrial sites (typically <3%), they have an enormous influence on overall site energy use as they control the operation of all the processes such as ovens, furnaces and reactors, and the operation of utilities, such as steam and compressed air. Adopting best practice in process control can result in energy savings of between 5% and 15%, depending on the quality of existing process control systems and the nature of the process.

Technology overview:

Process measurement and control refers to a range of techniques that can be used to improve the performance of processes. The secret of a good and economic operation depends upon reducing process variability and operating close to specification limits. Process measurement and control helps to achieve this by maintaining effective operation and efficient production.



Basic closed-loop control

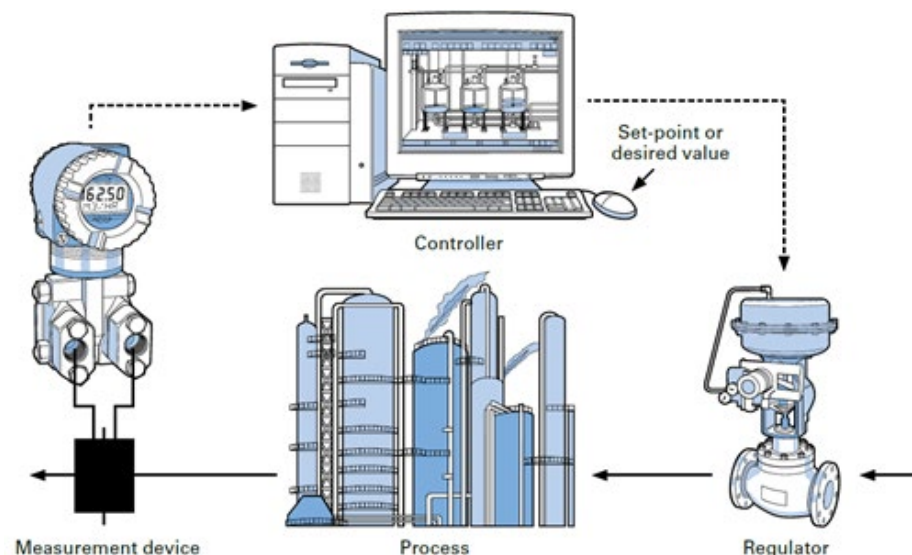
Basic closed-loop control is the main building block of any plant control hierarchy, which typically includes many hundreds of individual control loops.

The task of a control loop is to hold a particular process variable (for example, the speed of a mixer or the temperature of a baking oven) at its desired value, or its set-

point. This is either determined by higher levels in the control hierarchy or by the operator. The control loop must implement changes in set-point quickly, smoothly and efficiently without disturbing process operation.

The control loop consists of three main components (Figure 1):

Figure 1: The main components of a control loop.



1. The measurement device

To control a process parameter accurately, the control loop needs to be able to measure its value on a regular basis. This is usually done by a sensor that measures a particular physical property (such as temperature or flow rate) and a transmitter that converts the output of the sensor into a standard control signal. This signal is then sent to the controller, which is usually located in a protective enclosure in a central equipment room.

These signals may be sent to the control room individually or transmitted along with other control signals through a dedicated network, known as a Fieldbus.

2. The controller

The controller compares the measured value with its set-point and, where there is a difference, adjusts the process parameter to return the measured value to its set-

point. For example, the controller would measure the actual flow rate of a liquid through a process and compare it with the set flow rate. If there was a difference, it would set in motion appropriate changes, such as adjusting the speed of the pump, until the flow rate returned to the desired rate.

Controllers can be configured in many ways, depending on the characteristics of the control loop, the need for accuracy and the desired speed of response.

The single-loop controller is able to handle most of the control tasks found within the process industries if it is correctly chosen and well-tuned. For example, single-loop controllers may be used to control temperature in baking ovens within the food and drink industry. In this case, when a sensor detects a drop in temperature, more fuel would be sent to the burners to bring the temperature up to the required set-point.



Basic closed-loop control

The single-loop controller normally monitors one measurement and adjusts one regulator, but it can be used to adjust the set-point of another controller. This is known as a 'cascade system'. An example is where water is used to heat milk in dairy pasteurisation. A cascade system is used to control two loops; one measuring the temperature of milk and the other measuring the water temperature. In this case, the cascade relies on the measurement recorded by the rising temperature of the milk to slowly decrease the heat of the water, allowing the milk to be continually heated at the appropriate set point temperature.

3. The regulator

A regulator is used to control the throughput of the process. The most common type of regulator consists of a control valve that

adjusts the flow in response to the output from the controller. For example, control valves are used to regulate the flow of steam and chilled water to maintain the temperature of glass-lined batch reactors typically used in food and beverage processes.

Alternatively, a variable speed pump may be used to control the flow of the fluid. This not only reduces the amount of energy wasted by throttling the flow, it also allows more accurate control of the flow and eliminates the problem of sticky valves.

Where the controller is regulating the movement of solid materials, rather than a liquid or gas, for example: moving pulverized coal along a conveyor belt into a boiler system, a variable speed drive may be used as the regulator.





Types of control systems

As well as basic control loops, there are also different types of system that may be employed, dependent on the functions and complexity of the control required: The most common types are:

- **Sequence controllers**
- **Distributed control systems (DCS)**
- **Supervisory control and data-acquisition (SCADA) systems**

1. Sequence controllers

On some industrial sites, electronic relays and simple on-off controllers are still used to sequence, for example, valve movements and carry out other mechanical operations involved in process start-up and shut-down.

However, these systems are progressively being replaced by sequence controllers such as programmable logic controllers (PLCs). PLCs have a flexible, modular design so they can be expanded in a low-cost way to cover more aspects of process operation as it is automated. Modern PLCs can incorporate single-loop controllers along with more advanced types of controllers. PLCs may be used to carry out a sequence of actions such as adding a colouring dye to cake dough at preset intervals that corresponds with particular consistencies.

2. Distributed control systems

Distributed control systems (DCS) are normally used to control large or complex processes. They are modular systems that enable operators to adjust the set-points of many individual controllers from a central control room. DCS also include capabilities to sequence process start up and shut down operations and to apply advanced control techniques. For example, DCS may be used in the chemical industry to control multi-process sites. This will enable handling of significant numbers of measurement devices and control loops within the one control system.

Modern, digital DCS are built around a highspeed network or 'control bus' that connects each controller to a central supervisory control unit. This unit monitors the operation of each of the controllers and makes data available to other high-level systems, such as fault diagnosis, process

optimisation and production-scheduling systems. This enables the production of high-quality products, while maintaining cost-effective operation and minimising downtime.

3. Supervisory control and data-acquisition systems

Supervisory control and data-acquisition (SCADA) systems can be used to control a wide range of industrial processes and are often used to provide an operator interface for PLC-based control systems. SCADA systems are software packages designed to run on a computer workstation or industrial PC and include facilities for storing and distributing process data for future analysis.



Types of control systems

Advanced SCADA systems also incorporate advanced control algorithms that can help operators to automatically optimise process operations and to control them. This avoids the need for frequent, manual intervention that may be required on more basic SCADA systems. Pulping sugar beet is an example of an application for this type of system. In this case, an advanced SCADA system would automatically adjust the steam input necessary to take account of the variation in moisture content of sugar beet to produce a consistent pulp. Some advanced SCADA systems also include fault diagnosis and production scheduling systems.

In addition to the above established control systems, the F&B sector will increasingly benefit from transformative technologies such as the 'Internet of Things' (IoT) and 'Industry 4.0' which generate and exploit data to improve overall equipment effectiveness (OEE) and optimise energy use. When procuring new process equipment, ask prospective vendors how their products can digitally connect with the cloud and with other devices and whether use is made of machine learning to optimise performance.

Energy savings opportunities in process and measurement control

By improving control, companies can certainly reduce energy consumption. This reduction in consumption could translate to energy cost savings of up to 15%.

Assess the quality of measurements

Effective process control needs to start with accurate measurements of key indicators such as temperatures, pressures, levels, flow rates and energy use. Ask operators for their views on the reliability of different process measurements and investigate areas where readings may be problematic. For example, do operators record data at all? Do the readings look about right? When was the last time that the machinery was calibrated?

Operators should also consider whether measurements are taken at the correct position in the process, as incorrect siting may lead to mis-measurement and erroneous actions.

Other recommended checks include considering how they vary when introducing a known change upstream and, once a problem has been identified, asking what is the likely time delay before corrective action can be taken.

Findings may show that:

- ➔ A measuring device is un-calibrated or badly chosen.
- ➔ Signals are corrupted.
- ➔ Equipment has been poorly installed or maintained.
- ➔ Measurements are now inadequate or inappropriate.

Whenever these are found they should be rectified with the help of a qualified technician.

Establish a programme of staff training and preventive maintenance

Process efficiency often deteriorates because of the way that operators respond to faults. Operators make adjustments to control settings to overcome a short-term problem (such as reducing the feed-rate to compensate for a blocked filter) but then fail to readjust settings when the problem is fixed. As a result, systems become inefficient.

To prevent this happening, establish a regular maintenance strategy, train staff to report process faults promptly and ensure that operators are fully aware of the consequences of adjusting control settings.

Consider automating where possible

Manual control can introduce human error. List all areas on the site where manual control is used and consider whether automatic controls

In the food and beverage industry, automatic control can be used for applications such as controlling product moisture levels to eliminate over-drying, or optimising product quality.

Many food and beverage manufacturers also use simple sensors to detect when a product is present on a conveyor, meaning that less energy is expended, as the conveyor does not have to operate continually.

Scheduling for energy efficiency

Batch processing and frequent product changeovers are commonplace in the food and beverage industry. As a result, there are often marked changes in the requirements placed on the system and this can reduce its overall efficiency.

A product changeover, for example, from baking bread to baking morning goods, will usually result in changes to the temperature and the duration of the baking process. The changeover will also result in an increase in energy demand caused by replacing warm with cold baking trays and the reheating of the oven to the required temperature.

Understanding the impact of changeovers can help identify energy savings. Common opportunities include reducing the number and timing of changeovers in a schedule and employing better control to make sure that each is efficient.

Process measurement and control helps to achieve improved product yield and quality, increased plant capacity, reduced wastage or give-away, reduced environmental impact and often vary efficient use of manpower, materials and energy.

Beyond energy savings, process control can also increase their operational efficiency in many other ways. Other benefits include:

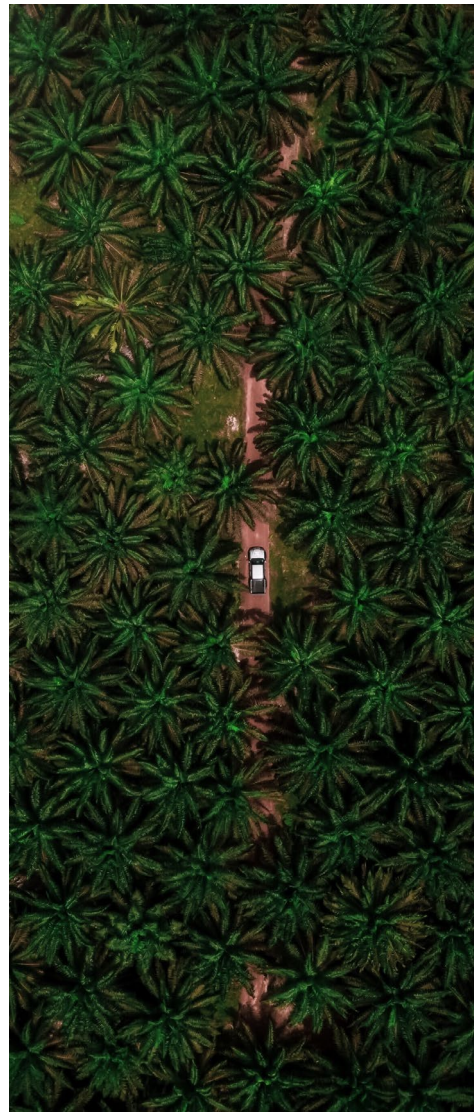
- Reduce manufacturing costs by optimising product throughput and yield. Companies often find that they can achieve a greater output from the same levels of throughput, simply by improving the control on operational processes.
- Consistent product quality by greatly reducing variation in product quality, hence ensuring that customer specifications are met and wastage is reduced.
- Safety improvement by warning of hazardous conditions or safety trips to cease operations if operators fail to respond.
- Better environmental performance through early warning loss of containment and excessive emissions to the environment.
- Process insight gained from measurements providing a 'window' on the process parameters that enhance profit opportunities.

Case study:

Cargill Palm Products, Malaysia¹

The plant operates seven days a week and has an overall output of about 450,000 tonnes of palm oil and its by-products, more than 90 per cent of which are exported. Crude palm oil passes through several processes in the company's two refining and two fractionation plants to produce edible and refined oils. These require large amounts of thermal and electrical energy to be fed to high and low pressure boilers, heaters, compressors, motors, pumps, and refrigeration and water cooling systems. About 85 per cent of the energy consumed is in the form of thermal energy (steam and a hot oil system) from fuel, while the remaining 15 per cent is in the form of electricity. Fuel represents 61 per cent of the energy costs and electricity 37 per cent.

As part of the **Malaysian Industrial Energy Efficiency Improvement Project**, nine significant energy efficiency modifications were



undertaken. As part of process and measurement control, the measures included:

Repair of compressed air pipe leakages in the membrane presses, joints and pressure regulator in a fractionation plant that were resulting in a 30 per cent air leakage loss in the system. Immediate repairs reduced electricity consumption. On-going maintenance measures included operating the system at the lowest possible pressure, keeping the air intake clean and cool, and reducing leakage loss to an acceptable maximum of 5–10 per cent.

Steam leak minimization was a no-cost measure that was achieved by a monthly maintenance program. Inspection of piping joints and the remedying of small leaks reduced heat loss and made savings that cumulatively amounted to tens of thousands of Malaysian Ringgit annually.

Steam trap maintenance was also readily accomplished by extending the company's regular maintenance and replacement procedures to more than 300 steam traps.

Thermal insulation maintenance was identified by the audit team as a significant issue that was occurring as a result of uninsulated pipes and fittings. This was not a simple matter to resolve as structural and maintenance issues discouraged or precluded insulation. Detachable insulating jackets and detachable types of insulation housings for valves and flanges overcame most of these problems.

Process control measures to avoid unnecessary heating of the stearin holding tanks required the installation of temperature regulators to maintain the temperature at 60°C. The cost of this installation was significant but was exceeded by the energy savings in the first year.

¹<https://www.unclearn.org/sites/default/files/inventory/undp44.pdf>

The Carbon Trust is an independent company with a mission to accelerate the move to a sustainable, low-carbon economy.

The Carbon Trust:

- advises businesses, governments and the public sector on opportunities in a sustainable, low-carbon world;
- measures and certifies the environmental footprint of organisations, products and services;
- helps develop and deploy low-carbon technologies and solutions, from energy efficiency to renewable power.

www.carbontrust.com

Whilst reasonable steps have been taken to ensure that the information contained within this publication is correct, the authors, the Carbon Trust, its agents, contractors and sub-contractors give no warranty and make no representation as to its accuracy and accept no liability for any errors or omissions. Any trademarks, service marks or logos used in this publication, and copyright in it, are the property of the Carbon Trust. Nothing in this publication shall be construed as granting any licence or right to use or reproduce any of the trademarks, service marks, logos, copyright or any proprietary information in any way without the Carbon Trust's prior written permission. The Carbon Trust enforces infringements of its intellectual property rights to the full extent permitted by law.

The Carbon Trust is a company limited by guarantee and registered in England and Wales under Company number 4190230 with its Registered Office at: 4th Floor, Dorset House, 27-45 Stamford Street, London SE1 9NT.

© The Carbon Trust 2020. All rights reserved.