CONFIGURATION AND EVALUATION OF A PID CONTROL SYSTEM BASED ON STATIC PRESSURE CRITERIA APPLIED TO AIRFLOW CONTROL

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ABSTRACT: With the growing concerns around environmental and health issues related to air pollution, farmers have recently invested in the construction of biofilters in order to reduce or even remove hazardous and odorous gases from the swine stored waste exhausted air. In this process known as bioconversion the waste air is pulled from the tank headspace and forced through a biofilter media. This procedure is done with a ventilation control system that detects variations on static pressure differential inside and outside storage tank and automatically controls the fan rotation in order to correct the air flow rate, maintaining it at a set-point value. This work presents the configuration and evaluation of the equipments used to control the biofilter ventilation. Results show that the composing equipments of the biofilter's ventilation control system were efficient and had good performance.

KEYWORDS: bioconversion, ventilation, PID.

CONFIGURAÇÃO E AVALIAÇÃO DE UM SISTEMA DE CONTROLE PID BASEADO NO CRITÉRIO DE PRESSÃO ESTÁTICA APLICADO AO CONTROLE DE FLUXO DE AR

RESUMO: Com o crescimento das preocupações em torno dos problemas ambientais e de saúde relacionados à poluição do ar, produtores agrícolas têm investido recentemente na construção de biofiltros para a redução ou mesmo a remoção de gases perigosos e odoríferos oriundos de dejetos armazenados removidos por exaustores. Neste processo, conhecido como biofiltragem, o ar poluído é succionado da parte superior do tanque e forçado através de um meio permeável. Este procedimento é feito com um sistema de controle de ventilação que detecta variações no diferencial de pressão estática no interior e fora do tanque de armazenagem e automaticamente controla a rotação do ventilador para corrigir o fluxo de ar, mantendo-o em um valor fixo. Este trabalho apresenta a configuração e avaliação dos equipamentos usados para controlar a ventilação em biofiltros. Os resultados mostram que os equipamentos componentes do sistema de ventilação do biofiltros foram eficientes e tem bom desempenho.

PALAVRAS-CHAVE: bioconversão, ventilação, PID

INTRODUCTION: Public concerns over air pollution from swine production and stricter environmental regulations have created a great need for odor-related research in the swine industry (THU, 2002). Stored wastes release offensive and hazardous gases to the atmosphere, such as ammonia, methane and hydrogen sulfide, that are considered harmful to the environment, are odorous and even explosive at high concentrations (MUEHLING, 1970, and ZAHN et al., 2001). Biofiltration is an odor removal technology in which odorous airstream is passed through a moist, porous filter medium prior to emission into the atmosphere (MANN et al., 2002). While the airstream passes through the moist, the bioconversion occurs, that is the transformation of a specific product into another product by microorganisms fixed to a porous medium that break down pollutants present in an air stream in order to reduce gas emission (DEVINNY et al., 1998, and PHILLIPS et al., 1995). The biofiltration is performed by a biofilter, which has a ventilation control system based on Proportional-Integral-Derivative (PID) logic, whose role is to draw gases from the storage tank (maintaining a desirable negative pressure inside the tank) and to force them to pass through the filter medium (GREEN et al., 2005). The ventilation control system is comprised of a static pressure controller, a variable frequency drive, a motor and a fan. The objective of this work is to configure and evaluate the ventilation control system equipments – and to verify the accuracy of the static pressure controllers – for a biofilter in laboratory in order to test the equipment's effectiveness to ensure that it will work as expected when installed in the biofilter system at the farm.

MATERIALS AND METHODS: The equipment's configuration and evaluation were conducted at the Environment Control Laboratory of the University of Kentucky/College of Agriculture – USA. Three sets of devices that comprise the aeration system were acquired by the Institution, one set for each tank to be ventilated. A ventilation control system is comprised of a static pressure controller based on PID logic, a variable frequency drive, and a reinforced plastic pressure blower powered by a motor with 3.57 kW (GATES, 2002). For the static pressure controllers' evaluation, a ventilation chamber was used, along with a standard level manometer in the laboratory. Each controller unit and the standard level manometer were connected to the chamber at the same point (Figure 1) and a motor connected to a variable frequency drive was used to power the chamber's fan. As the variable frequency drive was tuned using its 12 stages of frequency in order to vary the airflow inside the chamber, the static pressure measurements from both the controllers and the standard level manometer were written down and inserted to the Microsoft® Excel to be compared, in order to generate the calibration curves, for each controller, and their respective R^2 values allowing the controllers' accuracy verification.

RESULTS AND DISCUSSION: The electronic devices that comprise the controlled aeration system were tested in laboratory before and after being mounted, by using a ventilation chamber with a fan. The static pressure was the variable in study. The curves' R^2 values were equal to 1 for two device and, approximately equal to 1 for the one remaining device (Figure 2), confirming that the three controllers were well calibrated. The next step was configuring the variable frequency drives to work in manual mode and in automatic mode. In manual mode, the drive is connected directly to the source of energy and to the motor, and the operation mode parameter is selected as manual mode, then, it can be controlled by using keys on the drive's display. In automatic mode, the drive is connected to a variable voltage source and to the motor, and the operation mode parameter is selected as automatic mode, then, the drive itself controls the fan speed according to the received voltage signal. In both operation modes, the drive played well its role, showing to be effective. After that, the static pressure controllers were configured to operate in automatic mode, where the controller output that modulates the need to maintain the process in a desirable value of static pressure differential, established as a reference value or set-point, sending PID current signals to the drive that controls the fan rotation. The PID parameters were maintained as default values. Subsequently, all devices were connected together (Figure 3), in a linear way, where the chamber's fan causes a static pressure variation, which is detected by the static pressure controller, that sends PID signals to the variable frequency drive that, automatically, adjust the fan rotation, varying the airflow, in order to correct the measurement, reaching the set-point value. The system showed effective, working automatically as expected in laboratory. When the pressure was adjusted for a value below the set-point, the system increased the fan's speed in order to reach the set-point. For values above the set-point, the speed was maintained in the minimal value in order to maintain the fan working, but not causing a negative pressure increase inside the tank. The response of the system varied according to the speed of change of the static pressure value: when the value of the static pressure decreased fast, the speed of the fan increased fast. That response speed was modulated by the controller PID of the static pressure controller.

CONCLUSION:

This study presented the configuration and evaluation of the equipments used to control the biofilter ventilation. The static pressure controllers showed calibrated and all the equipments that comprise the ventilation control system showed effective and appropriate to control the static pressure in laboratory. Then, it is possible to conclude that the ventilation control system devices will work as expected in the field, when installed in the biofilter system.

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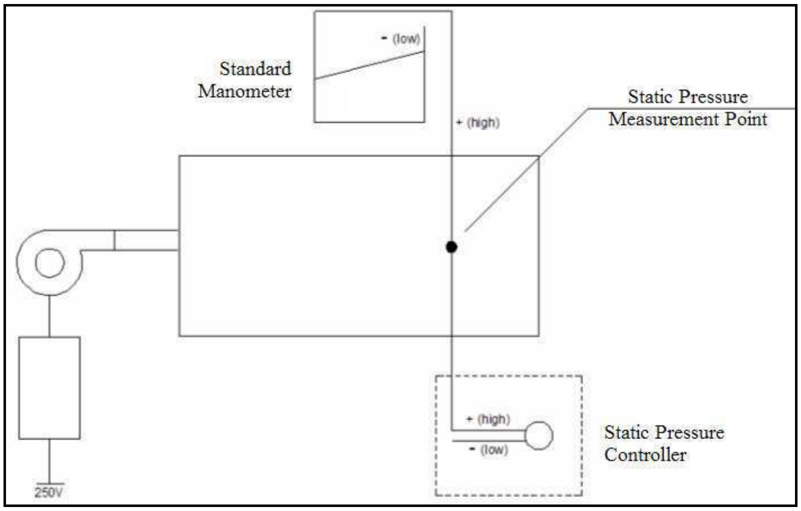

Figure 1 - Outline showing the mounted system for controllers' transducers evaluation.

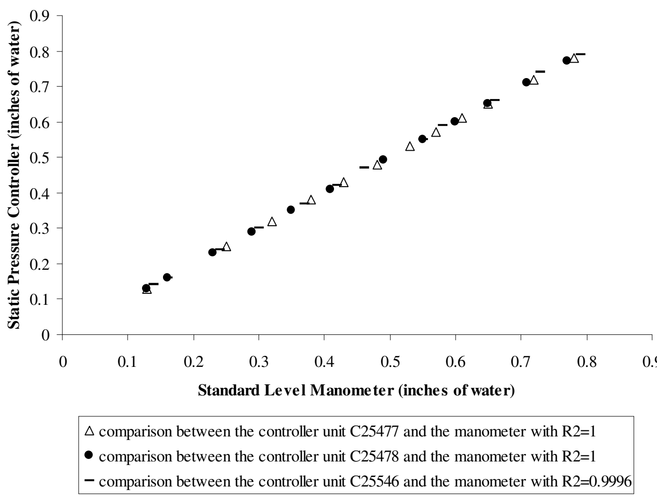

Figure 2 – Comparison between each one of the controllers and the standard level manometer.

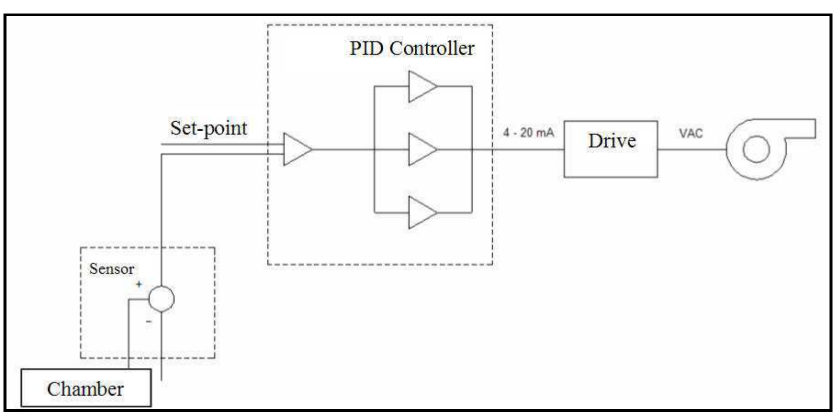

Figure 3 - Outline showing connections between the Chamber, the Controller, the Drive, and the Fan.