Computational Fluid Dynamics Study on the Influence of Airflow Patterns on Carbon Dioxide Distribution in a Scaled Livestock Building

<strong/>

Rong, Li; Nielsen, Peter V.; Tong, Guohong; Ravn, Peter; Zhang, Guoqiang

Published in:
AgEng2008 : International Conference on Agricultural Engineering

Publication date:
2008

Document Version
Publisher's PDF, also known as Version of record

COMPUTATIONAL FLUID DYNAMICS STUDY ON THE INFLUENCE OF AIRFLOW PATTERNS ON CARBON DIOXIDE DISTRIBUTION IN A SCALED LIVESTOCK BUILDING

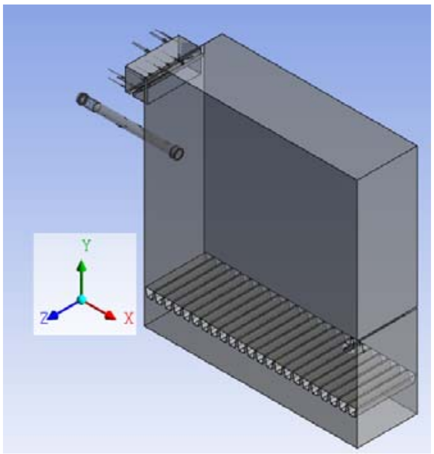
Li Rong[1], Peter V. Nieslen[1*], Guohong Tong[2], Peter Ravn[3], Guoqiang Zhang[3]

[1] **Department of Civil Engineering, Aalborg University, Sohngaardsholmsvej 57, DK-9000 Aalborg e-mail: pvn@civil.aau.dk**

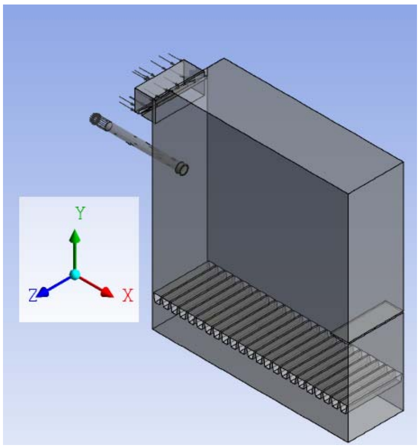
[2] **College of Water Conservancy, Shenyang Agricultural University, Shenyang 110161, China e-mail: guohongtong@yahoo.com.cn**

[3] **Department of Agricultural Engineering, Research Centre Bygholm, University of Aarhus,Schuttesvej17, DK-8700 Horsens, Denmark, e-mail: guoqiang.zhang@agrsci.dk**

Airflow patterns and airflow rate have an important influence on contaminant distribution in swine buildings. The objective of this paper is to model and evaluate the effect of airflow rates and airflow patterns on CO_2 concentration distribution. Contaminant sources are assumed to be modeled as a constant concentration on the manure surface. Three different ventilation rates and three different deflector degrees are studied, in which the deflector is used to change the airflow patterns. A CFD (Computational Fluid Dynamics) commercial software code has been applied to simulate the air velocity and contaminant distribution. Experimental data of tracer gas concentration distribution in the chamber are obtained to validate the turbulence model in CFD software. Simulation results show that different ventilation rates and airflow patterns effect the contaminant distribution within the room. With increasing the airflow rate, the emission of CO_2 will increase and the dimensionless CO_2 concentration above the slatted floor will also increase slightly, while the absolute CO_2 concentration in the room will decrease with increasing the airflow rate. Here the dimensionless CO_2 concentration is defined as: $c^* = \frac{c - c_0}{c_r - c_0}$, and $c*$ is the dimensionless CO_2 concentration, c is the CO_2 concentration in the room, c_0 is the inlet CO_2 concentration, c_r is the outlet CO_2 concentration.

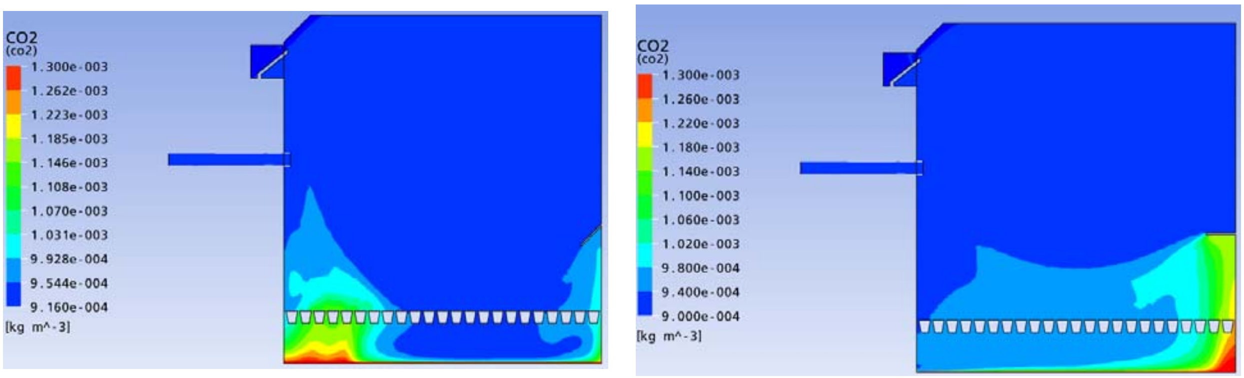


(a) 45 degree's deflector



(b) 90 degree's deflector

Figure 1 model for simulation



(a) 45 degree's deflector (b) 90 degree's deflector

Figure 2 CO_2 concentration distribution in the middle plane with Z=0.31m

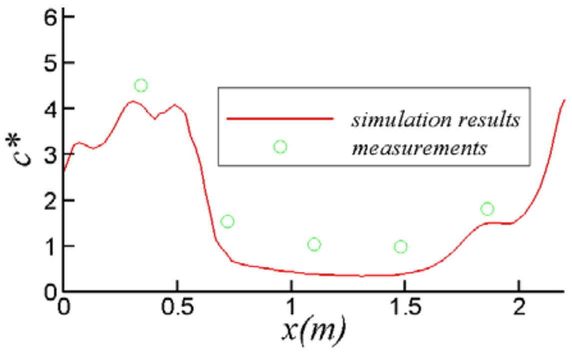


Figure 3 Comparison of dimensionless CO_2 concentration between simulation result and measurement above the slatted floor of y=0.51m with 45 degree's deflector

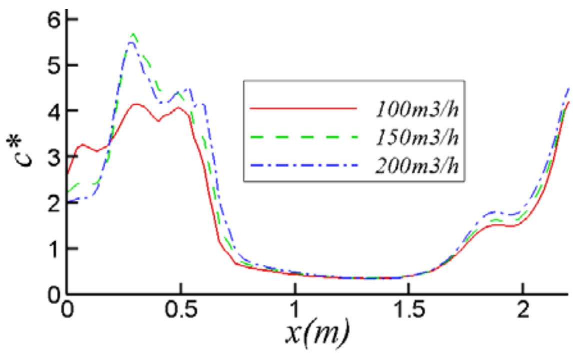


Figure 4 Comparison of dimensionless CO_2 concentration among three various airflow rates along the line y=0.51m above the slatted floor with 45 degree's deflector

Reference

1. Jiqin Ni, Albert J. Helber, Daniel T. Kelly and Alan L. Sutton. Mechanism of Gas Release from Liquid Swine Wastes. ASAE Meeting Paper No. 01-4091. ST. Joseph, Mich. : ASAE.
2. Jiqin Ni, Christiaan Vinckier, Jos Hendriks, Jan Coenegrachts. Production of carbon dioxide in a fattening pig house under field conditions. Ⅱ. Release from the manure. *Atmospheric Environment*. 1999, 33, 3697-3703.
3. Heber A J, Boon C R, Peugh M V. Air Patterns and Turbulence in an Experimental Livestock Building. *Journal of Agricultural Engineering Research*. 1996, 64, 209-226.
4. B. Bjerg, S. Morsing, K. Svidt, G. Zhang. Three-dimensional Airflow in a Livestock Test Room with Two-dimensional Boundary Conditions. *Journal of Agricultural Engineering Research*. 1999, 74, 267-274.
5. P. V. Nielsen. The selection of Turbulence models for prediction of room airflow. *ASHARE Transactions*. 1998, 104, Part 1B, 1119-1127.
6. P. V. Nielsen. Computational fluid dynamics and room air movement. *Indoor Air*. 2004, 14, 134-143.
7. Zhang G., Morsing S., Bjerg B., Svidt K., Strøm J.S.. Test room for validation of airflow patterns estimated by computational fluid dynamics. *Journal of Agricultural Engineering Research*. **2000**, 76, 141-148.