AIR STREAMS IN BUILDING FOR BROILERS

PAVEL KIC - MILAN ZAJÍČEK

ABSTRACT

The Fluent CFD software is used to do numerical analysis of existing poultry house during the summer and winter periods. Principal problem solved by simulations is the velocity field determination. Possible influences of geometry and flow conditions on the temperature field are also given. Better arrangement of air inlets leads to lowering of energy costs needed to additional heating of the poultry house during the winter.

Keywords: ventilation, air velocity, poultry, simulation, model, CFD, Fluent

INTRODUCTION

Air flow with suitable velocity in living area of poultry is one of the main important parameters, which create the suitable or not suitable microclimatic conditions inside the building for housing of poultry during the whole year. Specific problems are in the buildings for broilers, because they are growing in artificial conditions since the first day of their live (several grams of the weight) to the end of fattening (several kilograms). Especially summer period with highest outside temperatures and winter with low outside temperatures are problematic.

The need of exact control of temperature, humidity and air velocity is main reason, why the application of different simulation methods is very suitable and progressive help for designers and researchers. This paper is focused on the method of air streams study with prediction of expected air velocities and temperatures during the summer and winter periods with the use of computer fluid dynamics (CFD).

MATERIAL AND METHODS

For this research study a broiler house at University farm in Červený Újezd (ownership of Czech University of Life Sciences Prague) was used. The poultry house is 41 m long and 17,2 m wide. Total volume of air inside the ventilated area is 2000 m3.

There are two rows of windows (one row consists of 9 windows in three equidistant sections) on opposite long sides, used as an inlets of the fresh air. Outlets with dimension 0,8 x 0,8 m are situated at the central line along the length of the hall and they are equipped by axial fans with automatic control capacity according to the indoor temperature. Model experiments are done both in winter and in summer fattening period.

For the summer conditions the bottom edge of window is at the height of 0,75 m above the floor, but for the winter conditions we analyze the theoretical case, where the windows are situated at the top of side wall at the height 2,5 m. Details of the poultry house are given in figure 1.

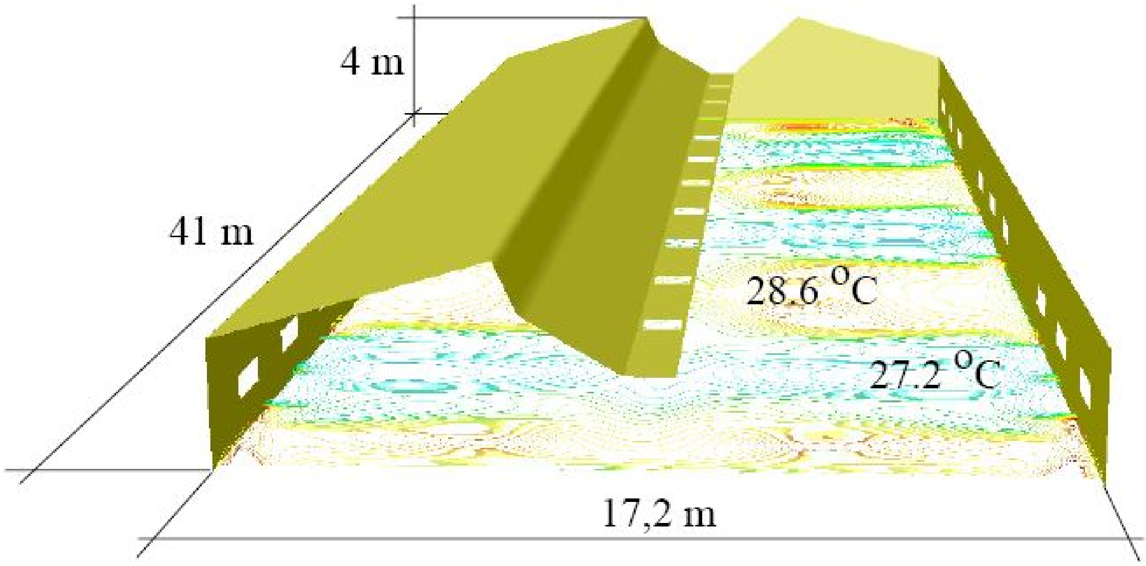

Figure 1 Construction of poultry house with basic dimensions and temperature distribution for summer conditions at the plane 150 mm above the floor

Calculations of biological productions and main ventilation parameters are based on the data from ČSN 73 0543-2 Internal environment in buildings for animal. Part 2: Ventilation and heating [2]. They are summarised at the table 1.

Table 1 Basic parameters of the model

The housing capacity of the broiler house	15 000 heads
Weight of 1 broiler	1,5 kg
Winter outside temperature	− 15 °C
Winter total flow rate	21 000 kg.h^{-1}
Summer outside temperature	+ 27 °C
Summer total flow rate	117 000 kg.h^{-1}

The Fluent CFD software is used for the numerical simulation. Geometrical model is prepared with generic Fluent's pre-processor Gambit, completely from scratch according to the geometrical dimensions of existing facility. The numerical results presented in this article was obtained as a fully 3D solution of mass and heat transfer equations on about four million finite volume cells, with pressure boundary conditions and the total mass flow rate was used as a tuning parameter.

Thermal boundary conditions of two kinds are used and set up according to Fluent's documentation [3] with using of air parameters obtained from tables [1]. The first is the far field temperature defined at inlets and outlets. Second one is the volumetric heat source, which is uniformly distributed over the chicken living volume and represents the heat produced by animals.

RESULTS AND DISCUSSION

Two main results are obtained from numerical models – the velocity field and the temperature distribution in animal zone. They both are illustrated at plots, which are the sets of temperature and velocity profiles along the lines situated at the level 150 mm above the floor.

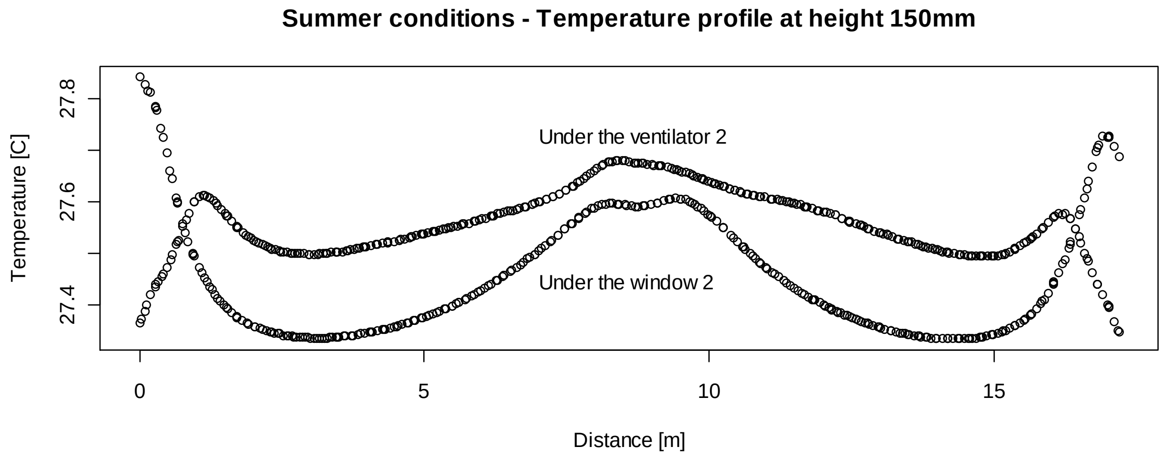

Figure 2 Temperature profile under the ventilator and under the window during summer

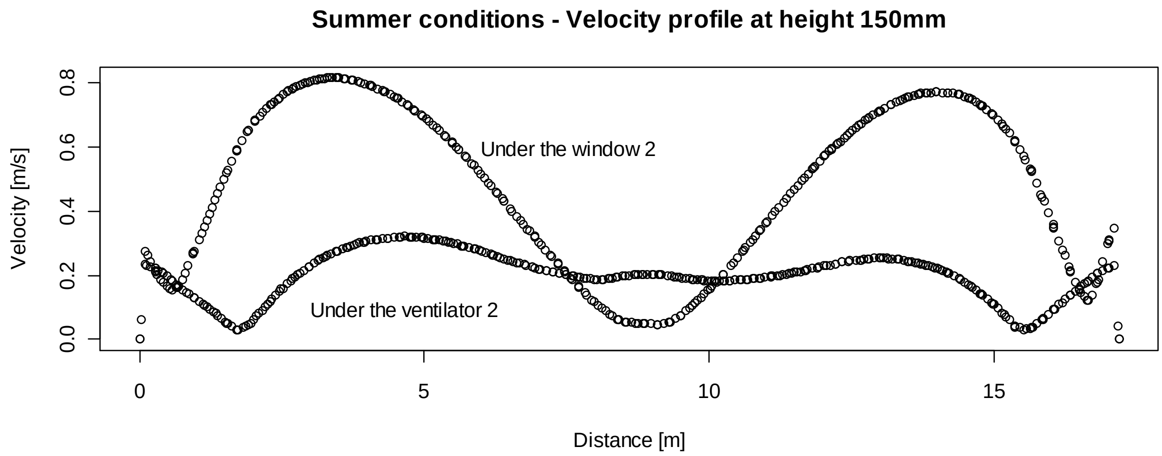

Figure 3 Velocity profile under the ventilator and under the window during summer.

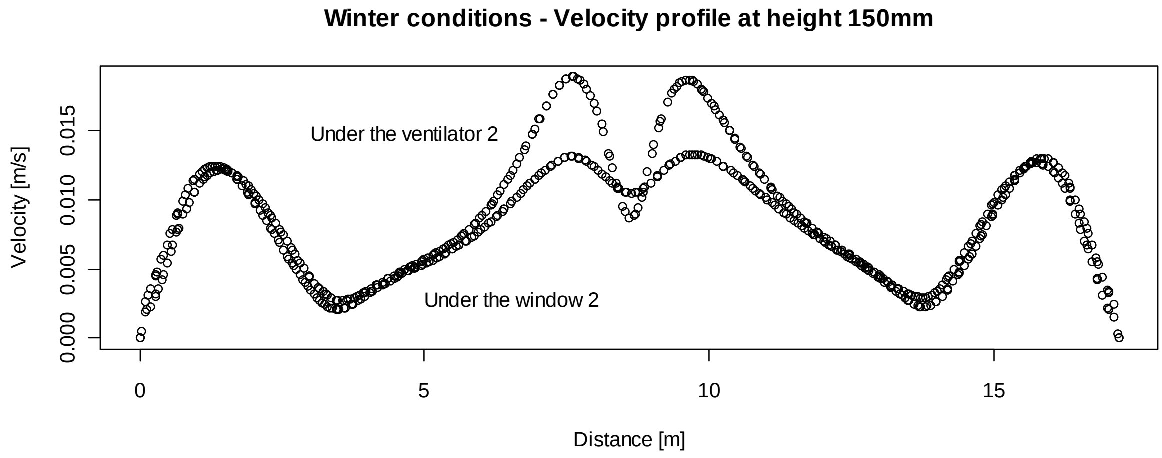

Figure 4 Velocity profile under the ventilator and under the window during winter.

Simplification of real state was made and some physical effects were neglected in this stage of research work. There are no natural convection effects and no heat flow through side walls. It should be remembered, that it leads to errors in thermal balances. It has nearly no effect in summer condition, where the principal mechanism of heat transfer is forced convection and the difference between outside and inside temperature isn't so big. Greater influence of natural convection can be expected during the winter, where the difference between outside temperature and temperature demanded by animals can be sometimes about more than 20 degrees.

Temperature and velocity profiles for summer period are shown at figures 2 and 3. There are obtained at height of 150 mm beyond the floor under axis of window 2 and under axis of fan 2 during summer. They are situated under the second window and second fan counted from the gable of the building. Maximal velocities in the first and third quarter of the profile under the window correspond to minimal temperatures. It is caused by the strong and relatively quick input stream, which cools these (not so large) zones nearly to the outside temperature.

Winter configuration was changed against the geometry of existing building. Windows at this case are moved up to the height of 2,5 m. It brings two very good results. At first the velocities during winter are very low and it is seen, that profiles under the window and under the fan are nearly the same along the cross section of the hall. It is typical for the homogenous flow field. The second benefit is the extension of the distance between air inlets and animals zone, which leads to the better pre-heating of the inlet air and leads to lowering of energy costs needed to additional heating of the poultry house.

CONCLUSIONS

The numerical model solved with Fluent can be used for the simulation of flow and thermal state inside agricultural buildings. It is the perfect solution for finding the critical zones with any extreme parameter. Presented cases give the imagination how to analyse results of such simulations and find a suitable solution of construction and positioning and control of ventilation system and equipment.

The future research will be focused on the other development of the application in rural buildings. The expected way is to make this theoretical CFD model more complex and tune it against the real detailed measuring, not only against integral mass and energy flow rates.

REFERENCES

1. Šesták, J, Bukovský, J., Houška, M.: Tepelné pochody - transportní a termodynamická data, 4. vydání, ČVUT Praha, 1998 (in Czech)
2. ČSN 73 0543-2 Internal environment in buildings for animal. Part 2: Ventilation and heating (in Czech)
3. Fluent Inc, Fluent user's guide - Chapter 9 , Version 6.3, Fluent Inc., Lebanon, NH, USA. 2006

Addresses:
Prof. Ing. Pavel Kic, DrSc., FE CULS Prague, 165 21 Prague 6 – Suchdol, kic@tf.czu.cz
Ing. Milan Zajíček, ITIA AS CR v.v.i., Pod vodárenskou věží 4, 182 08 Prague 8, zajicek@utia.cas.cz