



Cascade control with multiple inner loops

This white paper describes an application heating liquid in a large vat utilizing cascade control to limit the maximum temperature of the heaters. If the heaters get too hot, the liquid will degrade.

This vat uses three zones of heaters supplying heat energy to one main zone of the process, the vat. The sensor in the vat is used by the outer loop control to send setpoints to the three inner loop controls to regulate the heater power in the three inner loops.

Theory of operation and setup:

A Series 96 controller is used to regulate the vat temperature (outer loop control) with a 4-20mA output used to send a signal to the remote setpoint inputs of the three heater controllers (inner loop controller).

The three inner loop controllers will regulate the amount of heat energy added by each of the three heat zones into the process. Each inner loop Series 96 is setup to control one heater zone with operating temperature limits placed on the zone. The circulation heaters will vary temperature of the fluid entering the vat based on the output from the outer loop controller by varying the setpoints of the inner loop controllers.

System Components:

Qty Description

- 1) 96A0-FAAA-00RG controller for the outer loop.
- 3) 96A1-CAAA-00RG controller for the inner loops.
- 3) Din-a-mites DC21-60C0-0000; 65 Amp, 480 Volt, 3 Phase power switching relay
- 3) 36 KW, 480 Volt, 3 Phase circulation heaters
- 1) RTD 100 ohm platinum sensor
- 3) Type K Thermocouple

Note this is a simplified system example, the functional application would include high limit, safety shutdown circuitry for the heaters.

Implementation and connection:

Connect the RTD sensor to 96A0-FAAA-00RG controller. The Series 96 controller used in the outer loop will measure the vat temperature with an RTD. Connect a type 'K' thermocouple to each of the 96A1-CAAA-00RG. Thermocouples in the outlet of the circulation heaters will sense the temperature of the liquid exiting the heaters and send information back to the input of the inner loop controllers. This information is compared to the remote setpoint from the outer loop controller. Connect the 4-20 mA output of the 96A0-FAAA-00RG in series to all 96A1-CAAA-00RG input 2. The inner loop controls will be wired in series so all controllers see the same remote setpoint. Connect the output switched DC signal of each 96A1-CAAA-00RG to the appropriate input of relay DC21-60C0-0000. The inner loop control's DC outputs will switch power to the circulation heaters utilizing Din-a-mite solid-state power switches. Connect the circulation heaters to each of the appropriate relays. Connect fused power to the input of each relay. Connect fused power to each of the controllers.



Setup Controllers

Setup 96A1-CAAA-00RG for inner loop control

Input 1

Sen1 = tc

In 1 = K

RL 1 = 50, minimum setpoint limit for heat source

RH 1 = 210, maximum setpoint limit for heat source

Ftr1 = 0

Input 2

In 2 = 4 to 20ma (Remote setpoint)

RL 2 = 50, minimum setpoint limit for heat source

RH2 = 210, maximum setpoint limit for heat source

CAL2 = 0

Output 1

Out 1 = Heat

Global

Unit = US

C-F = *F

Err = nlat

Fail = Off

PLSP = 210

PL A = 100

PL B = 100

RP = off

OPLP = Off

Operations menu

User

A-M = Auto

Aut = Off

AtSp = 90

L-r = Remote

CAL 1 = 0

Setup 96A0-FAAA-00RG for outer loop control

Input 1

Sen1 = rtd

In 1 = 100 ohm platinum RTD

rL1 = 50, minimum setpoint limit for process

rH1 = 175, maximum setpoint limit for the process

CAL1 = 0

Ftr1 = 0

Output 1

Out 1 = Heat



Cascade control with multiple inner loops

Global

Unit = US

C-F = *F

Err = nlat

Fail = Off

PLSP = 175

PL A = 100

PL B = 100

RP = off

OPLP = Off

Operations menu

User

A-M = Auto

Aut = Off

AtSp = 90

CAL 1 = 0

Tuning the System

The inner loop controls need to be tuned first at a temperature where the heaters typically will be operated. When tuning cascade control the inner loop range high can be set a little higher and tuned for proportional operation without any integral action (reset). The integral from the outer loop will offset the setpoint to compensate for not reset action in the inner loop controls. To tune the inner loop, set the 96A1-CAAA-00RG controllers to local set point operation. Adjust the setpoint to 180 degrees. This value is selected to be where the heaters would normally operate. Adjust the Proportional band to 5 degrees. Watch the system for temperature fluctuation. If the system is not stable set the Proportional band to 10 degrees. The objective is to set the proportional band wide enough to establish stable control. If the proportional band gets too large, the system will be slow and lethargic. When the proportional band is set too narrow the heaters temperature will oscillate.

After the controls on the inner loops are tuned, set to remote control operation. Select a normally operated setpoint for the outer loop (vat), then autotune. When auto-tuning is complete, additional manual tuning may be required to improve performance.

Pid 1 for 96A1-CAAA-00RG

Tune P (proportional band only) or PD (proportional band and rate band) before tuning the outer loop. Integral (reset band) will be set to 0 making integral inactive.

Pid 1 for 96A0-FAAA-00RG

Tune PI (proportional band and reset band only) or PID (proportional band, reset band and rate band). Tune PD or PID after the inner loop zones have been tuned.

