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Annual performance monitoring of a demand controlled ventilation system in a university library

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Abstract

Demand controlled ventilation (DCV) is an important opportunity to reduce energy requirement especially in presence of variable occupancy. An evaluation of the possible amount of the energy savings consequent this more flexible control strategy are here presented in a real application case. This refers to the case of an ancient building in Venice. A part of this building was recently transformed in a modern university library. By recording all the measured data from the supervisory system an analysis of the annual performance of the DCV system was carried on. The investigation has pointed out the possibility of remarkable energy savings without compromising internal comfort conditions.

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Keywords: demand control ventilation; smart building, energy saving, annual monitoring.

1. Introduction

Modern energy regulations have strongly reduced the heat losses of the building envelope by imposing high thermal insulation performances for the opaque surfaces and the windows. To obtain a further significant reduction of the energy requirement of the building now it is fundamental a major attention devoted to minimize the energy consumption due to ventilation also considering the general trend to increase the design air change rate for comfort exigencies. Demand controlled ventilation (DCV) is a control strategy of the ventilation rate which results recently

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very attracting as applicable to traditional plants also in the case of retrofit and therefore studied for many possible application cases [1]. DCV is highly suitable of those places where occupancy rate shows higher fluctuation such as office, meeting room, break room, school, sport facility. However its installation results more simple and cost profitable in presence of great open spaces rather than in buildings subdivided in small rooms because a fine-grained occupancy information is required in this second eventuality [2, 3].

The number of presences can be assessed in real-time indirectly by monitoring indoor CO_2 concentration variations as in buildings the occupants are normally the major source of carbon dioxide. In several guidelines and standard therefore CO_2 concentration is considered as an air quality indicator to control the outdoor ventilation rate in order to maintain reasonable IAQ without resulting an excessive energy consumption. CO_2-based DCV is most likely to be cost-effective when there are unpredictable variations in occupancy and a climate where heating and air conditioning are required for most of the year. CO_2 sensors can provide a correct average measurement if installed in the main return ducts. They can be connected to programmable controllers of dampers and inverter devices which feed the electric motors of the fans in order to modulate the speed and consequently also the air flow rate.

The real amount of the energy savings is however strong dependent from the particular application case. The occupancy profile and the characteristics of building and HVAC system deeply influence the final performance. In addition fundamental are the settings chosen for the modulating devices and their controller. An ideal control approach should keep indoor CO_2 concentration as close as possible to the CO_2 set point during occupied periods.

Different control algorithms can be adopted among which proportional and exponential controls are the most discussed and popular ones. Both approaches modulate the ventilation between a lower set point of indoor CO_2 and an upper set point that individuate the equilibrium concentration of CO_2 corresponding to the design ventilation rate. Exponential control is able to adjust ventilation rate more quickly to changes in CO_2 concentration by using a standard proportional-integral (PI) or proportional-integral-derivative (PID) control algorithm. However the potential energy saving is affected by the factor how fast the actual design ventilation rate achieves the ventilation required for the actual occupancy in the space. In practice, the design ventilation rate is calculated based on the assumption of a CO_2 steady state condition. But actual occupant density is frequently more variable than the action of the control speed and therefore it is possible to assist to wide oscillations of the CO_2 concentration in the rooms.

In this paper an analysis of the annual performance of a CO_2 based -DCV system is presented in comparison with a corresponding constant air volume (CAV) system in the case of a university library. The aims of this analysis were to measure the energy saving in a precise context and in addition to verify the ability to achieve the level of comfort required.

The study is based on the experimental data provided by the building management system (BMS) which also records the information necessary for energy and comfort control. DCV system adopts a typical PID algorithm rather than one of the new and more sophisticated controllers recently proposed. But the continuous monitoring of the DCV working have permitted to verify the validity of the values established for the PID parameters and optimized for this particular case study.

Nomenclature

n	actual rotor speed (rpm)
n_0	asynchronous speed (1500 rpm)
f	line frequency (Hz)
p	number of poles (4)
s	slip (-)
$\dot{V}$	air flow rate (m^3/h)
$\dot{V}_{nom}$	nominal air flow rate (m^3/h)