Presenting Intelligent Iterative Control: PID Replacement for Setpoint Control

New approach makes better use of digital controls

Editor's note: This is the first part in a three-part series.

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In a December 2001 article,[1] a new network control approach that can be used in place of PID control for the operation of much of the equipment that constitutes a building's HVAC system was introduced. Called "demand-based control," it avoids the extra energy requirements, control-stability problems, and frequent repositioning of PID control. Furthermore, it is simpler to apply because it provides stable, optimized control in a single step, while PID control requires two separate steps: (1) setting up a control loop to maintain a setpoint and (2) continuously adjusting the setpoint to optimize operation.

Using the equal-marginal-performance principle, the 2001 article showed that demand-based control enables stable, optimized control of building-comfort-system components in a single step and does not require any of the energy-wasting design rules that PID control does. That is why energy costs with demand-based control are 30 to 50 percent lower than they are with PID control.

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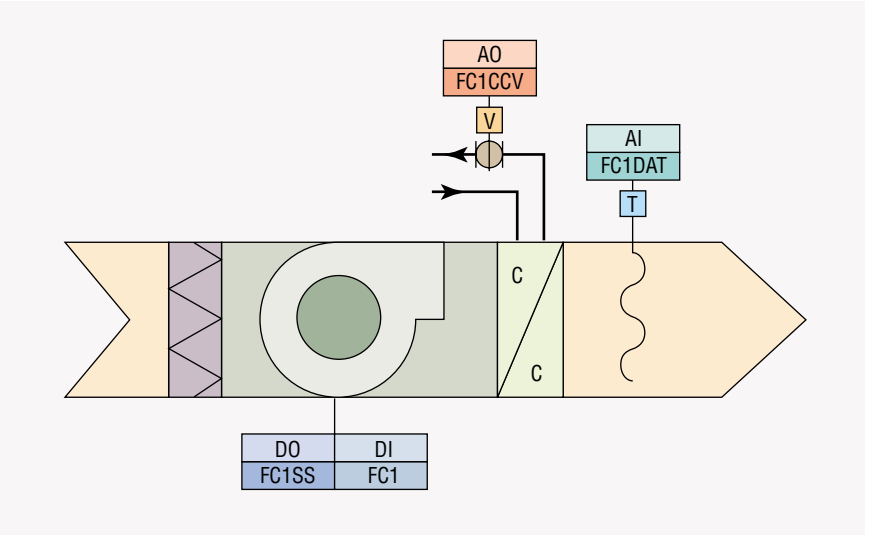

FIGURE 1. A simple cooling-only fan coil.

However, demand-based control typically uses direct power relationships, rather than temperature and pressure setpoints, to control equipment. In some instances, temperature- or pressure-setpoint control is required to achieve effective HVAC-system operation. Some consider this to be a reason to continue using PID control. But with the availability of digital network controls, there is a far more efficient and effective alternative.

REPLACING PID CONTROL WITH INTELLIGENT ITERATIVE CONTROL

When temperature- or pressure-setpoint control is necessary, designers should consider new approaches that make better use of modern networked digital controls before relying on PID control. As indicated earlier, the use of PID control usually wastes energy by requiring 25 percent to more than 90 percent of the fluid total dynamic head to be dissipated through the control valve under various operating conditions. This makes the power requirements of the system far greater than should be necessary to distribute air or water to the loads served. Furthermore, a number of other factors in modern HVAC systems, including the application of optimization setpoint reset, cause PID control loops to be non-proportional much of the time. This requires modulation readjustments at short intervals, which reduce equipment life and add to maintenance costs.

For applications requiring temperature- or pressure-setpoint control, a new approach called "intelligent iterative control" can avoid these PID pitfalls, providing more efficient and stable systems with longer-lasting devices requiring less maintenance. Intelligent iterative control is a method of control based on the iterative problem-solving techniques used by computers since the beginning of digital processing. To show how an intelligent-iterative-control procedure can be developed to operate more efficiently and effectively than PID control in a temperature-setpoint-control appli-

cation, consider the simple cooling-only fan coil depicted in Figure 1.

The fan coil in Figure 1 serves a space the temperature of which is monitored with a space-temperature sensor. To ensure even comfort, control of the fan coil involves maintenance of a discharge-air-temperature setpoint in response to space-temperature conditions. The control we are interested in for this discussion is that of the cooling coil in maintaining a specific fan-coil discharge-air-temperature setpoint.

If conventional PID control were to be used, the designer would face several problems. First, conventions dictate that the cooling-coil control valve be sized for a substantial pressure drop at full flow (the ASHRAE 2000 HVAC Systems and Equipment Handbook recommends the pressure drop across the valve at full flow be 25 to 50 percent of the total pressure drop of the chilled-water distribution network). This radical undersizing of control valves adds dramatically to pump size and cost and, just as troublesome, long-term pumping-energy cost. Also, to maintain stable PID control, the valve may have to be repositioned every several seconds, reducing its life and adding to maintenance costs.

These problems can be avoided by using an iterative-control technique that marshals the computing and networking capacity of modern DDC systems more effectively. Instead of PID control, imagine the incorporation of line-sized and full-ported control valves on all of the fan coils in an effort to reduce pump size and the pumping-energy requirements of the chilled-water distribution system. We then could adjust pump speed using demand-based control and the valve-orifice-area method outlined in my August 2002 column.[2] That approach would reduce the pumping power from fixed pressure-setpoint control. The question then becomes how can line-sized valves be operated to provide stable and precise control to maintain the fan-coil discharge-air-temperature setpoint.

Next month, Part 2 in this series will discuss the implementation of an intelligent-iterative-control algorithm.

REFERENCES

1) Hartman, T. (2001, December). Ultra-efficient cooling with demand-based control. *HPAC Engineering*, pp. 29-32, 34, 35.

2) Hartman, T. (2002, August). Out with the old, in with the new. *HPAC Engineering*, pp. 9, 11.

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