ADVANCED INDUSTRIAL SYSTEMS, INC.

Applications Note 504
PID Control

Q: What is PID control and how does it work?

Answer: PID Control refers to Proportional, Integral, and Derivative. It is basically an algorithm that controls both phases of process control, start-up and static.

Alternate control techniques include on-off, and proportional.

We will explain on-off first. It is very basic, if the temperature is too cold, it turns the heat on until the temperature is warm enough. Adding Hysterisis causes the heat to stay on until the set-point is exceeded by some amount. Thus at a setpoint of 100, heat would turn on at 100 but might not turn off until 105 (5° Hysterisis). This helps the system avoid cycling continuously. With on-off control the heat is on full-blast when it is on, and off completely when it is off.

Another way to control is with **P** (proportional) only. Here we measure how far from setpoint we are, and turn the heat on proportionally to the distance from set-point. We determine how much to turn on using the Proportional Band. Thus if the Proportional band is 10°, at 10° below setpoint the heat would be on 100%, at 5° below setpoint it would be on 50%, and at setpoint it would be off. The idea behind **P** control is to adjust the heat so that it maintains the desired temperature as closely as possible. (With on-off the temperature will continuously go up and down.)

Of course with only **P** control, you will always have an error. If we could somehow accumulate the error, we could modify the **P** control a little to add some heat if it was consistently too cool, or take some heat away if it was consistently too hot we would have a lot better control. We do this with the **I** term. We sum all of the errors, and then add a little heat, or subtract some depending on what we need to get the process right on target. Thus if we were supplying 50% heat and the process was a little too cool, we would add up the errors, adding a little bit of heat each cycle until the heat was just right to cause the process to be exactly at setpoint. Maybe we need 55% heat, so we would add a little to the **I** term each cycle, until we got to 55%. The **I** term is forced to be zero outside the proportional band to avoid what is called reset wind-up (wind-up refers to the **I** getting so big at start-up that it would take a very long time to settle out to set-point).

D is a rate control. **D** looks at the change in error as you approach the set-point. If the heater is heating too fast, the process will zoom right through set-point an overshoot badly. By setting up **D**, we look at how fast we are approaching set-point, and cut back the heat if we are approaching too fast. The idea is to minimize the overshoot at start-up. **D** does almost nothing once the process has settled out.

Add up the **P**+**I**+**D** and you have **PID** loop control. This is the actual equation:

$$\mathrm{Out} = \mathrm{Kp}(\mathrm{Error} + \mathrm{Ki}\int(\mathrm{error})dt + \mathrm{Kd} \times {}^{\mathrm{dError}}\!/_{\mathrm{dt}})$$

Now you see why **PID** controllers do not turn off once the process reaches set-point. They try to supply just the right amount of heat to maintain the process at the correct temperature.

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