ΔT Balancing is Easier and Better

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Some time back we carried a series on *Control Nuggets* by Amrish Chopra in the *Journal*. We begin a series on *Hydronic Nuggets* by the same author in this issue – ***Technical Editor***

Legacies are good, but not always. The concept of flow balancing has continued from the days of constant flow systems, whereas for energy conservation reasons, most of present day HVAC systems have switched over to variable flow. Variable flow systems require no balancing; the requirement is to limit the maximum flow through each circuit.

In HVAC systems, load is never constant, and therefore, some control device is required to regulate the flow through the heat exchanger or cooling/heating coil. The control device, generally, is a control valve connected to space conditions sensor.

Figure 1 shows the schematic of a single circuit constant flow system. In such a system, the pump operates at constant speed and delivers a fixed rate of water flow. Based on load conditions, the control valve regulates water flow through the coil, permitting the balance water to flow through the bypass line. The temperature difference (ΔT) across the circuit keeps changing as per load conditions.

In a multi-circuit system, as shown in *Figure 2*, pressure gradients develop across water lines due to frictional resistance to flow, and equipment located close to the pump may experience more pressure differential across it. More water than design flow may flow through such equipment, starving some other equipment, unless checked. A balancing valve is often used in such a system, as shown in *Figure 3*, to provide localized resistance to even out the water line pressure gradients.

The important point to note is that in constant flow systems, the control valve regulates the flow through the coil only, whereas the balancing valve regulates the flow through the complete circuit, which includes the coil as well as the bypass line.

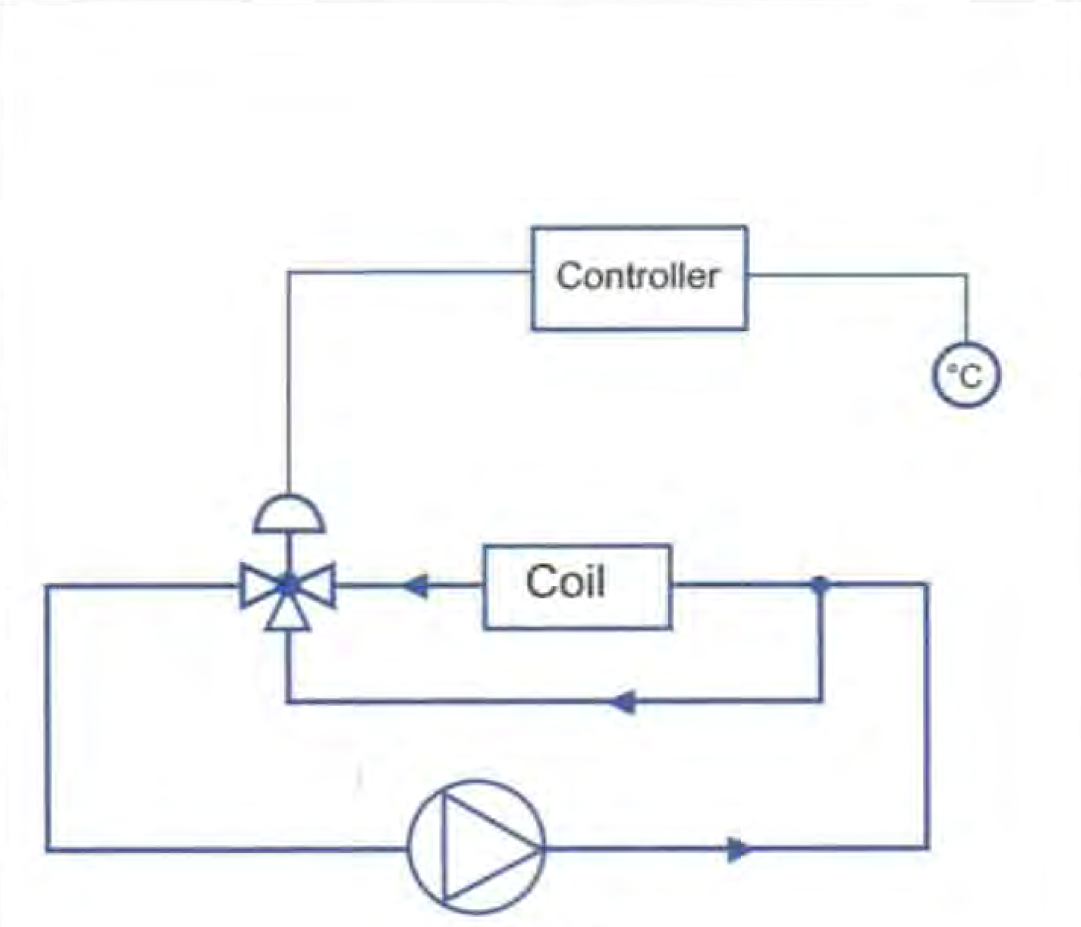

Figure 1

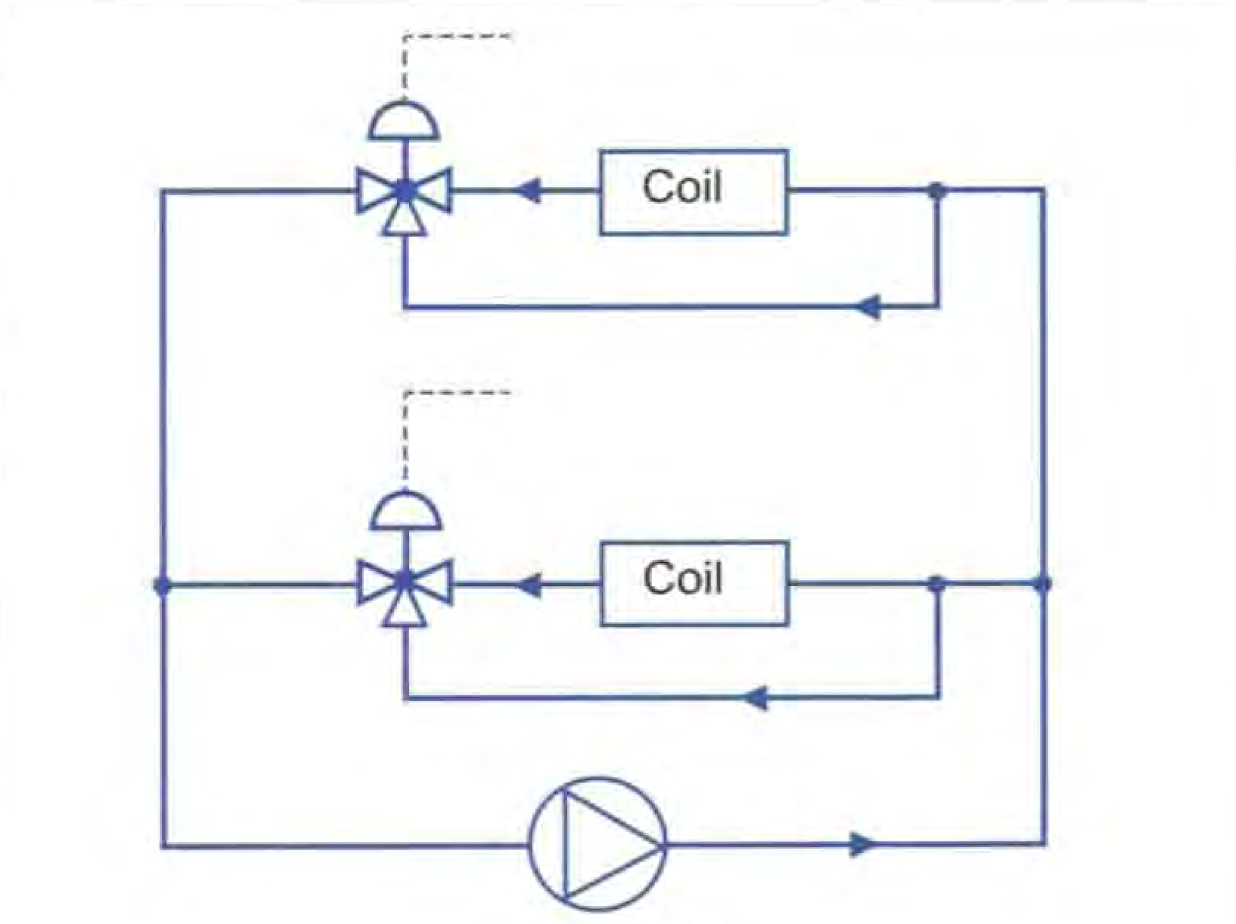

Figure 2

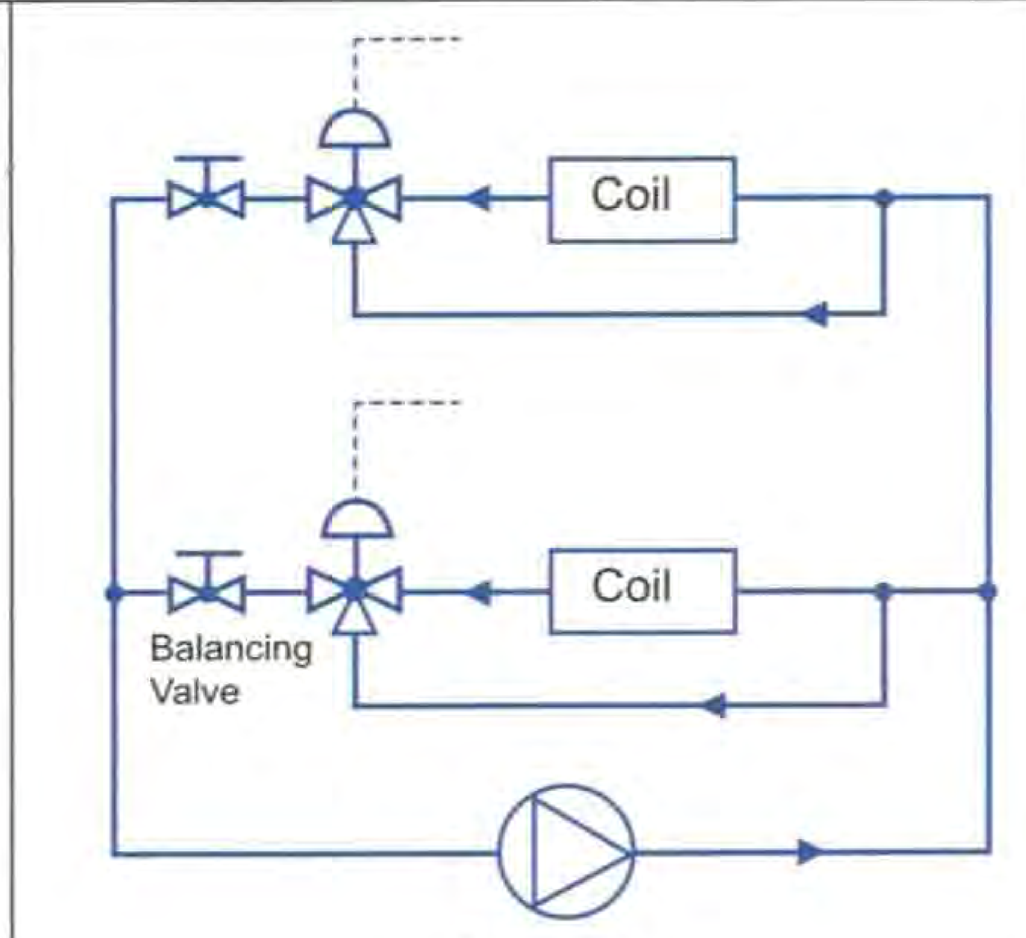

Figure 3

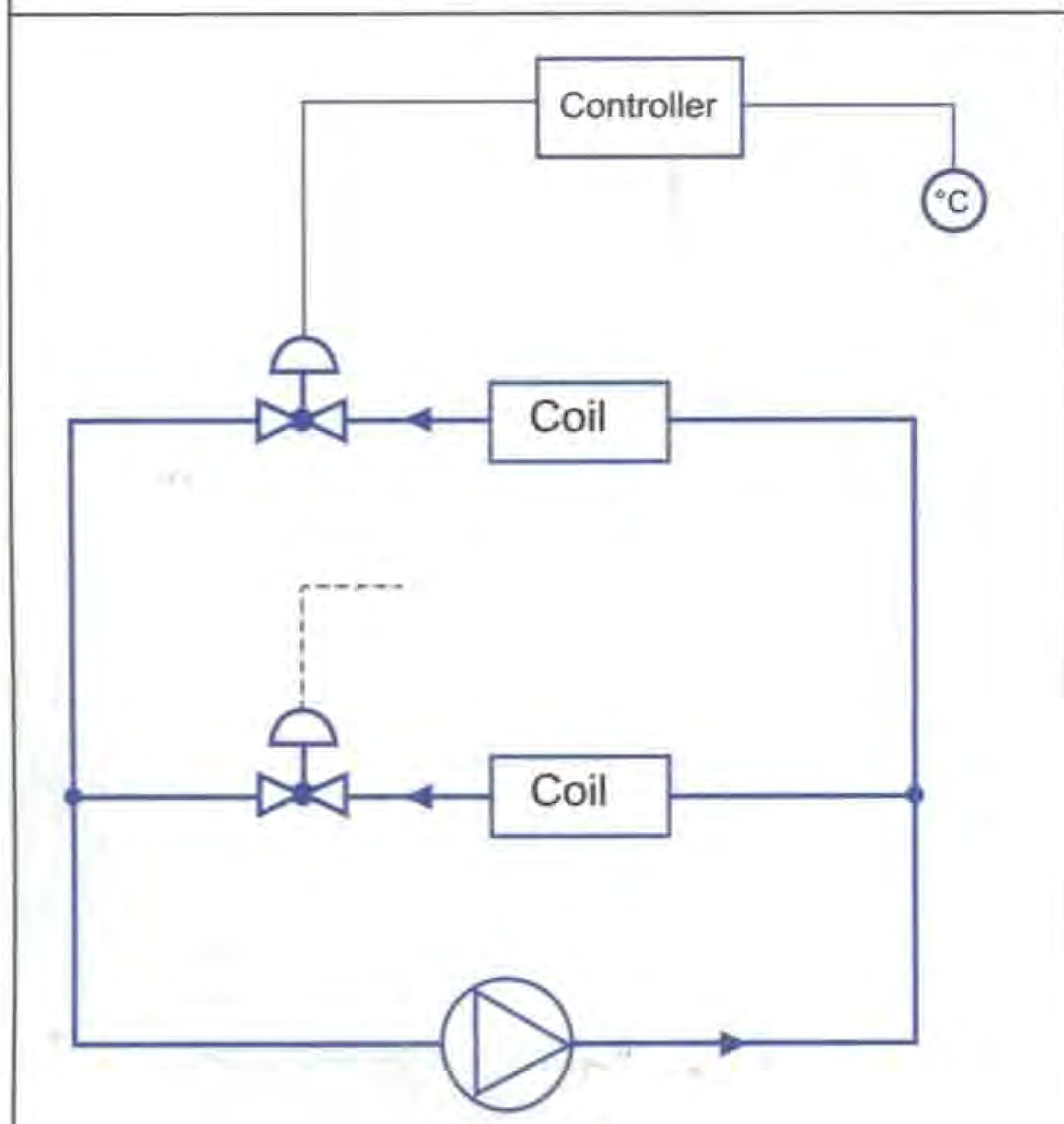

Figure 4

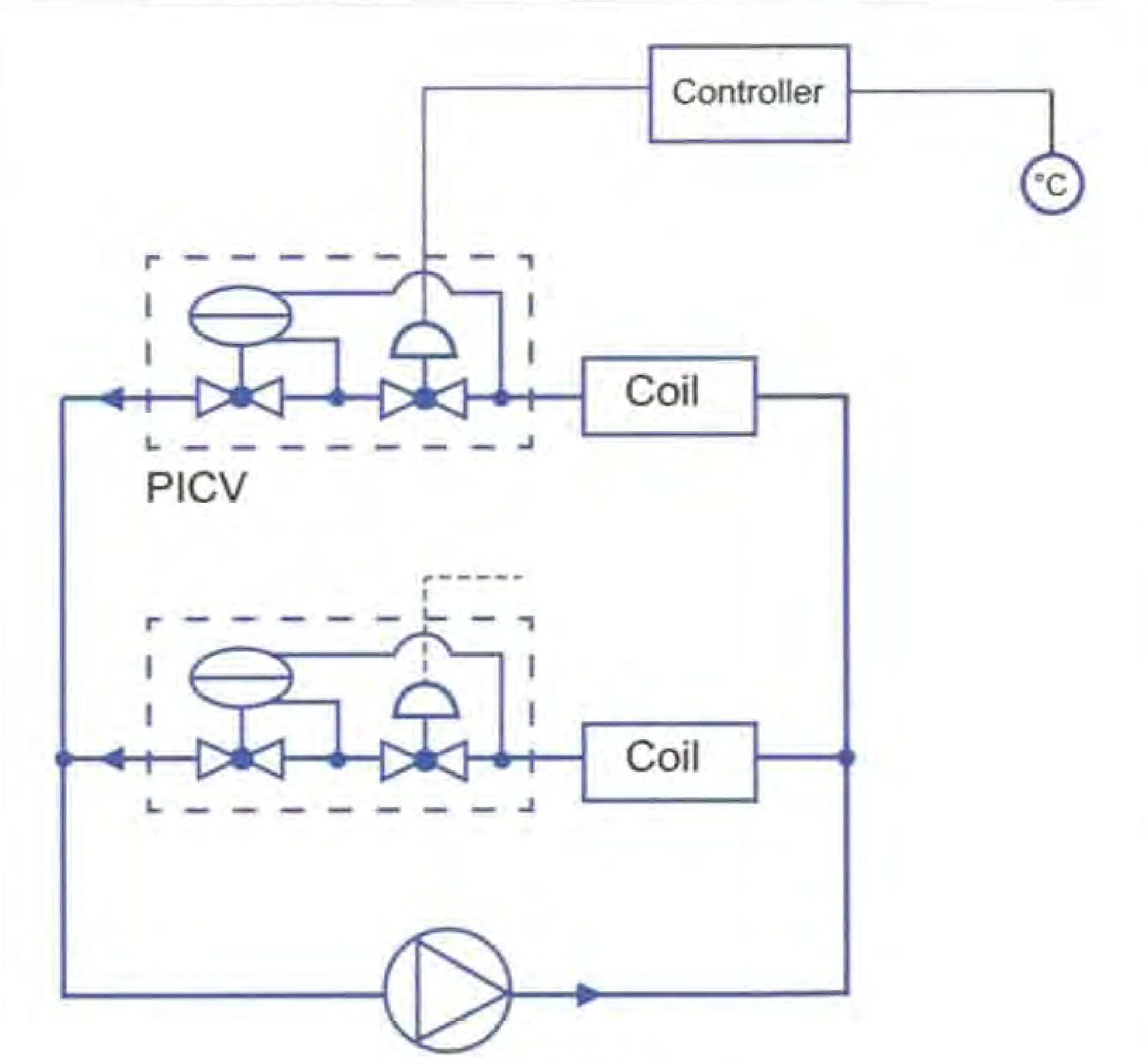

Figure 5

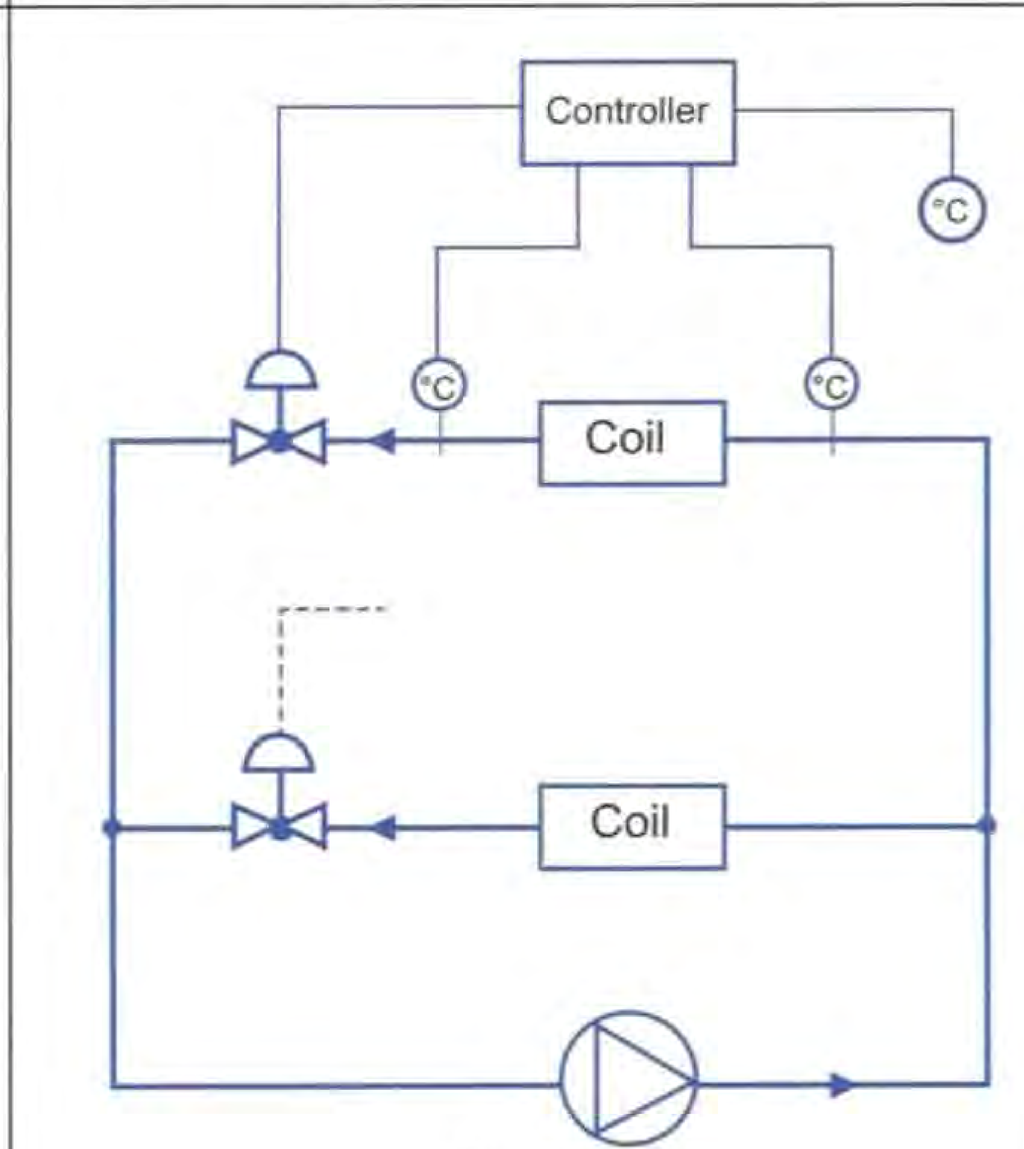

Figure 6

Figure 4 shows a multi-circuit variable flow system. In such a system, the total water flow is varied as per load, by either varying the pump speed or by providing a bypass across it. There being no bypass line across the coil, the control valve now regulates the water through coil as well as through the circuit, and under normal conditions it will allow only as much water to flow through the circuit as demanded by the space conditions sensor. It will not permit excessive water flow irrespective of the pressure differential across the circuit.

However, there is a glitch; the control valve may allow more than the design flow through a circuit with high pressure differential across, at high load condition, when the space sensor may demand the valve to be fully open. Thus, some arrangement is required to limit the maximum flow through a circuit when the load is high.

Pressure independent control valves (PICV) with circuit-setters tend to overcome this by limiting the stroke of the control orifice. This prevents the control orifice from opening beyond a certain limit even when the signal from the space conditions controller is at the maximum, thus limiting the maximum flow through the circuit. In order to have a reliable relationship between the opening of the control orifice and flow rate through it, the pressure drop across it is maintained at a near constant value by adding another orifice in series controlled by the pressure differential, as in *Figure 5*. These valves use a spring to balance the pressure differential, increasing pump head and power consumption.

Flow rate is difficult to measure and flow control devices are generally delicate and susceptible to poor quality of water, whereas temperature measurement is easy and sensors are more accurate, rugged and economical. It makes more sense to look at the option of limiting the maximum flow rate through a heat exchanger using temperature measurement.

The heat transfer equation used for heat-exchanger/coil design is

H = K.Q. ΔT

H = Rate of heat transfer

K = Constant representing heat exchanger design and heat transfer fluid parameters

Q = Fluid flow rate

ΔT = Change in fluid temperature across heat exchanger

Thus, for a known heat transfer rate, the fluid flow rate and change in its temperature are inversely related. Increase in fluid flow rate reduces the change in temperature and *vice-versa*. This property could easily be used to limit the maximum flow rate through a heat exchanger.

Figure 6 shows a control schematic wherein two temperature sensors, one at the inlet and the other at the outlet of coil, are connected to a controller. The space conditions sensor is also connected to the same controller. This controller normally operates the control valve under the dictates of the space sensor but under high load conditions, like at start-up or due to sudden increase in load, when space conditions sensor is likely to ask for valve to be full open, if temperature differential (ΔT) across coil drops below the design/set value, the controller over-rides the space sensor demand and starts operating the control valve based on ΔT signal.

In simple words, the controller shown in *Figure 6* is a combination of two controllers and a signal selector. One controller monitors the space conditions and outputs a signal based on deviation from its set-point, while the other controller monitors the temperature differential (ΔT) across the coil and outputs a signal based on deviation from its set-point. The signal selector compares these two signals and passes on the lower-of-the-two to the control valve.

This arrangement limits the maximum flow through each circuit to the heat exchanger's/coil's design flow value, the other advantages being:

- Use of only one control valve makes it less expensive and easier to maintain.
- Measurement of temperature is more accurate and less expensive.
- Addition of temperature sensors does not add to pump head requirement.
- Continuous monitoring of ΔT across each coil prevents low ΔT syndrome at chillers, resulting in better operating efficiency. ❖