Initial studies on Virtual Reality Visualisation of 3D airflow in ventilated livestock buildings

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ABSTRACT

This paper describes simulation of airflow and temperature distribution in livestock buildings. Four different configurations of ventilation system have been studied. Low momentum air supply was studied with air supply near the floor and through the ceiling respectively. High momentum air supply was studied in configurations with a slot inlet as well as a number of individual inlets. The three-dimensional airflow has been visualised in panorama and a six-sided CAVE. The flow was visualised by arbitrary planes of velocity vectors and air temperature as well as streamlines and moving particles.

KEYWORDS

Virtual Reality, CFD, airflow, livestock buildings

INTRODUCTION

Prediction of airflow and distribution of temperature and pollutants in buildings has been an important issue for engineers for many years. During the last ten years, Computational Fluid Dynamics (CFD) has shown quite promising results. Today, typical simulation results contain values of air velocity components, temperature, turbulence parameters etc. in 100,000 to 1 million grid nodes in the three-dimensional calculation domain. It is a great challenge to visualise such data in a suitable way. The possibilities are of course highly dependant of the available medium (e.g. black and white printing, colour animations, interactive VR).

The present work is based on a few cases from a Danish research programme on airflow in livestock buildings. Figure 1 and 2 shows examples from this project of visualising complex three-dimensional flow in black and white printing.

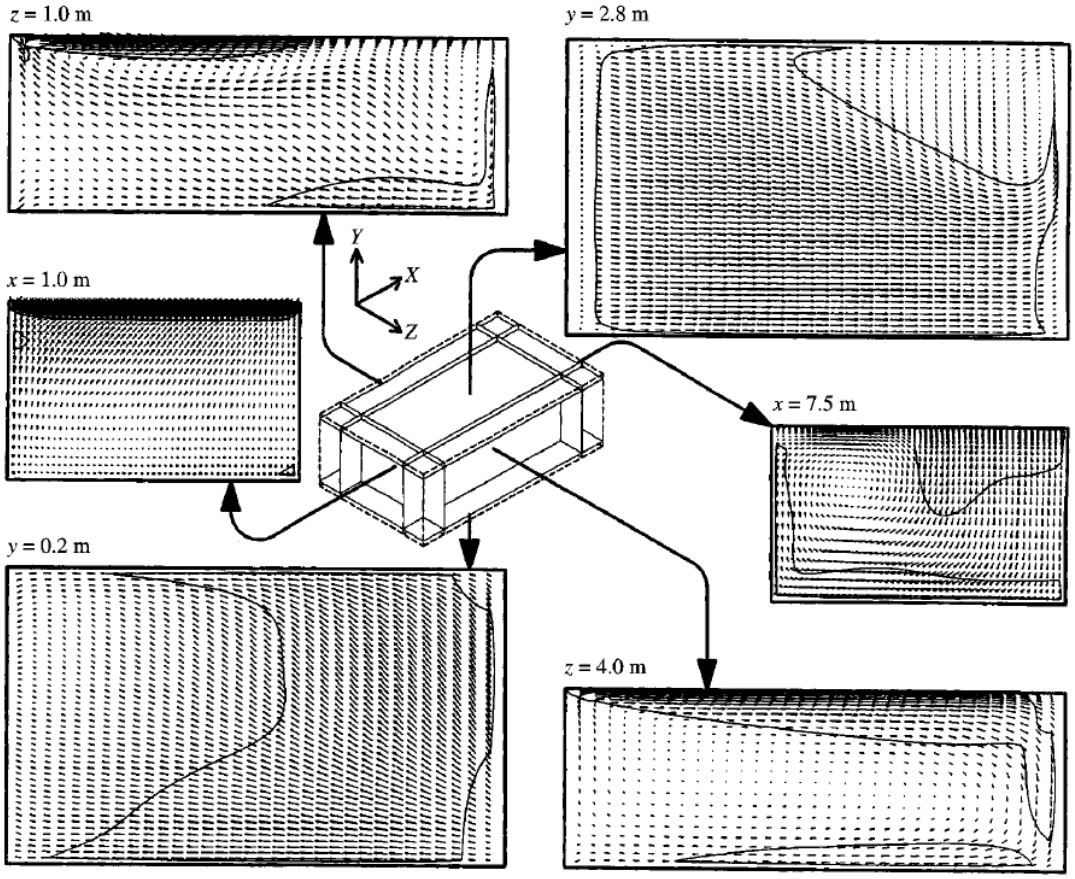

Figure 1. Three-dimensional airflow simulation results illustrated by a number of two-dimensional plots (Bjerg et.al. 1999)

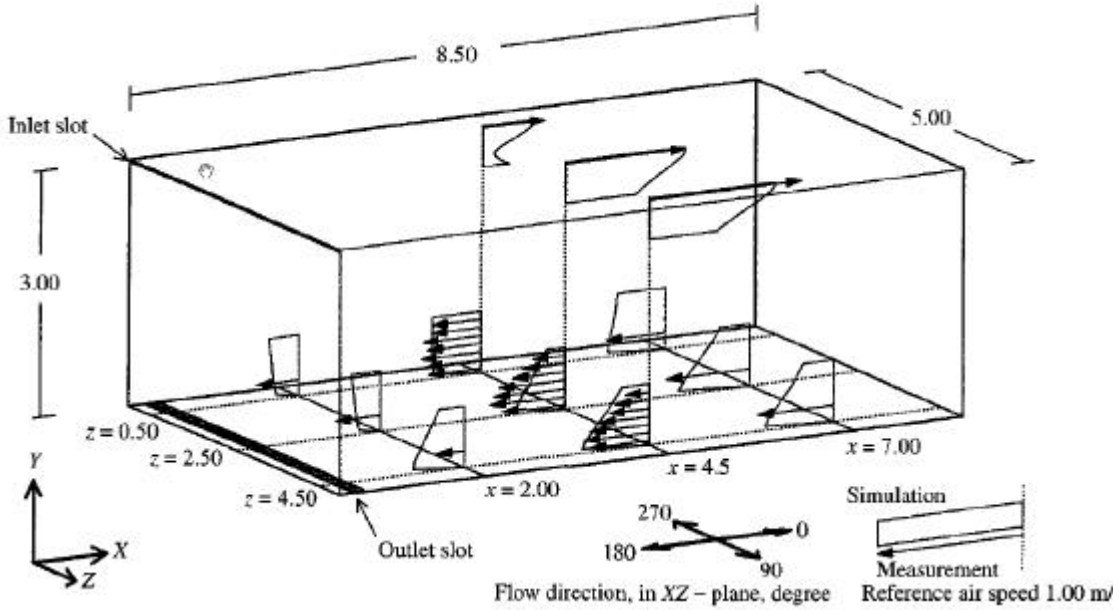

Figure 2. Another way of illustrating the three-dimensional airflow in a comparison with laboratory measurements (Bjerg et.al. 1999)

BACKGROUND AND METHODS

The Danish research programme *Control of airflow in livestock buildings* was a five-year project focusing on computer simulation of airflow and indoor environment in livestock buildings. During the project, the researchers have used different kinds of traditional post processing to analyse and visualise simulation results.

At the end of the project it was decided to make a one-day information seminar for professionals in the ventilation industry and consultants from the agricultural extension service.

For this seminar, a few cases reflecting research results as well as problem-cases from the industry were selected to be presented in the Virtual Reality facilities at Aalborg University.

Airflow was calculated with the commercial CFD-code *Fluent version 5.5*. Results were converted and displayed with the visualisation code VU (www.cerca.umontreal.ca/vu) . The results were displayed in the panorama as well as the six-sided CAVE.

CASES

The following cases were selected for VR presentation:

1. 3D airflow in a laboratory set-up with an isothermal slot inlet
2. Airflow and CO2-concentrations in a laboratory set-up with 4 wall inlets and "pig simulators"
3. Simulation of displacement ventilation in a room with closed pen partitions
4. Airflow in a similar room with a low momentum ceiling inlet
5. Airflow in a room with a radial inlet device

The cases are described in figures 3 – 6 on the next pages.

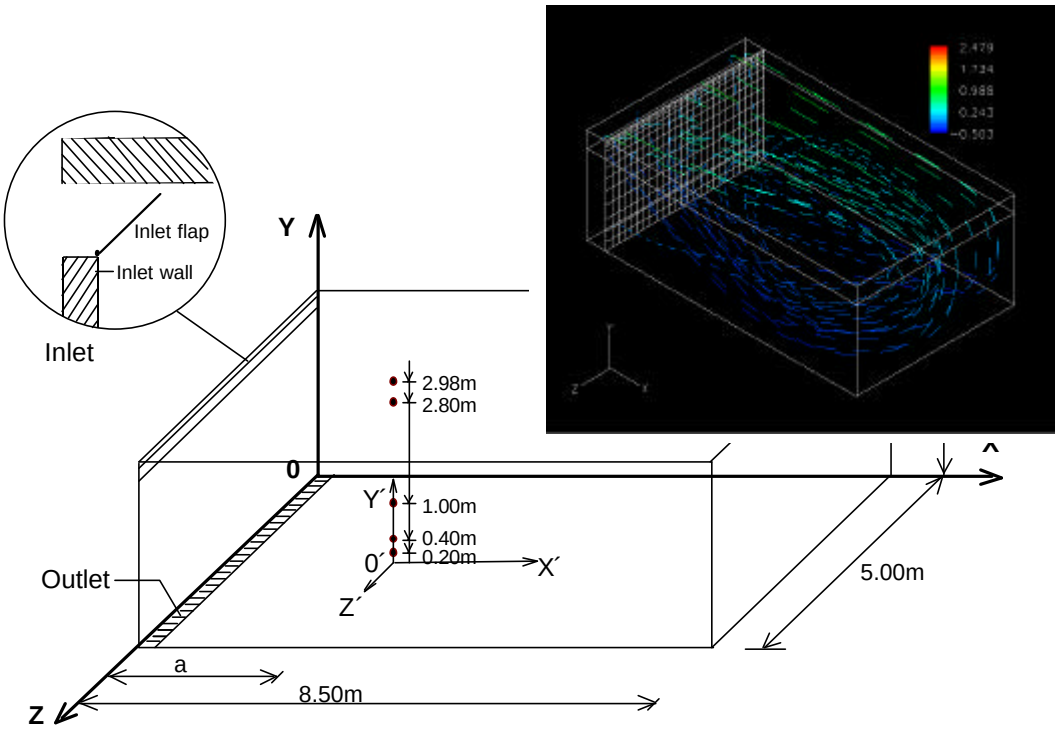

Figure 3. Case 1. 3D airflow in a laboratory set-up with an isothermal slot inlet.

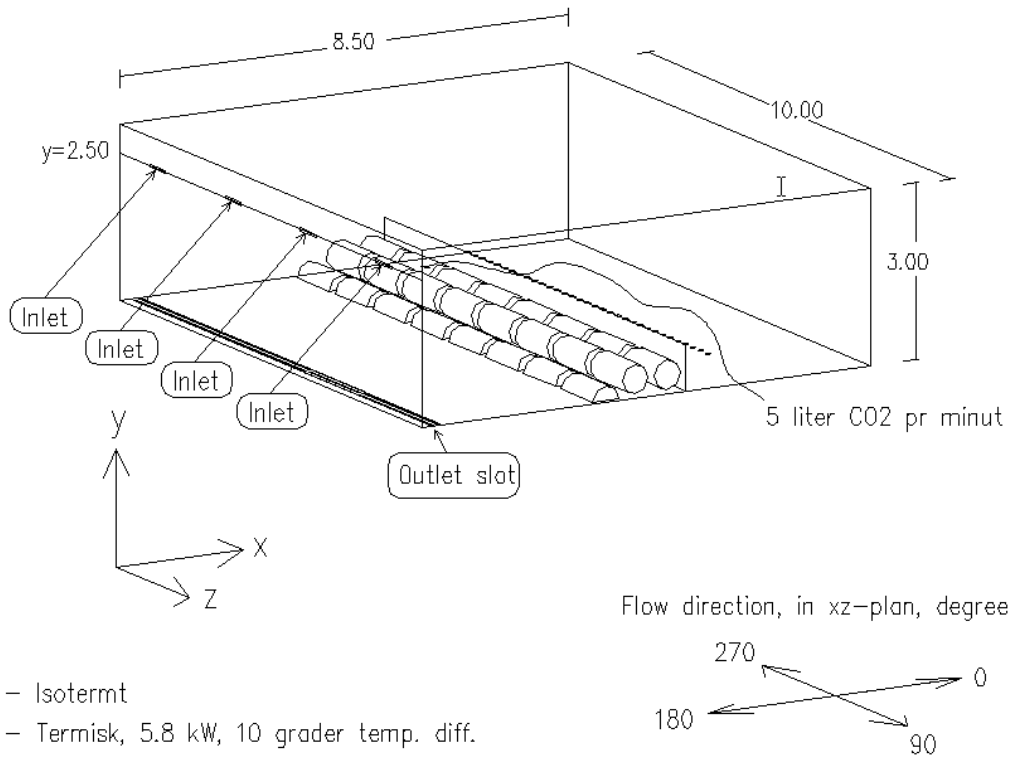

Figure 4. Case 2. Airflow and CO_2 concentration in a laboratory set-up with 4 wall inlets and "pig simulators"

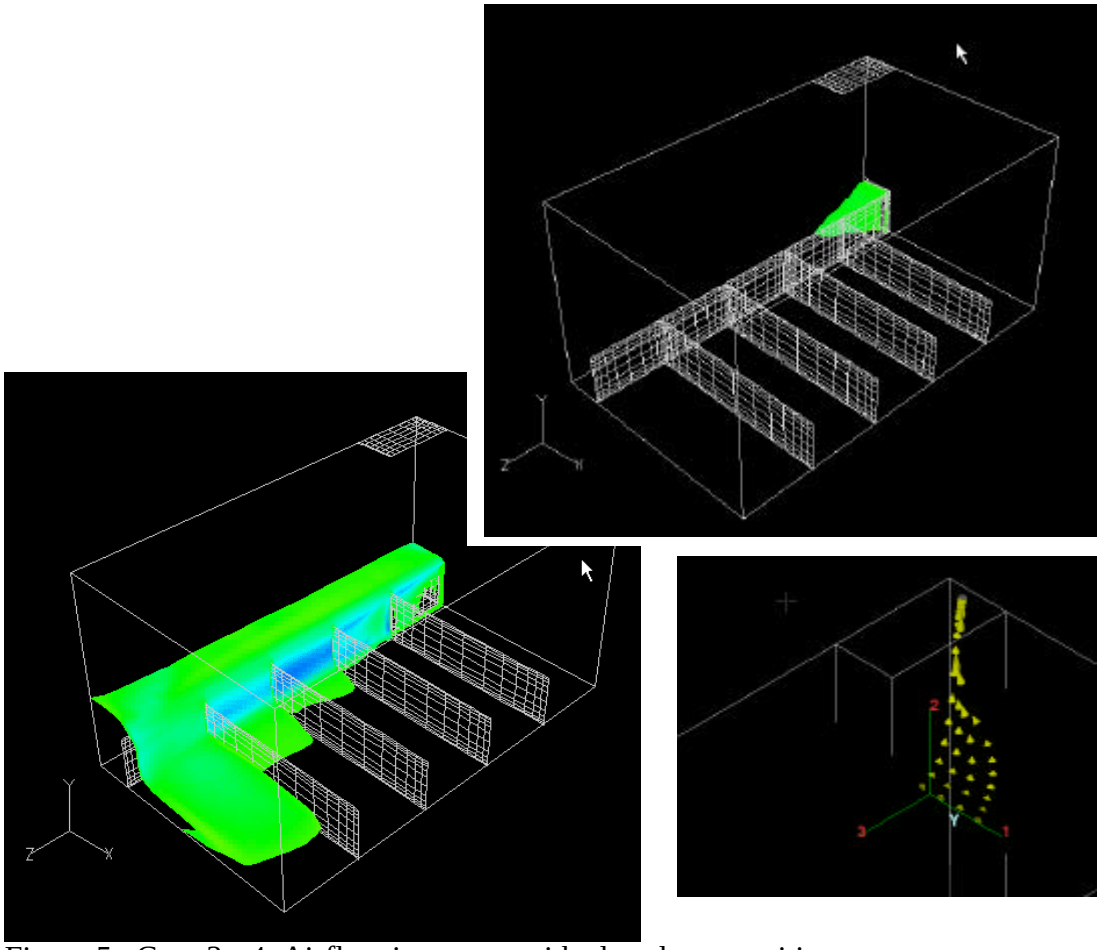

Figure 5. Case 3 - 4. Airflow in a room with closed pen partitions.

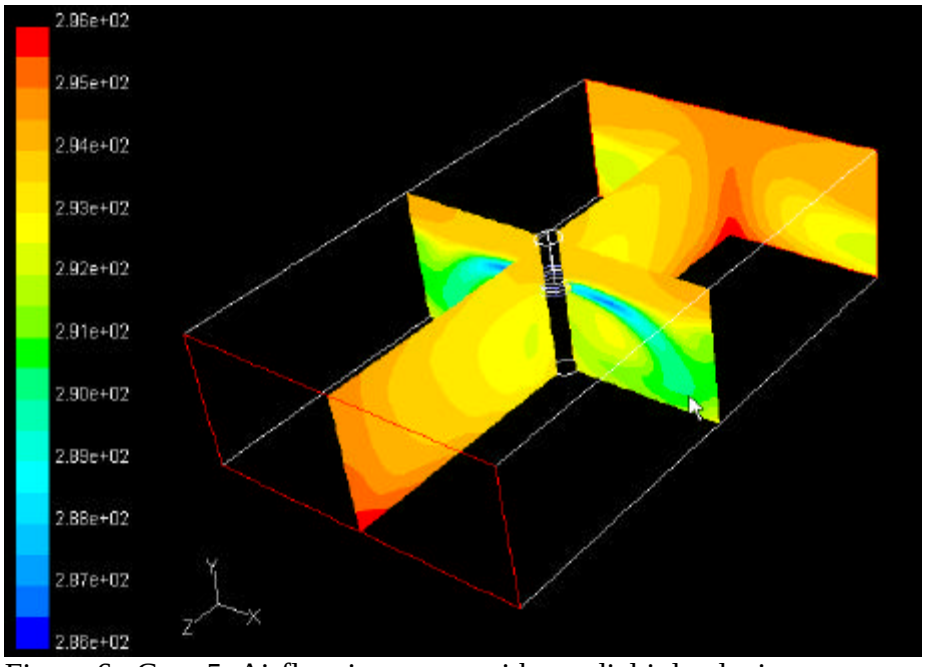

Figure 6. Case 5. Airflow in a room with a radial inlet device.

RESULTS AND CONCLUSIONS

The VR facilities proved to be very efficient to visualise the three-dimensional airflow for people with no special background in 3D modelling and fluid motion.

The results were visualised with filled contour planes or vector planes which the presenting person could move arbitrarily in the model. In addition he could place seed points for streamlines or particle tracks in an intuitive way by moving physically around in the model.

Especially the CAVE gave a very persuasive experience of being inside a virtual room with a virtual airflow.

However, it requires some training to navigate in the models and to scale and position them in a suitable way in relation to the physical surroundings (the audience, the panorama screen, the walls of the CAVE etc.)

In general we saw that inexperienced persons tend to stand in a fixed position trying to reach to the extents of the model instead of moving freely around in the available space.

REFERENCES

Bjerg, B., Morsing, S., Svidt, K., Zhang, G. 1999: *Three-dimensional airflow in a livestock test room with two-dimensional boundary conditions.* Journal of Agricultural Engineering Research, Vol. 74, No. 3, pp 267-274.