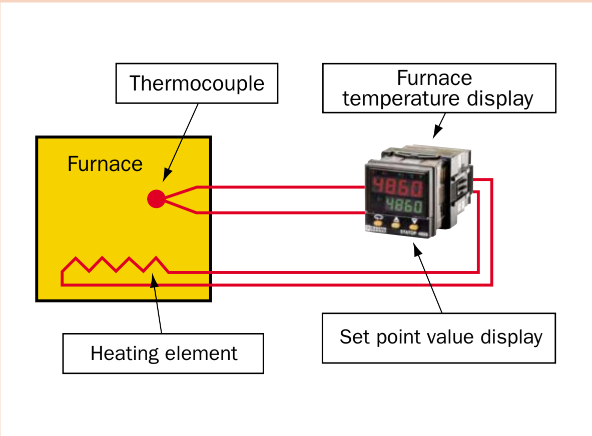
A review of temperature process control

Since the first temperature controller was manufactured by Chauvin Arnoux in 1934, the process control systems have developed considerably. Physical parameters which were still impossible to measure yesterday, are available today at a reasonable cost. This article offers you a clear insight into the current functions of temperature controller.

In "process control", in the last ten years, many programmable controllers with built-in control loops have been set up on the production line. For a long time, we thought that the traditional switchboard controllers were doomed to slowly disappear. Now, in the last few months, we have once again been seeing sales rise for the big manufacturers of this type of product. Do the functions that they offer today suffice to explain this phenomenon?

The principle of automatic control

Let us take the simple example of oven temperature control to define the key terms. The aim is to keep the oven's temperature at 200°C by varying the electric current in a resistor.



- The oven's temperature is the **controlled variable**
- The temperature fixed at 200°C is the **set point**
- The regulator's output variable is the **correcting variable**

What is a controller?

A controller is an automatic process control device which enables quality, comfort and safety to be improved, and energy consumption to be minimised. The controller permanently compares the divergence between the controlled variable and the set point (which is called the measurement-set point divergence) and sends a signal aiming to offset it. The different sorts of automatic control can be arranged into 4 large technological families:

- Electromechanics
- Pneumatics and hydraulics
- Analog electronics
- Digital electronics

The choice of technology must be made strictly depending on the degree of automatic control being sought and the cost-in-use, as well as the dynamic and static behaviour of the processes concerned.

Electromechanics

As a general rule, electromechanical controllers have only one function. They are suited to simple and standardised configurations. They convert a physical quantity into a mechanical movement aiming primarily to activate an electrical contact.

Pneumatics and Hydraulics

This technology has the advantage of having a simple and quick element. Very often used in a dangerous environment, this type of controller enables motors, valves or cylinders to be actuated without any risk of sparks.

Analog electronics

These controllers make it possible to carry out simple functions: detection, adjusting, displaying, and calculations. The forming of measuring chains is simplified by the standardisation of exchange signals. This technology can be bought at a very low cost.

Digital electronics

This technology uses one or more microprocessors. It makes possible complex calculations in very short spaces of time, data storage, and data transmission via a field bus. The user-friendliness of the man-machine interface has become a determining factor.

Programmable controllers

This type of product, originally designed for complex algorithms and to band together automatic operations, has progressively integrated new functionalities, like for example the control loops (PID action).

What is a control mode?

For control to be optimal - meaning accurate, quick, insensitive to interference, and therefore stable - the operating mode of the control system has to be suited to the process. The automatic controller must not make its presence felt! Different modes solve all the automatic functioning problems in the various installations, depending on their static and dynamic characteristics, as well as the action range.

Cascade control

The cascade system brings two control loops into play, with the first loop acting on the second. Its role is to "boost" reaction to the different disturbances which generate poor-quality controls.

Hot and cold control

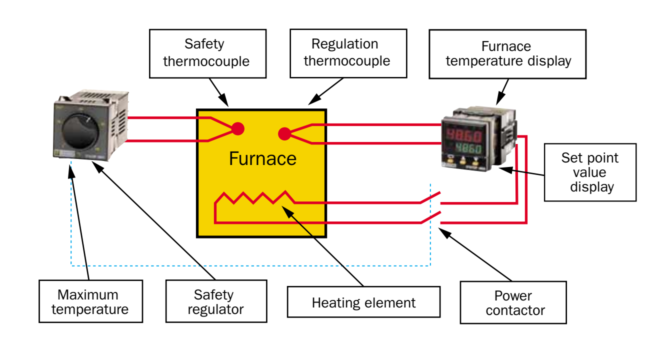
This is a single loop system but with two mutually opposed actions centered on the same control set point. Each action possesses its own PID parameterisation. Before the set point value is attained, the 'heating' action is set in motion; beyond that, the 'cooling action' takes over.

Ratio control

The controller calculates the ratio between two values measured at the input. This ratio is kept constant by the control loop. It is most frequently used in quantitative analysing processes.

Protected control

A second controller, functioning in on-off mode, protects the control loop by imposing a maximum temperature which should never be exceeded. This system provides a very high degree of safety for a very small cost.



"Feed forward" control

The heating power calculated by the controller is corrected by another variable, for example the network fluctuation or the load variation due to the ageing of the heating elements. This function is sometimes integrated into power controllers equipped with well-made thyristors.

Which outputs for electronic controllers?

On-off outputs

This is the simplest and best-known, frequently used for simple systems when regulating quality is not very important (electric convectors, liquid level, etc.). If the measurement is lower than the set point, the controller's output is active, and vice versa. Oscillations of the controlled variable occur around the set point which are more or less considerable depending on the system's inertia, hence its use in systems that do not require much precision.

Modulated output

The controller's output is modulated according to a fixed time period and a cyclic ratio (on/off) which will vary depending on a value calculated by the controller. The fixed time period will be a compromise between the wearout of the power element and the inertia of the process.

Direct current output

The controller's output varies proportionally to the calculated value, generally got from a PID unit. The weaker the measurement-set point divergence, the weaker the output signal. It is useless when the controlled variable is equivalent to the set point.

What are control parameters?

These enable the controllers to calculate the actions to be carried out in order to correct the divergences between the measurements and the set point.

The PID

This is the combination and complementarity of the following 3 actions:

- **Proportional:** it suppresses the oscillations in the process at a value specific to it.
- **Integrated:** this corrective action adapts the speed of the controlling element so as to offset the measurement-set point divergence.
- **Derivative:** functions together with the integrated action. It is useful in cases of rapid and sudden disruptions in the process, and it cancels itself out when the divergence is once again close to zero.

All these actions are known as PID and are defined by:

- The user, according to the process which is to be controlled.
- The **Self-controlling** algorithm: the PID is automatically controlled by the controller, with the procedure being launched by the user.
- The **Self-adaptive** algorithm: the PID is adjusted to the process with each measurement-set point divergence observed by the controller. This is a dynamic function.

Fuzzy logic

This algorithm calls on the "fuzzy" concept, which brings in subjective notions intended to be similar to human reasoning, for example: very cold, cold, warm, hot, very hot.

It is associated with the PID. This new hybrid system enables mathematical rigour to be combined with the flexibility of fuzzy logic.

What is the situation as regards the temperature controller market?

As mentioned above, during the last few years we have observed an increase in demand for switchboard controllers, to the detriment of industrial programmable controller PID boards. How can we analyse this? The following 2 points will begin to provide an explanation.

1. Control by programmable controller will never be as fine as with an automatic control, into which development teams have integrated all their professional know-how on the subject of control. Today, a precision of ±1°C is not easily achieved by a programmable controller, even one which is very sophisticated..

2. Industries which use continuous process manufacturing represent a mature market. Today, everybody is very aware of the place of each link in the chain and confusions are extremely rare. The tendency is to decentralise equipment, interlinking closely by means of field buses. The programmable controller has its place within the perspective of an integrated system, managing complex algorithms and **controlling separate elements.** In the event of a short "crash", these elements have to continue autonomously to monitor and control, to avoid production being destroyed. Thanks to that, the production teams will always be able to regain control in manual mode.

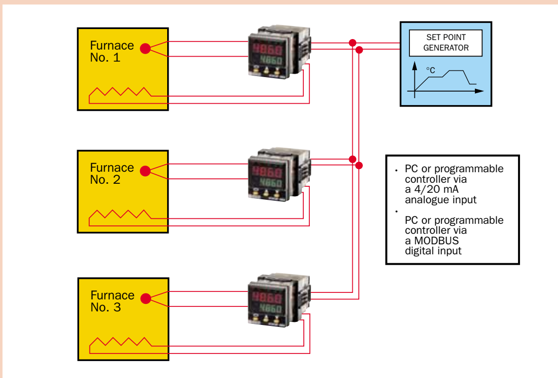
This is why, in the Temperature M and C Division, we think that the future in industrial process applications lies in independent controllers controlled by a system or a programmable controller.

Developments to Chauvin Arnoux's range

Year after year, the range expands with new products, which enables you to continually improve the quality of your controlling for a more and more modest product cost. Before, we did not have a product in our catalogue whose set point could be controlled by a system (programmable controller, supervisor and set point generator). Today, it is done: to our great satisfaction, this product has just come to life in our factories - the **STATOP 4860.**

Among a great many other novel features, it enables the control set point to be remote modified by:

- either a 4 - 20 mA or 0 - 10 V fine control mechanism
- or a digital fine control mechanism in ModBus (RTU protocol)



We invite you to turn the page to learn about it in more detail