TEMPERATURE CONTROLLERS- monitoring heat distribution

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ABSTRACT : *Temperature controllers in manufacturing are quite an essential part of proper product formation. If the temperature slips above or below the ideal range needed for a particular stage in a manufacturing process, the results can be harmful—improperly adhered coatings, a weakened base material, or an overall compromised component—so it becomes increasingly important that the manufacturer not only determine the proper temperature for each stage, but also monitor the temperature inside the machine and receive appropriate feedback.*

A temperature controller is an instrument used to control temperature. It does this by comparing the process temperature with the desired value (set value). The difference between these values is known as the error. Temperature controllers use this error to decide how much heating or cooling is required to bring the process temperature back to the desired value. Once this calculation is complete the controller will produce a signal that effects the change required. This output signal is known as the manipulated value and is normally connected to a heater, control valve, fan or some other "final control element" which actually injects or removes heat from the process.

How accurately you want to control the temperature will affect the type of temperature controller that you choose. Four basic types are normally considered: On/Off Control, PI Control and PID Control.

An experiment was performed to get the actual working of a controller in an actual water heating system using matlab.

KEYWORDS: Sensors, servo-controllers, set-point, AD/DA convertor

1. HISTORY OF TECHNOLOGY: TEMPERATURE CONTROLLERS

Controllers imply the restoration of desirable state which has been disturbed by external or internal influences. Initially incubators were operated at constant temperature. The “thermostats” were insulated with asbestos or linoleum, heat transfer to the exterior was provided through a water jacket, heating was done using gas and even double doors, calibrations of temperature controller was difficult; a device called thermo regulator was used.

Hence lately these incubators became a control element. The fact that metal surfaces expand due to heat was used. A heated metal plate was installed at the back of the incubator and connected to a control rod with a higher heat resistance. If the plate expanded due to heat , the control rod moved upwards , two contacts installed on a see saw engaged and a relay was triggered, disconnecting the power supply for the heating unit. This way it was used as a control element itself.

TEMPERATURE CONTROLLERS

2. INTRODUCTION

Temperature Controllers, used in wide variety of industries, is the starting and important tools for the controlling of the temperature to get desired results in various industries. They offer quick setup and provide precise temperature management and control for a variety of applications.It is an electronic device that controls a heating element to maintain a chosen temperature.

3. WORKING

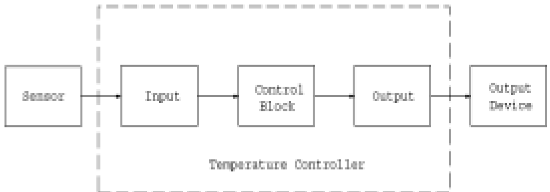

Fig 1: (control system)

Temperature controller is one of the parts of control system. It takes an input from a temperature sensor such as a thermocouple or RTD and has an output that is connected to a control element

such as a heater. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element.

4. TYPES OF SERVO CONTROLLER

There are basic three types of controllers: on-off, proportional and PID. Depending upon the system to be controlled, the operator will be able to use one type or another to control the process.

i. ON-OFF CONTROLLER

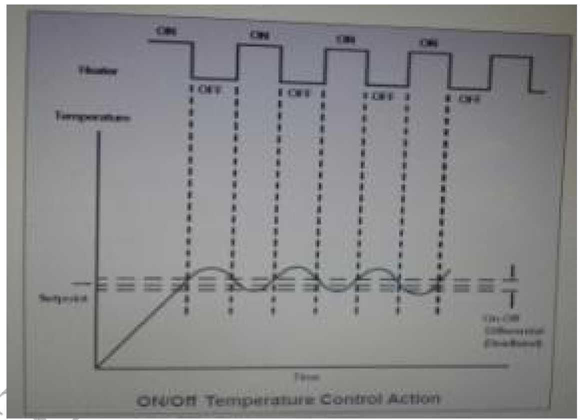

Fig 2.1: (graph of ON/OFF controllers)

An on-off controller is the simplest form of temperature control device. The output from the device is either on or off, with no middle state. An on-off controller will switch the output only when the temperature crosses the set point. For heating control, the output is on when the temperature is below the set point, and off above set point. Since the temperature crosses the set point to change the output state, the process temperature will be cycling continually, going from below set point to above, and back below.

ii. PROPORTIONAL CONTROLLER (P CONTROLLERS)

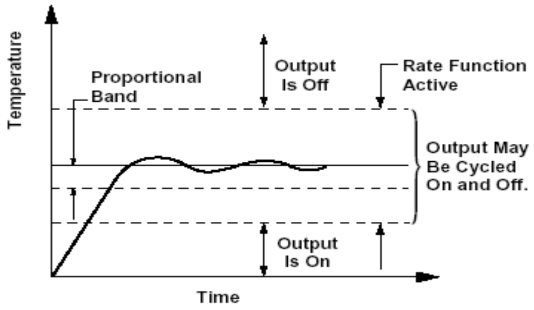

Fig 3: (graph of P controllers)

Proportional controls are designed to eliminate the cycling associated with on-off control. A proportional controller decreases the average power supplied to the heater as the temperature approaches set point. This has the effect of slowing down the heater so that it will not overshoot the set point, but will approach the set point and maintain a stable temperature. This proportioning action can be accomplished by turning the output on and off for short time intervals. This "time proportioning" varies the ratio of “on” time to "off" time to control the temperature. The proportioning action occurs within a “proportional band” around the set point temperature. Outside this band, the controller functions as an on-off unit, with the output either fully on (below the band) or fully off (above the band). However, within the band, the output is turned on and off in the ratio of the measurement difference from the set point. At the set point (the midpoint of the proportional band), the output on: off ratio is 1:1; that is, the on-time and off-time are equal. if the temperature is further from the set point, the on- and off-times vary in proportion to the temperature difference. If the temperature is below set point, the output will be on longer; if the temperature is too high, the output will be off longer.

iii. PROPORTIONAL INTEGRAL CONTROLLERS (PI CONTROLLERS)

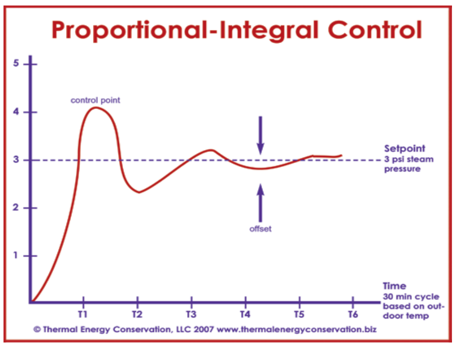

Fig 4: (graph of PI controllers)

PI controllers fuse the properties of proportional and integral controllers. It eliminates the forced oscillations and the steady state error. It has high overshoot and high settling time with zero steady state. However introducing integral mode has negative effect on the speed of response and overall stability of the system. Thus it will not increase the speed of response.

iv. PROPORTIONAL INTERGRAL DERIVATIVE CONTROLLERS (PID)

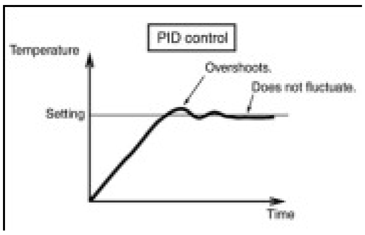

Fig 5: (graph of PID controllers)

The third controller type provides proportional with integral and derivative control, or PID. This controller combines proportional control with two additional adjustments, which helps the unit automatically compensate for changes in the system. These adjustments, integral and derivative, are expressed in time-based units; they are also referred to by their reciprocals, RESET and RATE, respectively.

A. Proportional

The first of these areas is proportional. The output of the proportional controller is relative to the difference between the temperature that is present and the set point. An adjustable proportional band is set up as a range of temperatures. The Proportional band is good for reducing the rise time of a process, and reduces, but never erases the steady-state error.

B. Integral

The second system in a PID controller is the integral control. The integral control eliminates the steady-error, but makes the transient response worse. It has a negative effect on stability. The controller output is proportional to the amount of time the error is present.

C. Derivative

The third system working in a PID controller is the derivative control. The derivative control affects the system by increasing stability, and by reducing the overshoot and undershoot of the function, and improving transient response. The output under derivative control is proportional to the rate of change of the error over time.

5. Experimental Setup:

Fig 6: pictorial view of the experimental set up

This is a continuous water flow system with agitator. The speed of the agitator is fixed using a motor. The system is having four thermocouples at different heights located in the tank, so as to measure the temperature variation at different levels. A temperature transmitter senses a temperature and transmit an output representative of the sensed temperature. . The transmitter injects a current into the temperature sensor and the resultant voltage drop across the temperature sensor is used to measure resistance. The voltage is converted into a digital format using an analog to digital converter and provided to a microprocessor. The microprocessor converts the measured voltage into a digital value representative of temperature. The sensor is k-type Thermocouple which is having sensing range of 0-200^{0}C. When the power supply is ON, the transmitter injects a current into the temperature sensor and the resultant voltage drop across the temperature sensor is used to measure resistance. The voltage is converted into a digital format using an analog to digital converter and provided to a microprocessor. The microprocessor converts the measured voltage into a digital value representative of temperature. Then the input is given to the system in terms of voltage, the DA convertor conveys this value to the Water tank and the temperature of the water is increased using heater.

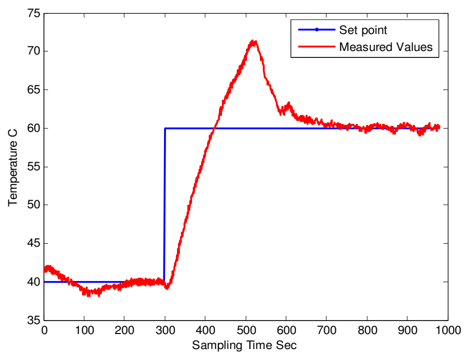

Fig7:generated graph of PI controller

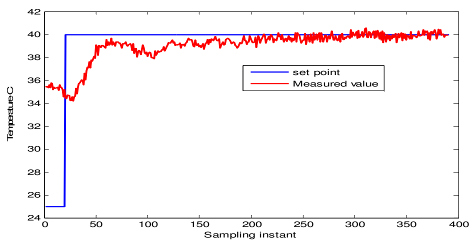

Fig 8: generated graph of P controller

6. CONCLUSION:

From the above experiment we concluded that PI controllers are better than P controllers. We would engage in new experiments and then analyze and compare the above results with the new developed controllers i.e. PID and Fuzzy Logic in the upcoming study.

7. REFRENCES

1.http://www.coulton.com/QandA_controller

2.http://www.facstaff.bucknell.edu/mastascu/econtrolhtml/Intro/Intro1.html

3.http://www.controlguru.com/wp/p69.html

4.http://www.instrumart.com/pages/283/temperature-controller-basics-handbook