Leveraging the Power of Intelligent Motor Control to Maximize HVAC System Efficiency

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Most HVAC systems, particularly those more than five years old, employ constant volume air handling units (AHU) that use simple on/off controls. In these spaces, air handling units are positioned in different zones. The building automation system monitors the temperature in these zones via sensors and turns the fan on or off as needed. With a constant volume air design, the HVAC system operates with the fan supplying air to the conditioned space at a flow rate designed to accommodate space heating and cooling requirements at 100 percent design loads. This does not take into consideration that most buildings typically operate at full load less than five percent of the time.

Since the supply of air is constant, fan horsepower – and therefore fan energy use – remains constant regardless of the load on the heating and air conditioning system. Using dampers to mechanically adjust the air flow output into the appropriate rooms does not save energy since the fan still is running at full power, regardless of damper position. With fans often operating 18 or more hours per day in many applications, fan energy requirements are a major component in a facility's energy costs.

Constant to Variable

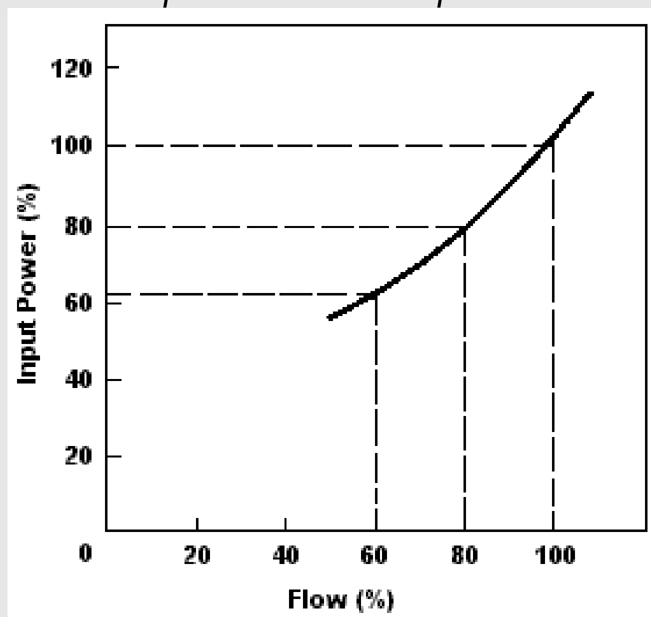
While most buildings use a variety of simple controls to manage HVAC systems, many facility managers have yet to take advantage of new control upgrade options capable of wringing more savings out of facility operations. Getting the most out of controls requires building systems that are capable of adjustment, such as the case with variable air volume systems. Variable air volume systems are designed to regulate the volume of air delivered to individual zones in proportion to the zone's current cooling or heating load.

In recent years, significant improvements have been made in energy-saving technology that allows building owners to convert constant volume HVAC systems to variable air volume (VAV) control without changes to the existing mechanical or building automation control system. These retrofit packages offer two core advantages. First, space temperatures can be controlled within acceptable limits over widely varying internal and external heat gains caused by factors like weather conditions or exposure to the sun. Second – and most importantly – energy consumption is reduced.

VAV systems regulate the air flow to conditioned spaces based on the facility's heating and cooling requirements. As heating and cooling loads drop off, the fan system decreases the quantity of air being supplied to the facility. Since the amount of energy required by the fan system is proportional to the air flow, and most buildings spend the majority of their operating hours at loads that range between 40 and 70 percent of their full load capacity, VAV systems can significantly reduce fan energy requirements.

As a rule, energy consumption in centrifugal loads, such as fans in an HVAC application, vary by the cube of the fan motor's speed. For example, if the speed of a fan's motor can be decreased by 20 percent, the energy used to power the motor is reduced by approximately 50 percent. In applications involving centrifugal loads, variable frequency drives can deliver significant energy savings when the HVAC system requires less than 100 percent usage.

Variable Speed - Power Requirements



As the fan speed is reduced, a significant reduction in power requirement is achieved

Energy-Saving Package

Converting a constant flow HVAC system to a VAV system used to be a complex and costly task. Today that's no longer the case due to the availability of new standalone energy-saving upgrade packages. These integrated control solutions are designed to deliver more energy savings at a fraction of the cost when compared to a traditional hardware retrofit conversion.

Designed for easy installation as part of a self-contained unit, the core energy-saving package includes temperature and carbon dioxide sensors, a microcontroller, a high-performance variable speed drive and a touch-screen operator interface. For many operations, this means the upgrade package can pay for itself in energy savings in a relatively short period of time, often in less than a year. The drive can adjust fan speeds in response to heating or cooling needs, and limit peak electrical demand.

On a constant volume air handler, fan speed is controlled through a contactor, resulting in the fan being either on or off. The building automation system provides the contact circuit that energizes a contactor and starts the fan. In most systems, the fan remains on most of the time and consumes 100 percent of the available electric current and energy needed to rotate the fan at full speed, even if only a small change in air temperature is needed.

With a VAV upgrade solution, temperature and carbon dioxide sensors are wired directly into the microcontroller. Based on sensor feedback, the microcontroller will tell the drive to speed up, slow down or turn a fan on or off. This eliminates the need to reprogram or make any changes to the existing building automation system, helping to simplify the conversion process and minimize engineering costs.

The energy-saving solution distributes heating and cooling BTUs in the same proportion as the original system design, using less fan energy. Using sensors tied to the controller, the system will adjust the speed of the supply fan, the return fan or both. This allows the HVAC system to minimize fan speed and energy use to reflect the actual amount of air flow required for the desired temperature change.

Simply put, when a minimal amount of heat or air conditioning is needed, the system minimizes the speed of the fan and energy use. Conversely, when a large amount of heat or air conditioning is needed, the system increases the speed of the fan to accommodate the need for heating or cooling transfer.

As with temperature control, ideal HVAC design provides sufficient fresh air to deal with the worst-case scenario, assuming full occupancy in a zone all the time. By using sensors to measure carbon dioxide in the return air, the energy-saving package adjusts the outside air flow to accommodate the estimated number of occupants. Reducing outside air intake means less cooling, heating, dehumidification and exhaust fan speed, thus saving energy several ways.

Reaping the Rewards

Some of the latest upgrade packages provide quantitative data that make it easier for users to calculate approximate energy savings and determine the potential payback. For example, the FanMaster™ Energy Saving Package from Rockwell Automation® offers a Web-based energy savings calculator that shows users their application-specific energy savings before they actually purchase the package.

In one application involving a leading food manufacturer, an energy saving package was installed, and potential savings were calculated over a period of 382 hours, or just under 16 days. The system calculated a total energy savings of $311.45 during the period. This total included an estimated $73.46 in savings associated with carbon dioxide demand ventilation.

During the trial operation period, fan speed reductions of 35, 45, 55 and 100 percent were verified and extrapolated to an annual fan speed reduction of 58.5 percent. This fan speed reduction equates to a potential yearly savings of more than $7,000 based on $0.05/kwh. Adding to the potential payback is the fact the manufacturer could achieve these savings without incurring the expense of having to modify the facility's existing controls or mechanical system.

The payback period of a VAV upgrade package can be as fast as 12 months or less. The period depends largely on the type and size of the system, and how much time the motor is operating at full speed versus how much flow is required to heat or cool the building. The life cycle of HVAC equipment in commercial buildings is typically 15 to 20 years, so a one- or two-year payback period can generate a substantial savings over time.

Converting to a VAV system helps save money, increase the comfort of the building occupants and reduce equipment maintenance costs and downtime. The system contributes to the building's overall comfort level by optimizing and regulating air flow and temperature into the building's occupant space. These benefits extend beyond occupant comfort levels and encompass other building spaces that may need regulated temperature control, such as warehouse storage areas and clean rooms. Unlike a fan that runs either full speed or off, a variable speed drive can run at all speeds in between, allowing facilities managers and building occupants more control to adjust the temperature.

In addition, the variable speed drives help reduce the long-term wear and tear on equipment. The drives provide a soft start instead of slamming motors on at full speed – so HVAC systems last longer, with less maintenance and fewer instances of unscheduled downtime.

As economic and competitive demands put increased pressure on organizations to aggressively find ways to reduce costs, effective energy management is no longer an option; it's a strategic business necessity. Advancements in energy-saving solutions that comprise intelligent motor control technology help building owners and managers take control of their energy costs and protect themselves from the fluctuations and uncertainties of the power market.

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