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Temperature control technical report

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Introduction

This report discusses temperature control and how it is a crucial part in the efficient and safe operation in refineries. Refineries operate under various temperature conditions; precise control is important to optimize chemical reactions involved in refining. The parts and the operation of a temperature control is discussed, as well as a piping and instrumentation diagram demonstrating the use of temperature control.

What is a temperature controller (TC)?

The TC serves a crucial role in maintaining optimal operating conditions. Represented on a P&ID (piping and instrumentation diagram), the TC will receive input from strategically placed temperature sensors. TC will be programmed with a temperature setpoint, when temperature deviates from the set point, the controller uses a PID algorithm will create an output signal to switch on temperature regulating devices, such as a heating or cooling element to bring that temperature closer to the set point.

PID control principles

The PID controller will operate on three different components:

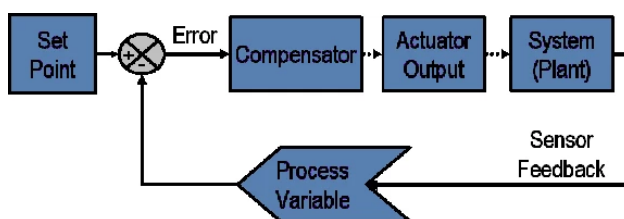
- P-Proportional,
- I-Integral,
- D-Derivative.

Proportional term: This will respond to the current error.

Integral term: Addresses past errors.

Derivative term: Anticipates future errors.

Figure 1

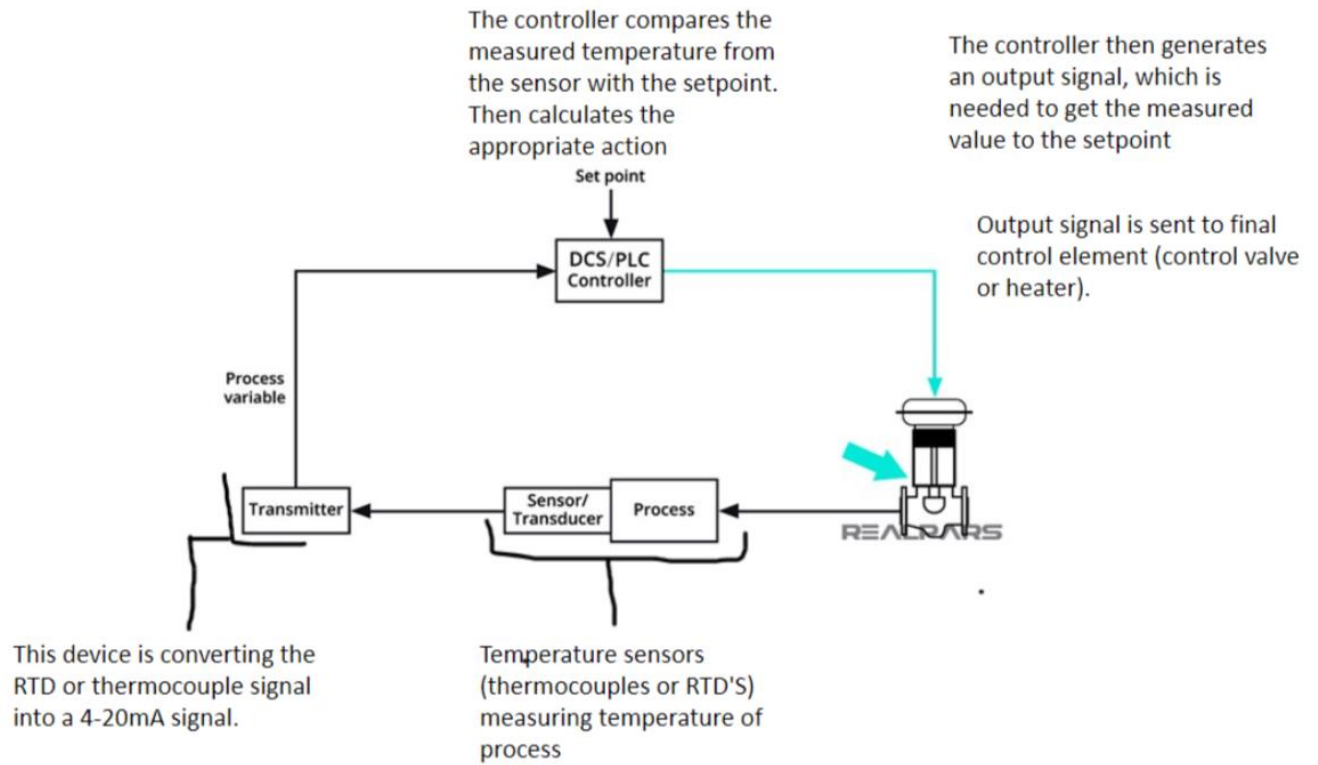


This is a break down of a PID used in temperature control:

- The sensors for temperature controllers are thermocouples or RTD's that measure the temperature of the process.
- Operators set a set point to the desired temperature based on process or safety requirements.
- The controller continuously compares the measured temperature from the sensor with the setpoint. Then using a PID algorithm to calculate the appropriate control action.
- The controller will generate an output signal that is needed to get the measured value to the set point.
- The output signal is sent to the final control element (example- control valve or heater).
- The system continuously monitors the temperature and adjusts the control output, creating a closed-loop feedback system to maintain the desired temperature.

Figure 2

The diagram below shows the cycle:



Parts of a temperature controller

Temperature controllers can differ, depending on the process being controlled. They all contain several common features, such as an input, output, and parameter.

Inputs

Temperature controllers all have inputs. The most common input sensors include thermocouples or resistive thermal devices (RTD).

The RTD is a sensor where the resistance changes as the temperature changes. So, when the resistance increases, temperature of the sensor increases. The resistance versus temperature relationship is well known and repeatable over time. A common type of RTD used is the PT100, this can come in the form of 2,3 or 4 wires to produce greater accuracy.

The other temperature sensor is a thermocouple, which is composed of two dissimilar metal wires joined together, generating a voltage proportional to the temperature difference between hot/cold.

Outputs

Controllers will have an output, which will be used to control a process, initiate an alarm or to transmit the process value to a PLC (programmable logic controller).

A relay output is the most common one. This is commonly a single pole double throw with a DC voltage coil. It operates by the controller energizing the relay coil, enabling the contacts to control an external voltage source to power the coil of a larger load.

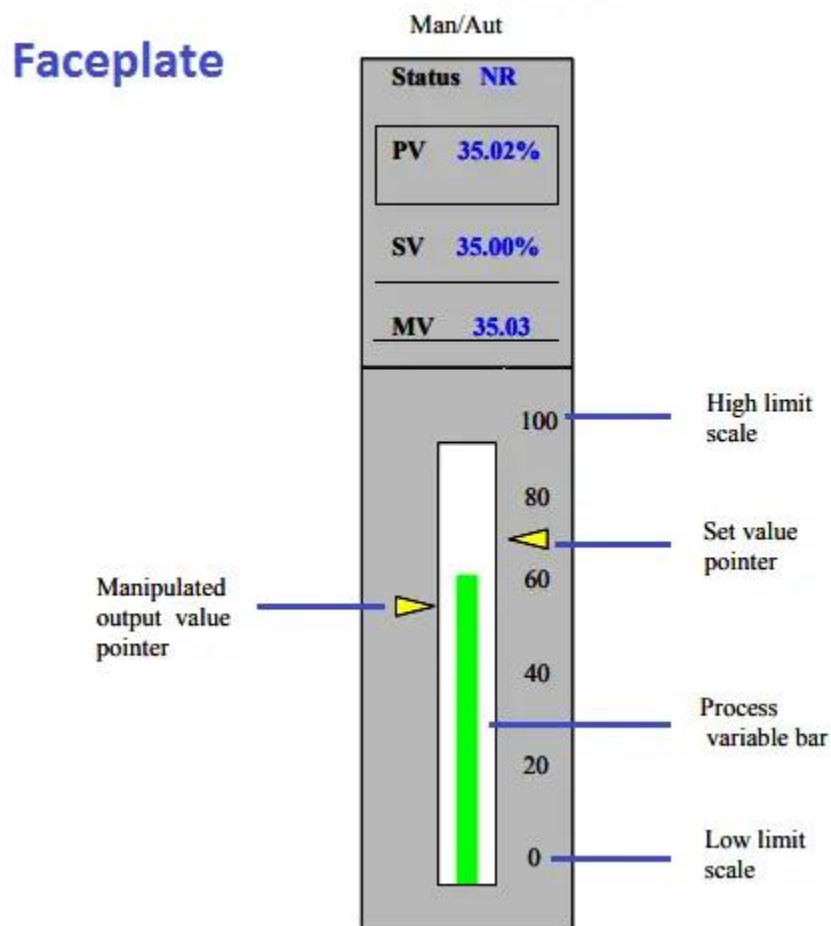
Parameters

Temperature controllers will have several parameters, one being a setpoint. A setpoint will be the target value set by the operator, which the controller aims at keeping steady.

Another common parameter is an alarm value. This will be used to indicate when the process has got to some given condition. On different types of alarms, there will be several variations. Example, for a high alarm it would show that the temperature has increased more than the set value and a low alarm will indicate the temperature has decreased below the set value.

In a TC system, the HiHi alarm will stop the heat source from damaging the components or equipment by switching off the heater or trip control valve if the temperature exceeds some setpoint value. The LoLo alarm will be set if a low temperature may potentially cause damage to components by freezing.

Figure 3



Pv = Process Variable

SV = Set Value (Set Point)

MV = Manipulated Value – Output value sent to the control valve.

Man/Auto = Manual or automatic control.

- If the operator wants to increase or decrease the PV then he would adjust the SV accordingly by entering a specific value.
- The PID controller will then use an algorithm formula to get an MV figure to send to the output (control valve).
- The PV will change due to the increase or decrease in temperature.
- This will happen continuously to keep the PV stable.
- If the operator wants to move the valve manually then he can put the control loop in manual.

Key reasons why temperature control is so important in the oil and gas industry.

Safety:

Refining processes include high temperatures and pressures. Inadequate temperature control can cause unsafe operating conditions, with the risk of equipment failure, leaks, or fires. Having temperature control in place in a system will help prevent accidents and ensure the safety of personnel and the surrounding environment.

Process efficiency:

Refining processes depend on temperature. Controlling temperatures within specific ranges helps to optimize chemical reactions, separation processes and minimize energy consumption.

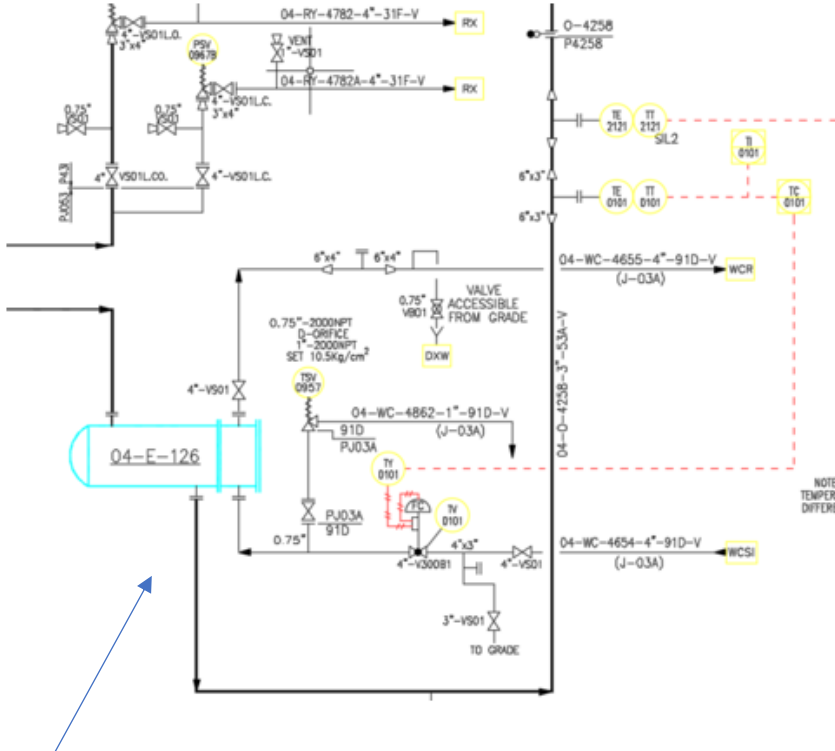
Refineries have heat exchangers in place to enable heat to be transferred between different process streams. Accurate temperature control is crucial to maximize the efficiency of the heat exchange, resulting in energy savings and an overall process optimization.

Equipment integrity:

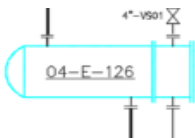
Excessive temperatures can result in wear on equipment in a system, such as pipes or exchangers. TC will extend the lifespan of equipment, decreasing maintenance costs and the likelihood of an unplanned shutdown.

TC is a crucial aspect of refinery operations. Proper system control will also help provide overall reliability within the refinery.

The consequences of not having a temperature control device in place can lead to undesirable reactions, equipment failure and safety hazards, which can pose a higher risk of accidents, harm to personnel and a significant economic loss.



This is a piping and instrumentation diagram (P&ID), demonstrating the use of temperature control. P&IDs are essential for engineers, operators and other professionals involved in design and the operation of industrial processes. It includes pipes, valves and other components, using symbols to convey information about the system's design and the operation of it.



 This symbol in the drawing represents a direct contact heat exchanger. This device is used to transfer heat from one medium to another. Both liquids undergo a change in temperature. It will include tube side fluid (cold), coming through one nozzle and shell side fluid

(hot) coming through the other surrounding the tubes. Baffles will be used to support the tubes, preventing vibration, and forcing the flow outside of the tube.



TE stands for temperature element. In this diagram, it's a thermocouple measuring temperature. Two dissimilar metals will be joined onto the end of thermocouple with both being heated, causing a continuous current that will flow in the thermoelectric circuit. When the junction of the two metals are heated/cooled a voltage is produced that can be correlated back to the temperature.



In this diagram, this symbol represents a temperature transmitter to transmit a signal for monitoring and controlling. This is usually an RTD (resistive thermal device) or in this case, it shows a thermocouple. The symbol illustrates converting an MV signal from the thermocouple into a 4-20mA signal. This signal is then transmitted to the DCS for operators to see the temperature reading.



A DCS (distributed control system) or standalone controller will control the valve by receiving inputs from the sensors, processing the given information through the controller, producing an output signal to the actuator, then adjusting the valve positioning based on the set points and the real time feedback from the process. When these components communicate, coordination and efficient control of industrial processes happens. An operator can also put a temperature control loop into 'manual' to move the valve if required.

Conclusion

I chose the topic, temperature control, as I wanted to explore why it is an important part in optimizing performance in various systems. Part of my job, (designing piping and instrumentation diagrams) without TC in place, the process could become unstable with the risk of overheating or underheating. This can all have a significant impact on the safety of personnel and causing other hazards in industrial operations.

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