Integrated Damper and Pressure Reset for VAV Supply Air Fan Control

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In a VAV system, total supply airflow rate decreases as the building load decreases until the airflow reaches the minimum value. To ensure adequate airflow under all load conditions, the supply air fan is often required to provide enough static pressure in a pre-selected duct location. When the duct static pressure is not satisfied, the control system can modulate the volume control device such as a variable frequency drive (VFD) on the fan motor to maintain the static pressure at its set point.

The duct static pressure sensor is typically located two-thirds of the way downstream in the main trunk of the supply air duct. Although this old rule of thumb is no longer recommended by ASHRAE (ASHRAE 1999), it is quite common in many existing systems. The fan usually maintains a constant static pressure set point. The set point is selected such that it provides enough static to terminal VAV boxes under design full load conditions. Under partial load conditions, the static pressure required at the terminal VAV boxes may be far less than this set point. Maintaining a constant static pressure not only wastes fan power, but can also produce unacceptable noises at some terminal VAV boxes due to excessive air-flow throttling by the volume control dampers.

To improve partial load operations, static pressure can be decreased to save fan power and decrease noise. A popular method is to reset the static pressure set point as a function of the outside air temperature. This is reasonably accurate in envelope-dominated buildings (i.e., buildings with large ratios of exterior zones). Other methods reset the static pressure based on total supply airflow rate or supply air fan speed, since they are also indicators of the building load. The selection of the reset schedule depends

on a number of factors, such as internal load, envelope, and occupancy schedule. Expert judgment is required to set up the reset schedule. Due to the complex nature of building systems, even those experts are very conservative in setting up the reset schedules.

The terminal regulated air volume (TRAV) control method integrates terminal box operation with supply air fan control. The TRAV controls the supply fan based on real-time terminal box airflow requirements (often calculated by the DDC controller) rather than meeting a duct static pressure set point. When the AHU and terminal boxes are flawless, it minimizes fan power consumption, similar control algorithms have been proposed by various researchers. One proposed control algorithm used primary airflow error signals from one or more zones to modulate the static pressure or fan speed. A control strategy was presented that resets the fan static pressure set point based on terminal box flow requirements. The reset signal increases if a sufficient number of zones are in low airflow alarm. The reset signal decreases if all the zones are satisfied. These methods are similar to TRAV in nature. Their successful implementation depends on the accuracy of terminal VAV box airflow sensors. However, bad airflow readings exist. Due to poor installation and/or lack of calibration, it is not uncommon to find VAV box airflow sensors that are installed at duct elbows, or wrong conversion coefficients are used in the controller to derive the airflow rate. When one or more airflow sensors fail and read no flow or very low flow (i.e., lower than the minimum flow requirement), the supply air fan could be commanded to full speed in order to meet the calculated airflow requirements, even under low load conditions. Therefore, care must be taken in implementing this type of control strategy; otherwise, the system operation could be unpredictable.

For some hybrid systems, the DDC system only has individual zone space temperature input information and actuators at the terminal VAV boxes are pneumatic controlled. These boxes interface with the DDC system through EP (electric to pneumatic) transducers. Since the DDC system does not have information on airflows at the box level, the above mentioned control strategies are not applicable. Therefore, an alternative or improvements for these control strategies are needed.

An improved control strategy can be used with full DDC system and hybrid system. To simplify, it is assumed that the VAV system is equipped with a VFD. In order to provide building comfort with low fan power consumption, the fan speed can be modulated based on the maximum VAV box damper position (damper control output signal), combined with a pre-defined static pressure reset schedule. This method is called the integrated damper and pressure reset (IDPR) method. It requires modulating the fan speed to maintain the maximum VAV box damper position at 95% (adjustable) open, as long as the static pressure is maintained below the calculated set point based on a reset schedule.