Selection of IRCON Temperature Controllers

INTRODUCTION

IRCON provides a selection of temperature controllers in its MODLINE 3 and MIRAGE series of instruments. These controllers are designed for a variety of switching, alarm and process temperature control applications. By careful selection of the controller and its available options, it is possible to integrate accurate, reliable process control into your system.

There are two types of controllers to choose from in the Modline 3 series instruments. Two/Point ON/OFF type with relay outputs and a Three Mode Proportional Controller (PID) with Auto/Tune feature and 4-20 or 0-20 mAdc output.

A Two-Point ON/OFF Controller is available in the MIRAGE Series of instruments. This controller provides independent relay contact switching at two selected set points, with front panel LED indicators to monitor the states of the two relays.

PROCESS CHARACTERISTICS

It is not always a simple job to equip the controller with the options that will give you a superior system. Very often system performance's governed more by the restrictions of the process dynamics then it is by the controller. You will need to know the essential characteristics of both your process and the available controllers before you can put together a well integrated system.

In continuous processes, such as heating of moving steel sheet, initial start-up conditions are not very often encountered. The real test of the control system is whether or not it can maintain a constant temperature and react quickly enough to overcome upsets in speed, power, or sudden environmental changes that are imposed on the process.

Even though the process is one of great speed, to the controller it appears to be a static situation if the same set point is always employed and the material temperature is always at, or near, this temperature.

In batch or individual piece part heating the start-up characteristics are often of prime importance. Generally, to reduce the production cycle time, it is desirable to bring the workpiece(s) to set point temperature very quickly. Here the controller must prevent unwanted overshoot and settle into the lineout temperature as soon as possible.

It should be apparent even from these few remarks that a more sophisticated controller is required in the intermittent process.

If cyclical variations of temperature can occur without damage to product properties, a simpler control can be used than if these variations are not permissible. If the thermal conductivity of the product is high, variations in heating will quickly average out. However, if the product thermal conductivity is very low, variations in temperature may be locked into the material and affect final appearance or performance.

If one plans for a static situation that is not truly static, then the control may be found not to react quickly enough when an “upset” occurs. Thus, in analyzing the process characteristics the extreme of possible variations must be taken into account.

In any process there are time delays or “lags” that are encountered between the control decision to change the temperature of the product and the actual accomplishment of that change. These lags can be due to several factors:

- When an increased temperature is called for, power is applied to the workpiece. If the process has been scaled to provide adequate reserve of power this change may occur very quickly; if the power available is just barely adequate for the control conditions this change may take quite a long time.

  Sometimes an adequate power reserve is dissipated by increasing conveyor speed, mass of product, batch size, seasonal ambient variations, overload of plant power busses, and the like. Lags of this nature cannot be overcome by improvement of controller response times.

- When a decreased temperature is called for, the power level is decreased. The cooling off time depends on the characteristics of conductive, convective and radiate losses from the workpiece.

  This time of temperature reduction will also vary depending on variables such as seasonal ambient temperatures, contract pressures, cooling water temperatures, conveyor speeds, etc. Thus, this type of lag is not always predictable and is outside the capability of some controllers to compensate for it.

- Thermal lags depend on the thermal inertia of the workpiece material itself. For a constant product these lags between the application of theat or power and the rise in temperature are measurable and fairly constant.

  Workpieces with small thermal masses and/or high conductivity require controllers with fast response. If the thermal mass is large and the transfer of heat slow, then the controller can be correspondingly slower in response.

  Note that if the thermal inertia is high the overshoots in temperature from an application of heat will be much greater than for a low mass workpiece. Therefore, this type of product requires anticipation of set point approach.

- Transport lags are those time delays which result from physical separation or time differential between the application of power and the measurement of temperature. Consider that in measurement of the temperature of steel strip the measuring point may be a great distance away from he burners supplying heat. The time delay is the separation distance divided by the velocity of the strip.

  Since this time delay will vary according to how fast the strip is moving, there may be enough delay under varying operating conditions to cause oscillation of the entire process control. Because of these uncertainties, transport lags are to be avoided in process control wherever possible.

- Control System lags result from finite times being required for controller responses. Generally, in purely electronic or electrical systems, there is no problem in making the controller much faster than any process requirement. Where mechanical motion is involved (such as valve opening) there can be significant delays and these must be accounted for in determining the required overall system response.

CONTROLLER CHARACTERISTICS

ON/OFF CONTROLLERS (FOR MODLINE 3 AND MIRAGE)

An ON/OFF CONTROLLER has only two states of operation — Power full ON when workpiece temperature is below the selected Set Point, and Power OFF when temperature above the Set Point temperature.

If the ON/OFF switching occurred at one very fine set point the output relay would constantly chatter. Hence, a small dead band (See Fig. 1) is normally designed into an ON/OFF controller. In the IRCON controllers, the dead band is ± 0.15% of span. If the dead band is made too wide very inaccurate control results; if too narrow relay chatter results.

If the power available is much greater than required to keep the process at set point the lineout temperature will be above set point and the product will spend most of its time above set point. Conversely, If the power available is a bit shy the lineout temperature will be below set point and the product will spend most of its time below set point.

Any difference between lineout temperature and set point temperature is called “droop”. Correctly scaling the power to the process reduces droop.

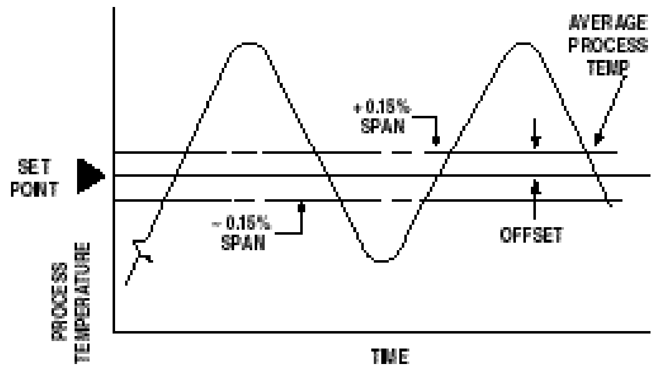
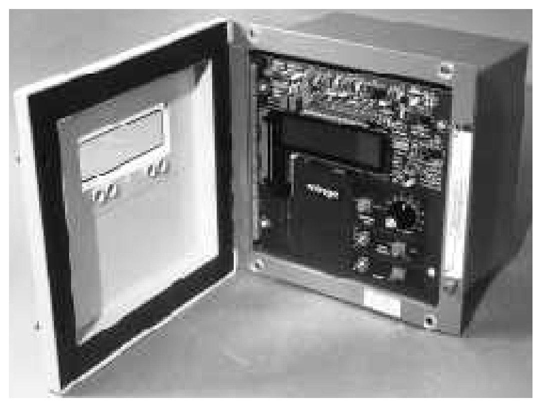


Fig. 1 — ON/OFF CONTROL



MIRAGE INDICATOR/PROCESSOR WITH ON-OFF CONTROLLER

PROPORTIONAL CONTROLLER (FOR MODLINE 3 ONLY)

Where cyclic deviations from set point temperature are not permissible and smooth control action is required a PROPORTIONAL CONTROLLER is the logical choice. This controller is so named because the magnitude of output control signal is proportional to the deviation (error) between workpiece temperature and set point temperature.

In a correctly adjusted system the load temperature will be brought to set point temperature with minimal overshoot as shown in Fig. 2. The process temperature will then line out at some average temperature differing from the set point by the droop of the system. The magnitude of the droop will depend on the proportional band setting — a small proportional band producing small droop.

To automatically eliminate offset or droop, an Automatic RESET circuit must be added to the controller. This circuitry senses any error that exists, and continuously seeks to reduce the error. This action is actually a continuous integration of whatever error exists. An output signal of the polarity required to cancel the error is added on the proportional signal. Ordinarily another function is

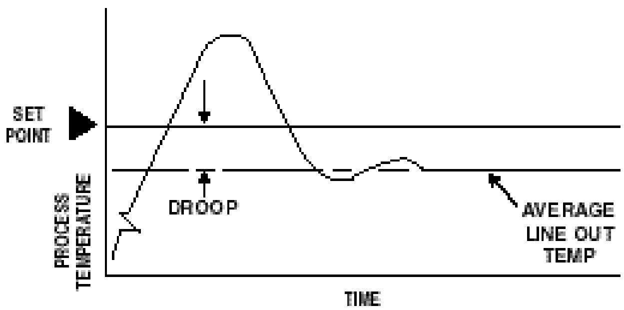


Fig. 2 – ONE-MODE PROPORTIONAL CONTROL

added, called RATE control, which senses how quickly error is changing and seeks to counteract this rate of change.

When all three modes (PROPORTIONAL BAND, RESET, RATE) are used the controller is appropriately known as a THREE MODE PROPORTIONAL CONTROLLER. This type of controller is called a PID Controller (P = Proportional Band, I = Integral, D = Derivative). Correctly adjusted this controller permits the fastest approach to set point temperature, with minimal overshoot and with continuing smooth control at set point with no droop, (as we attempt to show in Fig. 3).

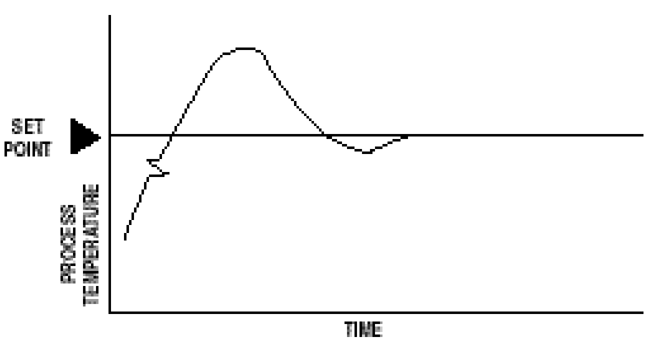


Fig. 3 – THREE-MODE PROPORTIONAL CONTROL

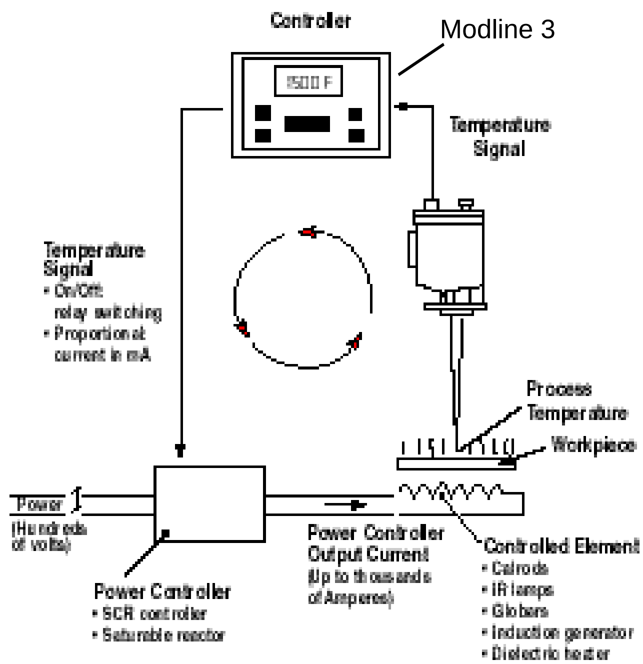
ON/OFF CONTROLLERS

ALARM OR LIMIT (FOR MIRAGE AND MODLINE 3)

TRUE/FALSE or ON/OFF action is required at set point temperature to:

- SORT: Hot from cool, or pass product within given temperature bounds.
- ALARM: Light or Sound Signal to warn of product being too hot or cold.
- CONTROL: START or STOP equipment, activate machinery sequence.

  Turn on or shut off heater or quench.



CONTROLLER LOOP

ON/OFF CONTROL (For MIRAGE and MODLINE 3)

ON/OFF control turns power full on or full off at set point.

It can be used when:

- Overall process is static or slow.
- Offset or “droop” can be tolerated.
- Process can withstand continuous cycling.
- Process can withstand full application of power.
- Fairly wide temperature deviations are acceptable.

Note: Droop is minimized when overall process heating and cooling rates are approximately symm=/trical.*

PROPORTIONAL CONTROLLERS (For MODLINE 3 Only)

ONE MODE PROPORTIONAL CONTROL

(Reset and rate parameters turned off)

Proportional control applies power proportional to the error between actual and set point temperature.

It should be used when:

- Process is fuel fired and requires a continuously throttled flame.
- There can be large lags in time before changes in power or load are measured by the radiation thermometer.
- Excessive overshoot could be damaging to the final product or heaters.
- Process upsets caused by changes in load, power, or environment can be large, fast, or frequent.
- Continuous or frequent cycling of contactors and heaters could result in short life and high maintenance.
- Process cannot stand full application of power.
- "Droop" can be tolerated or environment is relatively constant, permitting offsets to be manually adjusted out.

THREE MODE PROPORTIONAL CONTROL (PID)

Adds ability to integrate error out of control and provide fast settling time.

It should be used instead of one mode proportional control when all the conditions requiring one mode control are present and:

- Offset ("droop") cannot be tolerated.
- Frequent ambient, load, or power level changes render manual offset compensation unworkable.
- Fast pull in to set point temperature is required, particularly in heating individual pieces quickly.
- In fast, repetitive heating processes.

CONTROLLER SELECTION

In the tables on the previous pages, we have tried to set forth some condensed advice and remarks concerning the choice of a controller for significant process characteristics. Detailed specifications for Modline 3 controllers are shown in Catalog MO-300. Specifications for MIRAGE controllers are provided in Catalog MR-05.

We will be happy to help you select the most appropriate controller for your process. Call our Toll-Free Hotline (800) 323-7660 and ask for our Technical Services Department.

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