VENTI: experimental controller for inline duct fan

Paulo Abreu, Tiago Andrade, Rafael Tavares,
Fernando Carneiro, Maria Teresa Restivo
LAETA-INEGI, Faculty of Engineering, University of Porto,
Porto, Portugal
pabreu@fe.up.pt, tandrade@inegi.up.pt,
rtavares@inegi.up.pt, fcarneiro@inegi.up.pt,
trestivo@fe.up.pt

Vasco Peixoto de Freitas
Faculty of Engineering, University of Porto,
Porto, Portugal
vpfreita@fe.up.pt

Abstract—This demo exemplifies the use of a special built controller for an inline duct fan. This controller uses the temperature and humidity data, from the interior and exterior environment to implement programmable control strategies based on differential vapor pressure. The controller is able to operate the fan with variable velocity. The data from the sensors and the implemented control action are stored in a database so that it can be remotely accessed through the internet. This controller is an experimental platform to support current studies on demand-controlled ventilation and on control strategies with impact on indoor air quality and comfort.

Keywords—temperature and humidity remote monitoring, demanded controlled ventilation; indoor air quality;

I. INTRODUCTION

Mechanical ventilators are widely used for controlling the air quality of indoor spaces. Many ventilation systems are designed to provide a minimum level of outdoor air based on the expected occupancy of the interior space, on a base of a per-person ventilation requirement, as referred in standards such as ASHRAE 62 [1]. In other situations, ventilation systems are also controlled based on measured parameters of the indoor air, such as the temperature, humidity, VOCs, CO2, or even just based on a planned time frame [2, 3, 4]. For indoor spaces, in particular confined spaces in houses, where for multiple reasons, it is present a high level of humidity, with the consequent existence of mold, the use of ventilators can be though as an alternative to the use of dehumidifiers. In this situation, the external air is ventilated into the indoor environment. To be effective this process, it is necessary to consider the temperature and relative humidity of the external air. It would not be suitable to ventilate the indoor space when the relative humidity of the external air is higher than the internal air, if the air temperature inside and outside would be the same. This points to use the data from the differential vapor pressure to control the ventilation with a view to reduce the risk of water vapor condensation and mold prevention. In the field of greenhouses, the use of ventilation control, based on vapor pressure deficit, with a focus on improving plants growth has also been reported [5, 6].

Having this approach in mind, it was developed a system to control an inline duct fan to test and explore the use of different control strategies based on vapor pressure measurements. This controller is intended to be used with low-power ventilation fans that are common found in homes, used in spaces like bathrooms, kitchens or attics. As a research tool, the controller provides a monitoring software to be possible to register in a database the temperature and relative humidity data, as well as the used control action to adjust the velocity of the fan. Ease of Use

II. DEVELOPMENT OF CONTROL SYSTEM: VENTI

VENTi is a system for velocity control of in-line mixed flow duct fan, based on temperature and relative humidity measured both at indoor and outdoor, coupled with a monitoring software. VENTi (Figure 1) makes use of the following main components:

- Controller: embedded electronic based on Microchip and ATMEL microcontrollers responsible for sensor communication, controller implementation and USB computer interface;
- AC Phase Control Driver that enables the duct fan velocity control;
- Sensor units: two sensor units for temperature and relative humidity measurement to be placed in the indoor space and in the outdoor environment, from Bosch (BME280);
- Software Application: a Windows application to configure control mode, control parameters, data visualization and storage into a SQLite database. The use of a PC based application enables remote monitoring of the system.

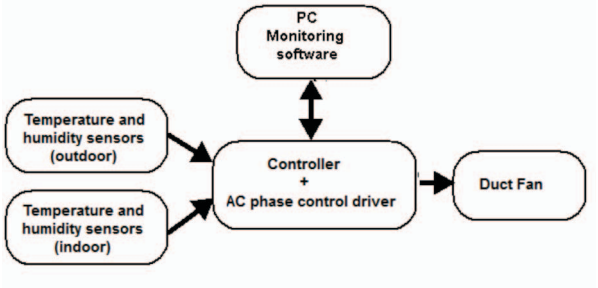

Fig. 1. VENTI system

III. VENTI Control Modes and Monitoring Software

The controller implements two control modes: "Vapor Pressure" and "Vapor Pressure + Temperature" that are able to be user configured. In the vapor pressure mode, the duct fan is under a classic on/off control based on the vapor pressure variation, and with the possibility to configure a hysteresis behavior, as shown in Figure 2. In this control mode, the user can configure three parameters: vapor pressure hysteresis, control period and monitoring period. Control Period defines the control action update time in the controller firmware (Range: [1, 540] s). Monitoring Period defines the data monitoring and recording update time in the software (minimum: 10 s).

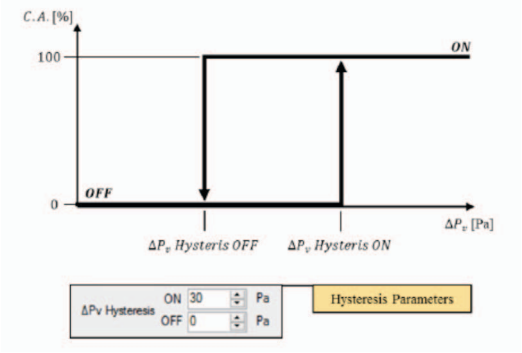

Fig. 2. Vapor pressure hysteresis control

In the other control mode (Figure 3), the duct fan is under variable AC phase control based on vapor pressure and temperature variation. In this mode the user, apart from configuring the vapor pressure hysteresis, defines the desired modulation of the fan velocity based on the external temperature.

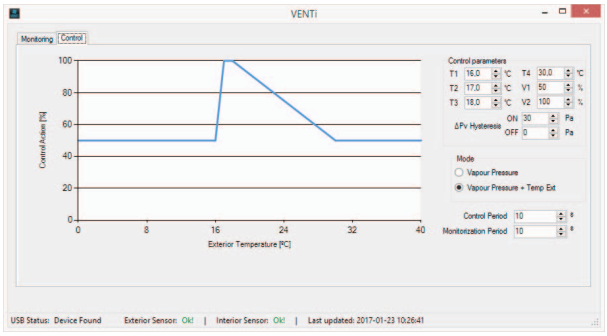

Fig. 3. VENTi control tab in "Vapor Pressure + Temp Ext" control mode

The developed VENTi software application stores sensor values, ventilator's control action and control parameters into a database file for further analysis. The software runs on a PC and provides on a graphical window to view the acquired data (Figure 4). With standard software tools, the computer is accessed through the internet, and the data is remotely available.

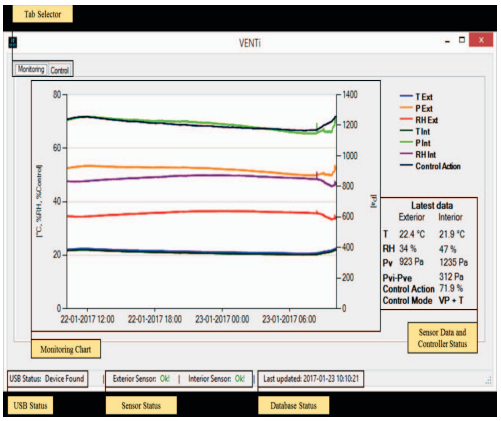

Fig. 4. Monitoring software

IV. Conclusions

The developed system, VENTI, is installed in a Laboratory in the Civil Engineering Department of the Faculty of Engineering where it is being used with an existing ventilation system. This installation insufflates air into the lab, using an inline duct fan from S&P (model TD-160/100 N Silent, 25W). The system is remotely accessed and is currently under test to explore different control strategies and its influence on the indoor temperature and humidity. The developed controller can be applied to other type of mechanical air supply or exhaust systems, powered by single-phase ac motors up to 70W

Acknowledgment

Authors gratefully acknowledge the funding of Project NORTE-01-0145-FEDER-000022 - SciTech - Science and Technology for Competitive and Sustainable Industries, cofinanced by Programa Operacional Regional do Norte (NORTE2020), through Fundo Europeu de Desenvolvimento Regional (FEDER).

References

[1] ANSI/ASHRAE Standard 62.1-2016, "Ventilation for Acceptable Indoor Air Quality".

[2] B. Chenari, J. D.Carrilho, G. Botte, and M. G. da Silva, Towards Energy-Efficient Ventilation in Buildings: Development of the Smart Window Ventilation System, JOCET 2016 Vol.4(6): 457-461

[3] Kevin Michael Smith, Svend Svendsen, The effect of a rotary heat exchanger in room-based ventilation on indoor humidity in existing apartments in temperate climates, Energy and Buildings, Volume 116, 15 March 2016, Pages 349-361.

[4] Samira Rahnama, Alireza Afshari, Niels Christian Bergsøe, Sasan Sadrizadeh, Experimental study of the pressure reset control strategy for energy-efficient fan operation: Part 1: Variable air volume ventilation system with dampers, Energy and Buildings, Volume 139, 15 March 2017, Pages 72-77

[5] Na Lu, Tsunaki Nukaya, Taichi Kamimura, Dalong Zhang, Ikusaburo Kurimoto, Michiko Takagaki, Toru Maruo, Toyoki Kozai, Wataru Yamori, Control of vapor pressure deficit (VPD) in greenhouse enhanced tomato growth and productivity during the winter season, Scientia Horticulturae, Volume 197, 14 December 2015, Pages 17-23.

[6] Roop Pahuja, Harish Kumar Verma, Moin Uddin, Implementation of greenhouse climate control simulator based on dynamic model and vapor pressure deficit controller, Engineering in Agriculture, Environment and Food, Volume 8, Issue 4, October 2015, Pages 273-2